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“A face in the crowd”

(Street Photographer in Singapore).

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If you want to truly understand something, try to change it.

Kurt Lewin (1936)

Principles of Topological Psychology

Chapter 1

General introduction

Probing the Relation between Attentional Bias for Threat and Anxiety:

A Theoretical and Empirical Review

As commonly shared in folk wisdom, some people see their glass as being half full while for others it is half empty. In accordance to folk wisdom, research has documented that people vary in the extent to which they attend to negative or positive cues. More precisely, it is now well known that those who are prone to anxiety are more likely than others to pay more attention to concern-related cues (e.g., Mathews & MacLeod, 2005). Such findings suggest the existence of connections between attentional selectivity for emotional cues and emotional responses (e.g., anxiety).

In the same vein, since Broadbent (1958) and Treisman (1964), many researchers have highlighted that selective attention stands out as one the most important core process in human cognition because it acts as an initial filter in processing the environment and, through a snowballing effect, interacts with all subsequent cognitive processes, such as memory systems (e.g., Pessoa, Kastner, & Ungerleider, 2002), interpretation of situations (e.g., Gross, 2002; White et al., 2011), decision-making and motor systems of guiding actions and behaviors (e.g., Desimone & Duncan, 1995).

A core assumption guiding current research in psychopathology is that anxious individuals process information differently than do people without anxiety, and that such attentional biases play an important role in the maintenance, and perhaps in the etiology, of pathological anxiety and fear. Fear and anxiety disorders are the most prevalent class of mental disorders in Western countries, with over 28% of the population meeting criteria for an anxiety disorder at some point in their lifetime (Bijl, Ravelli, Van Zessen, 1998; Canino et al., 2004; Kessler, Chiu, Demler, & Walters, 2005a; Roberts, Roberts, & Xing, 2007). In addition to being highly prevalent, anxiety disorders significantly burden society through lower educational and

occupational impairment and increased health care utilization. At a diagnostic level, both fear and anxiety disorders are included in the category of anxiety disorder of the Diagnostic and Statistical Manual of Mental Disorder (DSM; American Psychiatric Association, 1994). However, at a descriptive level, although both fear and anxiety disorders are marked by a heightened state of arousal and negative affect, they exhibit differences in their phenomenology. Fear has been defined as stimulus specific (e.g., LeDoux, 1992; Marks, 1969), characterized by a clear onset (coinciding with the confrontation with the threatening stimulus) and an equally clear offset (coinciding with the removal of the threatening stimulus). In contrast, anxiety is not associated with a specific discrete cue and time course but rather by the apprehensive anticipation of upcoming potential threats (Bouton, Mineka, & Barlow, 2001; Grillon, 2002; Grillon & Davis, 1997). Fear is more prevalent in specific phobia, while anxiety is the wholemark of generalized anxiety disorder, social phobia or obsessive-compulsive disorder (e.g., Kessler et al., 2005a).

Over the past decades, a wealth of studies on attentional bias for threatening information within the context of anxiety disorders has been published. Operationally, an attentional bias towards threat refers to a differential attention allocation towards threatening stimuli relative to neutral stimuli (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Cisler & Koster, 2010; MacLeod, Mathews, & Tata, 1986; Mogg & Bradley, 1998). Although the attentional bias for threat has been systematically demonstrated in anxious populations, uncertainty abounds regarding the relation between attentional bias and fear/anxiety. Further, while several theoretical models of anxiety disorders have formulated strong causal claims in which attentional bias appears as a critical factors in the etiology and/or maintenance of anxiety disorders, others have, in striking contrast, formulated

attentional bias as a mere consequence or a by-product of fear and anxiety. Therefore, in this review, we will examine the present state of knowledge on the relation between attentional bias for threat and anxiety disorders. Rather than exhaustively reviewing all studies, our aim is to provide the reader with a comprehensive overview of the empirical data and of the theoretical models that take the relation between attentional bias and anxiety into account.

To this aim, the present chapter is divided into three sections. In a first section, we will briefly present an overview of the different experimental paradigms commonly used in attentional bias research. Alongside the formal presentation of these paradigms, we will present the phenomenological features of attentional bias pointed up by these paradigms. In a second section, cognitive theoretical models of anxiety that take into account attentional bias for threat will be presented. For each model, we will discuss how the causal nature of the relation between attentional bias for threat and anxiety is conceived of. Finally, we will review the current state of evidence regarding causality of attentional bias for threat in the installation and/or maintenance of the disorder.

1.1. Attentional bias for threat: From paradigms to phenomenological features

In this section, we will describe the most common behavioral attentional paradigms (for a detailed review, see Weierich, Treat, & Hollingworth, 2008; Yiend 2010). It should be noted that we will exclusively focus on visual attention paradigms (for illustrations of auditory attentional task, such as the dichotic listening task, see Foa & McNally, 1986; Wood & Cowan, 1995a, 1995b). Rather than developing an exhaustive review of all studies and paradigms assessing attentional bias for threat in

anxiety, the main goal of this section is, through the presentation of these paradigms, to provide an overview of the critical features of the phenomenology of attentional bias for threat.

1.1.1. The Emotional Stroop Paradigm

The Stroop task (Stroop, 1935) was one of the first visual attentional paradigms that was emotionally tuned (e.g., Watts, McKenna, Sharrock & Trezise, 1986). In the emotional Stroop task, different types of words or pictures either threatening (e.g., spider) or neutral are displayed in varying colors on a computer screen (for exception, see Hester, Dixon & Garavan, 2006). Participants are asked to report, as fast as possible, the color – either verbally or by key press – while ignoring the semantic content of the word or the picture. Increased response times to report the color of the threat words compared to the neutral words are considered as an indication of an attentional bias (Williams, Mathews, & MacLeod, 1996).

Using this task, numerous studies have reported attentional biases in anxious participants (see Bar-Haim et al., 2007 for a review). The common interpretation of the emotional Stroop effect is that the more threat draws attention, the less attentional resources are left for naming of the color. Although the emotional Stroop task is the most commonly used task to measure attentional bias, it may not give an ideal measure of attention due to several interpretational difficulties. First, the emotional Stroop effect could reflect the fact that emotional stimuli are less readily suppressed or filtered, with negative consequences for primary-task performance (Yiend, 2010). Second, Algom, Chajut, and Lev (2004) have argued on the basis of six experiments that reading, lexical decision, and color naming are all slower with emotional words

and that this delay is immune to task-irrelevant variation and to changes in the relative salience of the words and the colors. Further, the delay was absent when emotional and neutral words appeared in a single block, suggesting that the so-called emotional Stroop effect could reflect a threat-driven generic slowdown effect rather than a selective attention mechanism such as those associated with the classical Stroop effect. Third, as pointed up by Macleod et al. (1986), the modified Stroop task does not allow for measurement of spatial attention allocation (i.e., facilitated attentional capture vs. delayed disengagement vs. attentional avoidance).

1.1.2. Probe Detection and Discrimination Paradigm

To overcome the limitations of the emotional Stroop task, MacLeod et al. (1986) have developed the dot probe task. It displays two stimuli (words or image), of different valence, simultaneously on both side of a fixation point on a computer screen. Following a brief stimulus presentation (traditionally 500 ms), the stimuli disappear and a probe (e.g., a dot, a letter, an arrow) appears on a location previously occupied by one of the stimuli. Participants are asked to indicate as fast as possible whether the right or left stimulus (or top or bottom) had been replaced by a probe (i.e., a probe detection task), or indicate the type of probe displayed (i.e., a probe discrimination task). The rationale is that if attention is biased for one type of stimulus then participants should be relatively faster to perform the task when it is located in the same spatial position as that stimulus, because reaction times will benefit from attention already being fixated at the appropriate location. This is called attentional vigilance for threat, with the opposite pattern indicating attentional avoidance. The result of MacLeod et al. (1986) showed that anxious individuals, relative to non-

anxious control, were faster to detect probes when they replaced threatening stimuli than when they replaced non-threatening stimuli. A wealth of studies has consistently observed this phenomenon (for a review, see Bar-Haim et al. 2007; Mogg & Bradley, 1998). It should be also noted that some studies have reported attentional avoidance among anxious individuals (e.g., Garner, Mogg, & Bradley, 2006; Mogg, Philippot, & Bradley, 2004). However, this effect of attentional avoidance of threat cues only appeared at stimulus duration of 1250 ms or more (Garner et al., 2006; Mogg et al., 2004; but for a non-replication, see Mogg, Bradley, Bono, & Painter, 1997). No attentional avoidance of threat cues was reported for shorter stimulus duration. Similar patterns of results were observed through other experimental tasks, such as visual search task (e.g., Pflugshaupt et al., 2005) and the spatial-cueing task (e.g., Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006a). These findings suggest that attentional avoidance may reflect strategic processing rather than automatic processing. According to Shiffrin and Schneider (1977), automatic processing refers to processing that is effortless, capacity free, unintentional, and outside of conscious control, whereas strategic processing refers to processing that is effortful, capacity-limited, subject to voluntary control. However, regarding the conceptualization of attentional bias in terms of automatic and strategic processing, it should be noted that research has shown that attributes of automaticity do not all apply to selective processing of threat. Indeed, as argued by McNally (1995), attentional biases are automatic in the sense of being involuntary, but not in the sense of being capacity-free. For a detailed discussion on automatic versus strategic features of attentional bias for threat, see Cisler, Bacon, and Williams (2009).

Although the probe discrimination/detection task is probably the most used task in the field, uncertainty abounds regarding the interpretation of the data. First,

this task only provides a discrete snapshot of the deployment of attention at the time of probe presentation. Even if attentional resources may be devoted to the processing of threat at the probed point, it remains uneasy to generalize the interpretation beyond this and uncertainty remains regarding the exact patterns of orienting before and after probing (Yiend, 2010). The often used 500 ms duration leaves ample time for several shifts in the direction of attention, the mean time for oculo-motor saccade being 189 ms (e.g., Priori, Bertolalis, Rothwell, Day, & Marsden, 1993). Second, although studies using the probe task suggest enhanced attentional processing of threatening stimuli, they provide little information about the underlying mechanisms. For instance, threatening material might be more effective at capturing anxious participants' attention (fast attentional engagement to threat), or disengagement from this material might be delayed, or a combination of both (e.g., Koster, Crombez, Verschuere, & De Houwer, 2004; 2006b; Salemink, van den Hout, & Kindt, 2007). As we will see below, the development of the single-cueing task allows overcoming some of these limitations.

1.1.3. The Visual Searching Paradigm (a.k.a. Face- in-the-Crowd Paradigm)

Based on the visual search paradigm developed by Treisman (1982), this task was emotionally tuned by Hansen and Hansen (1988). Participants are asked to detect a target stimulus that is embedded within a matrix of distracting stimuli (e.g., the disgust target face within a matrix of 3 row by 3 column of neutral distracters). More precisely, in the typical procedure an array of stimuli, often faces, is presented, and participants are required to pick out the one with a discrepant emotional expression as quickly as possible. Many combinations of target and distracter expressions are

possible (e.g., a threatening target within neutral-distracter arrays, a neutral target within a threat-distracter array). Attentional biases are featured as faster response times to detect a threatening stimulus within an array of neutral stimuli relative to response times to detect a neutral-target within a matrix of neutral stimuli. Another possibility is that attentional bias can also be featured as slower reaction times to detect neutral stimuli within a threat-distracter array compared to reaction times to detect a neutral target within neutral-distracter array.

Using this experimental task, an attentional bias for threat has been demonstrated among anxious participants (e.g., Douilliez, Yzerbyt, Gilboa-Schechtman, & Philippot, in press; Gilboa-Schechtman, Foa, & Amir, 1999; Rinck, Becker, Kellermann, & Roth, 2003). This paradigm provides a source of convergent data on the role of engagement of spatial attention. The method allows faster detection of emotional information to be measured directly without any predefined time window. It should be noted that this task is well fitted to examine issues of superiority of biologically relevant emotional information (stimuli so-called biologically prepared to be associated with fear such as snakes vs. stimuli whose relevance to fear must be acquired such as knife), and data suggest that stimuli of biological fear relevance are indeed prioritized for attentional selection. However, recent data suggested that the visual search task may be less sensitive than others to individual differences present at subclinical level (for a review, see Yiend, 2010).

1.1.4. The Attentional Blink Paradigm

In the attentional blink task, participants have to report two sequential targets (T1 and T2) that are embedded within a rapid serial visual presentation stream of

distractors (e.g., 19 items per second). Whereas performance for T1 remains constant, performance for T2 depends on the temporal lag between T1 and T2. If the targets are sufficiently close in presentation time to each other (i.e., between 200 and 500 ms), T2 is often missed. In contrast, this phenomenon does not occur when the lag is long (i.e., > 500 ms). The notion of attentional blink refers to the finding that the efficiency of detection of T2 is modulated by the lag between T1 and T2, leading to a negative effect of the first target on the second target identification within a period of 200–500 ms following T1 (Olivers & Meeter, 2008; Raymond, Shapiro, & Arnell, 1992). These authors interpreted this finding as implying that the identification of T1 consumes a large amount of limited attentional resources, leaving insufficient resources for the identification of T2 at short lags.

Two main emotional adaptations of the attentional blink task are encountered. In the first one, the threat value of T2 is manipulated, whereas T1 remains neutral. In that way, attentional bias towards threatening stimuli (i.e., T2) is featured as a smaller attentional blink effect with threatening T2 as compared to neutral T2 (Keil & Ihssen, 2004). As mentioned by Anderson (2005), the rationale is that threatening T2 is processed more efficiently and therefore reduced the blink effect. Therefore, T2 manipulation constitutes an index of how efficiently salient threat stimuli are processed. For instance, Fox, Russo, and Georgiou (2005) manipulated the threatening value of T2 (fearful vs. happy) and reported that high trait anxious exhibited a reduced attentional blink for fearful faces. They interpreted their data as implying reduced inhibition of threat.

In a second emotional tuning of the task, while T2 remains neutral, the threatening valence of T1 is manipulated. If emotional information processing requires additional attentional resources, the attentional blink should be enhanced

when threatening stimuli are processed at T1. Therefore, T1 manipulation constitutes an index of the difficulty in disengaging attentional resources from threat. For instance, Lystad, Rokke, and Stout (2009) manipulated T1 (threatening vs neutral stimuli) and reported that state-anxious participants (after induction of a negative state) exhibited an enhanced attentional blink at T2 when it was preceded by an anxiety-related stimulus at T1. Arend and Botella (2002) reported similar findings among high-anxious individuals. However, Peers and Lawrence (2009) as well as Barnard, Ramponi, Battye, and Mackintosh (2005) showed no such effect among high-anxious individuals. Similarly, de Jong & Martens (2007) did not report any enhanced attentional blink effect at T2 when threatening stimuli are presented in T1. In the same line, Cisler, Ries and Widner (2007) found no differences between spider-fearful and non-fearful participants in T2 accuracy when spider-related stimuli were presented in T1.

Alongside these two adaptations, it should be noted that recent studies have also reported an emotional adaptation including threatening stimuli as primes presented before the trials while keeping T1 and T2 neutral (e.g., Vermeulen, Godefroid, & Mermillod, 2009). Results of these studies suggest that processing threat before the trials impaired the detection of T2. Although current research suggests that emotional information modulates the attentional blink effect, and more precisely that threatening stimuli recruit more attentional resources than non-threatening stimuli during this task, this technique remains relatively new to the field. Further, replications are clearly needed, especially because some recent studies using the attentional blink paradigm among anxious individuals seem inconsistent. Further, this paradigm remains particularly complicated concerning data interpretation. Indeed, on the one hand, some authors suggest that attentional blink is caused by capacity

limitation. On the other hand, others authors argue that attentional blink reflects rather a selection deficit than a capacity limitation (Oliver & Meeter, 2008).

1.1.5. The Spatial Cueing Task (a.k.a. Modified Posner Task)

Beyond the limitations already mentioned above, previous paradigms assume a unitary conceptualization of attention (except for the Attentional blink task that is less clear about this question), and therefore cannot address component models of attention (e.g., Broomfield & Turpin, 2005). This unitary conceptualization of attentional bias was the direct consequence of previous basic research in the field of attention, such as models of Broadbent (1958) or Treisman (1964). During the eighties, Posner has suggested that the attention system comprises distinct measurable cognitive components (shift, engage, disengage; Posner 1980; Posner & Petersen, 1990). In the original cue-target paradigm that he developed, participants respond to a target appearing in the same (valid) or opposite (invalid) location compared to a previously presented cue (e.g., luminance change). In this task, two third of the trials were validly cued, one sixth were invalidly cued, and one other sixth uncued. Results indicated faster detection of targets on validly cued trials. This facilitation effect was taken as an evidence of the time-cost of disengaging attention from the cue to the target on invalidly cued trials (Posner, 1988; Posner & Peterson, 1990). As a consequence, since Posner developed his multi-component model of attention, researchers progressively developed interest in applying this model to emotional stimuli. In that way, there was a move from double to single emotional spatial cueing task. Regarding basic processes of the phenomenology of attentional bias, as argued by Yiend (2010), this shift reflects a critical distinction between selection and

orienting. Selection consists in the attention system singling out stimuli for further processing, whereas orienting implicates the putative spatial mechanisms by which selection occurs (Yiend, 2010; p. 25).

In the emotional adaption of the task, emotional material (e.g., emotional words) was used, instead of the usual luminance change, as a cue (e.g., Amir, Elias, Klumpp, & Przeworski, 2003; Stormark, Nordby, & Hugdal, 1995). For instance, Fox, Russo, Bowles, and Dutton (2001) were among the first to find support for the biased disengagement of attention using single cueing task. Single cues (e.g., faces) were presented briefly followed by a target in the same or in a different location. There were no anxiety-related differences when targets followed in the same location as the cues, but only when the threatening cues were followed by targets in a different location. This implies that there were no differences in engagement, but that anxious individuals were slower to disengage attention from the threatening stimuli in order to find the target elsewhere.

Since, many studies have replicated this finding implicating impaired disengagement of attention as the major contributor to anxiety-related attentional bias for threat. For instance, Fox et al. (2002) using angry, happy, and neutral facial expressions as single cues, found slowed disengagement for angry and happy faces in high trait anxiety. Similarly, Amir et al. (2003), using socially relevant threat words (e.g., embarrassed, stupid, humiliation), positive words (e.g., delighted, confident, steady), and neutral words (e.g., dishwasher, tile, hanger) as single cues presented during 600 ms reported that socially anxious individuals exhibited slower reactions times for invalidly cued trials previously occupied by socially threatening material. In the same vein, Woods, Marchetti, Biello, and Espie (2009) reported that individuals with a primary insomnia disorder exhibited a delayed disengagement from pictures

depicting a digital clock showing a time which is usually associated with sleeping in a normal sleep pattern (e.g., “02:00”) in comparison to clock showing other time.

However, as suggest by Cisler and Koster (2010), although research using the spatial cueing task has invariably demonstrated difficulty in disengagement among anxious individuals (e.g., Amir et al., 2003; Cisler & Olatunji, 2010; Fox et al., 2001; 2002), facilitated attention towards threat may be moderated by threat value (i.e., highly threatening stimuli) and stimulus duration (i.e., 100 ms or less). Regarding the stimulus duration, facilitated attention has been found among anxious individuals towards subliminally presented threat stimuli (e.g. Carlson & Reinke, 2008; for a non-replication, see Fox et al., 2001; Experiment 2), whereas delayed disengagement was observed towards supraliminally presented ones (e.g., Koster et al., 2006a; Salemink et al., 2007). Regarding the threat value, Koster et al. (2004, 2005) and Van Damme, Crombez, Hermans, Koster, and Eccleston (2006) used two different colored rectangles as cues, which prior to conditioning in a normal population showed no differential effects on attention. One of the rectangles (CS+) was subsequently conditioned to aversive stimuli (US; e.g., a noise burst) while the other colored rectangles was not conditioned to the US (CS-). Following conditioning, results revealed faster response times on validly cued trials using the CS+ cue compared to the valid trials with the CS- cue. Reaction times were slower on invalidly cued trials using the CS+ cue compared to invalidly cued trials with the CS- cue. Results of these three studies show that neutral stimuli paired with aversive stimuli in a classical conditioning paradigm elicited facilitated attention bias toward threat, suggesting that stimuli predicting imminent danger bring out facilitated attention bias.

While many cueing studies have argued that disengagement of attention is the primary spatial attentional mechanism underlying attentional bias, the evidence

regarding engagement remains equivocal. Data from the visual search tasks appears to implicate process more analogous to speeded engagement and should not be ignored. The context under which engagement/or disengagement effects are seen may be complex. Both processes could involve orienting to content and, separately, to location. As noted by Yiend (2010), current studies have indicated disengagement when content and location converge (i.e., when a location of recent threat must be disengage), whereas engagement effects have been most obviously demonstrated when threat was not actually present.

Although many studies consistently reported a delayed disengagement, suggesting the robustness of this phenomenon, one cannot exclude some limitations of the spatial cueing task. First, some studies reported that cued locations lose their attentional advantage after a certain time has elapsed, becoming inhibited relative to uncued locations (i.e., the inhibition of return effect; Posner, 1980). As noted by Yiend (2010), the effect is thought to represent an adaptive attentional mechanism whereby novel locations are prioritized for attentional processing over recently attended ones. Second, Mogg, Holmes, Garner, and Bradley (2008) have argued that the spatial cueing task may not provide unambiguous evidence for delayed disengagement, as there may be a confound between delayed disengagement and a generic slow-down effect caused by the presence of threat stimuli. Although that clearly limits the conclusions that can be drawn from this task, Cisler and Olatunji (2010) recently found that disengagement difficulty in the spatial cueing task remained in anxious individuals when statistically controlling for generic response slowing, suggesting that this task confound does not explain difficulties in disengagement. Further, the phenomenon of delayed disengagement is also corroborated by results observed in the visual search task (e.g., Gilboa-Schechtman et

al., 1999; Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005) and in the dot-probe task (e.g., Koster et al., 2006a; Salemink et al., 2007).

1.1.6. Summary and integration

Considered together, these findings suggest that attentional bias towards threat are constituted of three main phenomenological features: 1) a facilitated attention toward threatening stimulus, but only for stimuli exhibiting high threat intensity presented during a short duration, 2) a delayed disengagement from threat, and 3) an attentional avoidance of threat at late stage of processing.

As argued by Cisler and Koster (2010) as well as Bar-Haim et al. (2007), the fact that attentional biases for threatening stimuli have been observed in several different experimental tasks is critical because it suggests that this phenomenon is not an artifact of particular experimental paradigms or task confounds. Further, the demonstration that this effect occurs through different paradigms shows the generalizability and the ubiquity of this phenomenon. For instance, using a quantitative meta-analysis of 172 studies, Bar-Haim et al. (2007) revealed that anxious individuals exhibit an attentional bias towards threat across a range of populations (men, women, adult, children, elderly people), stimuli (words and pictures) as well as stimuli presentation duration (subliminal and supraliminal).

1.2. Cognitive models of anxiety and attentional bias for threat

Several cognitive models of anxiety have taken into account the phenomenon of attentional bias for threat. However, these models present strong variability in the

way they consider the causal nature of the relation between such biases and anxiety. In this section, we will briefly present each of these models and examine the way they consider the causal nature of this relation.

1.2.1. Attentional bias for threat: The result of a threat detection mechanism

A series of six influential models of emotional disorders have proposed that attentional bias for threat results from an initial threat appraisal process, which in turn lead to the activation of cognitive, physiological and behavioural anxious response. These models are Beck and Clark's (1997) model of anxiety, Williams, Watts, MacLeod and Mathews' model (1997), Mogg and Bradley's cognitive-motivational model (1998; 2002), the Feature Detection System of Öhman (1996), Matthews and Machkintosh's model (1998), and the integrative model of Bar-Haim et al. (2007). In the section below, we will briefly discuss the conceptualization of attentional bias for each of these models.

i. Beck and Clark's model of anxiety

Beck and Clark (1997) have proposed a three-stage schema-based information model of anxiety that implies different levels of automaticity from rapid and unconscious to controlled, strategic and elaborative processes. The first processing stage, *the initial registration of a threat stimulus*, involves an automatic recognition of the valence or the personal relevance of stimuli, denoting an *orienting mode*. If the stimulus is assessed as threatening, attentional resources are allocated in order to process it. The second stage, *the immediate preparation phase*, involves the activation

of a *primal mode* that triggers a series of physiological, behavioral, and cognitive emotional responses in reaction to the initial registration of threat. The primal mode results in biased cognitive processing such as attentional bias for threat cues rather than safety cues. According to Beck and Clark (1997), at this stage attention remains captured by threat and actions involve coping with threat. Finally, the secondary elaboration stage is characterized by a full activation of the relevant schema. In anxious individuals, schemas are thought to be biased towards threat. As a consequence, threat-related material is favored at all stages of processing, including early process such as attention.

For example, as a consequence of the *initial registration of a threat stimulus*, when giving a speech, a socially anxious individual would appraise negatively the audience. As a consequence of *the immediate preparation phase*, the attentional resources are oriented towards this threatening stimulus and *the primal mode*, that triggers a series of physiological, behavioral, and cognitive emotional responses of anxiety, is activated. During this phase, attention remains allocated towards threatening stimuli. After that, the individual will activate a more schema-driven processing of threat, involving conscious and explicit evaluation of the availability and the efficiency of the coping resources. So, according to this model, attentional bias for threat results from an initial threat appraisal process, which in turn leads to the activation of cognitive, physiological and behavioral anxious response.

ii. Williams, Watts, MacLeod and Mathews' model

Williams, Watts, MacLeod, Mathews (1988; 1997) proposed an influential account of information processing biases in anxiety. According to their model, two

critical mechanisms may lead to anxiety: (1) an *Affective Decision Mechanism* and, (2) *Resource Allocation Mechanism*. The former, a pre-attentive mechanism, assesses the threat value of all incoming stimuli. Its output is directed to a *Resource Allocation Mechanism* that allocates attentional resources to threat. These authors proposed a causal relation between attentional biases and anxiety, but only for high-trait anxious. Indeed, they argued that trait anxiety modulates the *Resource Allocation Mechanism*: High-trait anxious allocate their resources to threat (attentional bias towards threat), whereas low trait anxious individuals direct their attention away from threat (attentional avoidance of threat). Furthermore, they suggested that the tendency to allocate attention to threat may prolong episodes of emotional disorder.

As noted by Mogg and Bradley (1998), the modulation of trait anxiety appears as a strong limitation of this model and it seems unlikely that attention would not be attract for severe threat regardless of an individual's anxiety level. Congruently, Wilson and MacLeod (2003) demonstrated that an attentional bias from severe threat appears regardless of the level of anxiety. Similarly, Bar-Haim et al.'s meta-analysis (2007) indicated that the prediction of Williams et al.'s (1988, 1997) regarding the presence of attentional bias for threat only among high-trait anxious is not statistically significant.

iii. *Mogg and Bradley's cognitive-motivational model*

Mogg and Bradley (1998) have formulated a cognitive-motivational model of anxiety. According to their model, two motivational systems mediate the impacts of threatening stimuli on cognitive and behavioral responses. First, a *valence evaluation system* is in charge of an initial appraisal of the stimulus threat value. Output from this

system is also modulated by situational context, state anxiety, biological preparedness, and prior learning. Second, a *goal engagement system* orients allocation of attention as a function of the result of the valence evaluation system. If a stimulus is evaluated as non-threatening, then the goal engagement system ensures the pursuit of the current goals. In contrast, if a stimulus in the environment is evaluated as threatening, the goal engagement system interrupts ongoing activities and orients attention towards the threat. As highlighted by Mogg and Bradley (2002), this cognitive-motivational view postulates that attentional bias in anxious individuals is the consequence of an evaluation of negative situations and does not play a causal role of the installation of anxiety.

According to these authors, the inadequate reactivity for threat in the valence evaluation system is determined by the level of trait anxiety. If trait anxiety is high, the valence evaluation system values a stimulus as more threatening than it actually is, even when the true threat value of the stimulus is mild. Thus, whereas all individuals will attend to highly threatening stimuli, only high anxious individuals will attend to mild threat (Mogg & Bradley, 1998). Therefore, according to this model, an attentional bias towards mildly threatening stimuli is conceptualized as a sign of anxiety vulnerability. More precisely, at a functional level, attentional bias to mild threat may be considered as a maintenance factor of anxiety. Indeed, if initial allocation of attention to threat is followed by avoidant behaviors, extinction to CS+ will abort and anxiety is maintained. More precisely, there is some evidence suggesting that anxious individuals orient towards threat in the early (automatic) stages of attentional processing but attend away from threat in the later (strategic) stages (e.g., Garner, Mogg, & Bradley, 2006; Mogg et al., 2004). According to Mogg and Bradley (1998), this tendency, known as the vigilance-avoidance pattern, impairs

extinction to feared stimuli, resulting in the maintenance or enhancement of anxiety. This cognitive-motivational view is similar to the model of Williams et al. (1988; 1997, see above). The only important difference is the system that determines anxiety and attentional bias. According to Mogg and Bradley (1998; 2002), individual differences in threshold sensitivity (modulated by situational context, state anxiety, biological preparedness, and prior learning) of the Valence Evaluation System lead to allocation of attentional resources and, subsequently, to anxiety (see above). In contrast, Williams et al. (1988) suggest that individual differences in vulnerability to trait-anxiety influence the Resource Allocation Mechanism, which, in turn, increases the tendency to orient attention towards threat.

iv. The Feature Detection System of Öhman

Based on a conceptualization of attention to threat within an evolutionary adaptive perspective, Öhman (1996; 2005) proposed that the stimulus input is analyzed through a *Feature Detection System*. According to this model, biologically prepared (e.g., snake) or high intense stimuli (e.g., threatening faces) can exert a direct influence, without any mediation of conscious processing of threat, on the arousal system through this detection system and facilitate attentional allocation to threat. Then, after having passed through this Feature Detection System, information is analyzed in a *Significance Evaluation System* that allows a conscious appraisal of meaning through the interaction with memories of previous emotional stimuli. Interestingly, this model also postulated feedback loops between the autonomic nervous system and the Significance Evaluation System (i.e., elevated arousal sensitizes the Significance Evaluation System). At a functional level, Öhman (1996)

postulated that, although threat detection mechanism is primarily automatic, some strategic feedback loop might be involved in the maintenance of the attentional bias for threat (e.g., memory system). This last point is particularly relevant because it suggests that more volitional process, memory in this case, may override processes that are usually more automatic.

v. Matthews and Mackintosh's model.

Matthews and Mackintosh (1998, see also Matthews, Mackintosh, and Fulcher, 1997) developed a model that shares many features with the previous models. Very similarly to the Affective Decision Mechanism assumed by Williams et al. (1988; 1997), Matthews and Mackintosh (1998) propose that incoming stimuli are automatically evaluated by a *Threat Evaluation System*. Essential features of this model are that attributes or meanings of stimuli are processed in parallel and compete for attentional resources. Further, the authors were among the first to posit that interference caused by attentional capture towards threat may be countered by a certain level of voluntary effort

vi. The integrative model of Bar-Haim and colleagues

Based on a meta-analysis examining the boundary conditions of threat-related attentional bias in anxiety, Bar-Haim et al. (2007) developed an integrative model that combines several aspects of the previous models mentioned above. According to this model, a *preattentive threat evaluation system* evaluates stimuli in the environment. A stimulus that is tagged with a high threat value feeds forwards into a *resource*

allocation system and triggers a physiological alert state, the interruption of ongoing activity, the allocation of processing resources to threat, and a conscious anxious state. The outcome leads to a set of strategic processes carried out by a *guided threat evaluation system*. At this stage, assessment of the context of the threat stimulus, comparison of the present threat with prior learning and memory, and assessment of the availability of coping resources take place (through the *Goal Engagement System*). If the outcome of this guided threat evaluation results in low conscious threat evaluation, a feedback process is triggered that overrides the input emanating from the preattentive threat evaluation system and decreases the alert state imposed by the resource allocation system. If, in contrast, the result of this guided evaluation corroborates the threat alert invoked by the preattentive threat evaluation system, a high state of anxiety is likely to proceed.

According to this model, attentional bias is located in the resource allocation system. Centrally, as argued by Bar-Haim et al. (2007), different anxiety disorders may stem from a bias in the resource allocation system, that is, a tendency to allocate resources even to stimuli evaluated as only mildly threatening by the preattentive evaluation system.

1.2.2. Attentional bias for threat: A multi-componential approach

As we mentioned above, during the eighties, Posner has suggested that the attention system comprises distinct measurable cognitive components (shift, engage, disengage; Posner 1980; Posner & Petersen, 1990). Two recent cognitive models of anxiety disorders have taken into account this multi-componential conceptualization

of the attentional bias for threatening stimuli. In the following section, we will briefly discuss the conceptualization of attentional bias for each of these models.

i. Attention Control Theory

Attention Control Theory (Eysenck & Derakshan 2011; Eysenck, Derakshan, Santos, and Calvo, 2007) is an approach to anxiety and cognition representing a major development of Eysenck and Calvo's (1992) processing efficiency theory. The basic tenet of Attention Control Theory (Eysenck, 1997; Eysenck & al., 2007) is that attentional processes play a critical role in the maintenance of anxiety. More specifically, it is assumed that individuals who suffer from anxious disorders (and not only from high-trait anxiety) show impairment in the efficient functioning of the goal-directed attentional system, which determines the extent to which processing is influenced by the stimulus-driven attention system. This assumption is made on the basis of previous works that support the notion of two distinct attentional systems (e.g., Corbetta & Shulman, 2002; Posner & Petersen, 1990). For instance, Corbetta and Shulman distinguish between a goal-directed attentional system influenced by expectation, knowledge, and current goals and a stimulus-driven attentional system influenced by salience of environmental input. The former system is similar to the anterior attentional system proposed by Posner and Petersen (1990) and is assumed to be located in the prefrontal cortex. The latter is similar to the posterior attentional system that was also proposed by Posner and Petersen, which is located in temporo-parietal and ventral frontal areas of the brain.

In both conceptions (i.e., Corbetta & Shulman, 2002; Posner & Petersen, 1990), the former system is involved in top-down control of attention and is centered

in the prefrontal cortex, whereas the latter is involved in the bottom-up control of attention and it is assumed that it is recruited in the detection of behaviorally relevant sensory events, particularly when they are salient and unattended. These two systems are generally thought to interact in their functioning (for a review, see Pashler, Johnston, & Ruthroff, 2001). However, according to Eysenck et al. (2007), in anxiety disorders it is assumed that there is an imbalance that is due to an increase of the influence of the stimulus-driven system over the goal-directed attentional system. Anxiety would be experienced when a current goal is threatened. Therefore, threat to current goal causes attention to be allocated to detecting its source and to deciding how to respond. This assumption implies that anxiety typically reduces attentional focus on the current task unless it involves threatening stimuli.

More centrally, because of the decrease in goal-oriented top-down processing caused by anxiety, inhibition (i.e., the ability to inhibit a dominant responses) is impaired. In other words, anxiety reduces the degree to which inhibitory control can execute its top-down regulatory control on bottom-up processing. According to Eysenck et al. (2007), one behavioral manifestation of this effect is the difficulty to disengage attention from threatening stimuli. This imbalance between goal-directed and stimulus-driven attention also leads to an inefficient use of the shifting function of the attentional control (i.e., the ability to shift attention between tasks depending on context). According to Eysenck (2007), because of the increased stimulus-driven bottom-up processing caused by anxiety, shifting from one task to another becomes more difficult. As pointed by Eysenck et al. (2007), the facilitated attention towards threats is a consequence of this former mechanism.

ii. *The Cisler and Koster's (2010) integrative model of attentional bias*

Cisler and Koster (2010) formulated an integrative model exclusively dedicated to attentional bias for threat in fear and anxiety. The development of their model was based on a review of empirical data examining the cognitive and neural factors underlying attentional bias. As shown on Figure 1, the components of attentional bias they proposed directly refer to the observable and measurable features of the bias. As we reported above (see the point about experimental paradigms and the related phenomenological features), attentional bias towards threat comprises facilitated attention to threat at short stimulus durations and high threat intensities, delayed disengagement from threat, and attentional avoidance of threat at later stages of processing.

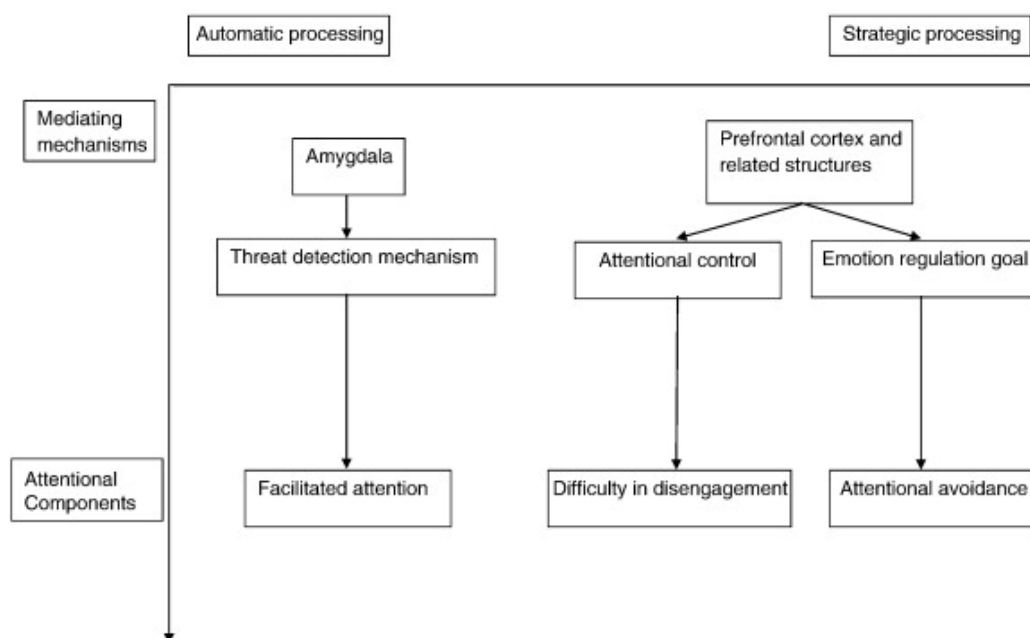


Figure 1. *The Cisler and Koster's integrative model of attentional bias for threat. Adapted from Cisler and Koster (2010).*

In addition, they proposed three main mediating factors that may underlie these observable components of attentional bias. These mediating mechanisms of attentional bias refer to the underlying mechanism that may produce the observable characteristics of the bias. Complementarily, they also postulate brain regions that might functionally underlie these mediating mechanisms.

The first mediating factor is a threat detection mechanism. This mechanism is based on a wealth of data that demonstrated that the amygdala is critically involved in the automatic processing of fear-related stimuli (Davis & Whalen, 2001; LeDoux, 2000; Myers & Davis, 2007; Öhman, 2005). For instance, Whalen et al. (2004) found greater activation of the amygdala to masked pictures of fearful eyes relative to masked pictures of normal eyes, suggesting that this brain area may respond automatically to specific fear-relevant features. It has been also observed that increased amygdala activity is involved in facilitated attention to threat. For instance, Carlson, Reinke, and Habib (2009) reported that, during a probe detection task, masked congruent threatening trials were associated with increased amygdala activity. A series of studies also reported strong correlations between increased amygdala activity and facilitated attention to threat (e.g., Anderson & Phelps, 2001; Monk et al., 2004, 2008). However, although these data suggest that the amygdala underlies the automatic detection of threat, Pessoa (2005) depicted a more complicated situation. According to this author, automatic activation towards threat depends on the availability of attentional resources. According to Cisler and Koster (2010), Pessoa's results suggest that this threat detection mechanism does not operate completely automatically, and, therefore, they recommended conceptualizing the amygdala as a central structure in a larger threat detection system rather than as the only underlying process of automatic detection of threat.

Alongside the threat detection mechanism, attentional control and emotional regulation strategies both appear to modulate attentional bias in distinct way. Cisler and Koster (2010) used the notion of emotion regulation strategies as it has been proposed by Gross (1998). According to the latter, it refers to an individual's strategy for coping with negative emotion (e.g., distraction). And more precisely, a series of recent studies suggested that attentional allocation constitutes an emotional regulation strategy. Further, several studies demonstrated that emotion regulation goals may moderate the components of attentional biases at late stages of processing and that attentional avoidance regulates emotion. According to Cisler and Koster (2010), attentional avoidance at late stages of processing reported among anxious individuals may occur because these individuals are attempting to voluntarily down-regulate negative affect via distraction.

The attention control mechanism they proposed is very similar to the eponymous notion proposed by Eysenck et al. (2007). Cisler and Koster (2010, p. 209) defined it as an *“individual difference variable that refers to individual's ability to regulate their attention allocation”*. This proposal is based on previous findings noting that attentional control modulates the difficulty in disengaging attention from threat. For instance, Derryberry and Reed (2002) have found that high-trait anxious individuals reporting poor attention control exhibited delayed disengagement from threat at 500 ms. In contrast, those who reported good attention control did not exhibit such effect. Similar findings were observed using rapid serial visual presentation task (e.g., Peers & Lawrence, 2009).

At a neural level, studies have reported that cortical structures centered around the prefrontal cortex and its functionally-related structures (i.e., anterior cingulate cortex and orbitofrontal cortex) may mediate delayed disengagement from threat

through individual difference in the ability to down-regulate the influence of limbic structures and maintain attention to task-relevant stimuli (e.g., Bishop, Duncan, Brett, and Lawrence, 2004; Miller & Cohen, 2001). Particularly, it has been suggested that specific subregions of the prefrontal cortex may play differing role in top-down attentional control, with the anterior cingulate cortex being involved in detecting the presence of competition for processing resources and the lateral prefrontal cortex in responding to increased expectation of processing competition by augmenting top-down control to support the processing of task-relevant stimuli (e.g., Botvinick, Cohen, & Carter, 2004; Cohen, Botvinick, & Carter, 2000). Prefrontal cortex regions may also mediate attentional avoidance, given that emotion regulation strategies also constitute top-down regulatory processes. Recent studies have reported that employing emotion regulation strategies (e.g., distraction, re-appraisal) results in increased dorsolateral prefrontal cortex, anterior cingulate cortex and orbitofrontal activity and reduced amygdala activity while watching aversive movies (e.g., Eippert et al., 2007; Ochsner et al., 2004). Subsequently, Cisler and Koster predicted that difficulty in disengaging from threat may be the result of a too strong influence of bottom-up processing (i.e., threat detection mechanism, amygdala) on attention control (i.e., prefrontal regulatory process and functionally-related structures).

As shown in Figure 1, while threat detection mechanism may be a predominantly automatic process, attentional avoidance may be a predominantly strategic process and delayed disengagement may be a mixture of both automatic and strategic processing. This conceptualization was based on previous findings showing that the nature of the attentional bias depends on the stage of information processing during which it operates (for further details, see the point on the experimental task above).

1.2.3. Attentional bias for threat is an anxiety maintenance factor

Three major cognitive models of anxiety disorder (i.e., Clark & Wells, 1995, Foa & Kozak, 1986; Rapee & Heimberg, 1997) have suggested that biased information processing, such as attentional bias for threat, plays a critical role in the maintenance of the disorder. Although both the models of Clark and Wells (1995) and Rapee and Heimberg (1997) are entirely focused on social anxiety, they are important because they clearly formulated that attentional biases for threat maintain anxiety in social situation in part by influencing judgments about environmental cues. The model of Foa and Kozak (1986) is quite different. According to this model, there is only the attentional avoidance of threatening stimuli that maintain anxiety. We will now briefly discuss the conceptualization of attentional bias for each of these models.

i. Clark and Wells' model

According to Clark and Wells' (1995) model, on the basis of early experience, social phobics develop a series of problematic assumptions about themselves and their social world (e.g., *I have to convey a favorable impression; People think I'm inferior; If people know I'm anxious, they will think I'm weak*). Such assumptions lead individuals to appraise social situations as dangerous, which in turn generates anxiety. Further, according to this model, anxiety and negative appraisal are maintained by a series of vicious circles. First, during social interaction, socially anxious individuals shift attention away from the social situation and become self-focused (e.g., anxious feelings, distorted images of themselves). They then use internal information to make

erroneous inferences about the way they appear to others. Second, they use a variety of safety behaviors to prevent feared catastrophes from occurring. As illustrated by Turk, Heimberg, and Magee (2008), a man who is afraid of his hand shaking while drinking coffee may grip the cup tightly, hoping to prevent any observable trembling. Such compensatory behaviors often make the feared outcome more likely. Further, these strategies maintain negative beliefs, because if the feared catastrophe does not happen, its nonoccurrence is attributed to the safety behaviors. Finally, socially anxious individuals' processing of external threat cues is biased in favor of detecting other responses that can be interpreted negatively. Therefore, these biases validate their negative beliefs, which in turn, reinforce anxiety. Hence, this model implies that biased information processing, such as attentional bias, plays a critical role in the maintenance of the disorder. Regarding the temporal course of the processes, Clark and Wells's (1995) hypothesize that socially anxious individuals engage in distorted information processing before and after social situation.

ii. Rapee and Heimberg's model

Although the model of Rapee and Heimberg (1997) is similar to the model of Clark and Wells (1995), it provides a more functional framework to understand the role of attentional bias for threat in the persistence of anxiety. Rapee and Heimberg (1997, p. 741) state that "*distortions and biases in the processing of social/evaluative information lead to heightened anxiety in social situations and, in turn, help to maintain social phobia*". These authors (Rapee and Heimberg, 1997; Heimberg & Becker, 2002; Roth & Heimberg 2001; Turk, Lerner, Heimberg, & Rapee, 2001) developed a cognitive-behavioural model describing how information is processed

when confronted with a situation that holds the potential for negative evaluation. The process begins when socially anxious individuals are in the presence of an audience. In this model, the term of audience captures the sense that socially anxious individuals have of being on stage in the presence of others, whether the situation of a speech, social interaction, or another observation in which others may observe them. In presence of the audience, it is assumed that socially anxious individuals construct a mental representation of how they appear. It is also assumed that they focus their attentional resources onto both this mental representation and any perceived threat in the social environment. According to this model, in addition to the allocation of attentional resources to these external and internal cues, the individual simultaneously formulates a prediction regarding the performance standard or norm to which he/she expects the audience to refer. The representation of how the audience would view the individual and the appraisal of the audience's presumed situational standards are compared to provide an estimate of the audience perception of the individual's current performance. The discrepancy between the person's perception of the audience appraisal of his/her performance and the person's perception of the audience standard for the evaluation of his/her behavior determines the perceived likelihood of negative evaluation from the audience and consideration of the social consequences of the expected negative evaluation. Beliefs of negative evaluation from others then motivate individuals with social anxiety to be hypervigilant for early indications of disapproval from others (e.g., frowns, yawns) and aspect of their own behavior or appearance that might elicit negative evaluation from others (e.g., not being dressed appropriately, making an inappropriate comment). The predicted negative evaluation further results in physiological, cognitive, and behavioral components of anxiety that subsequently retroactively loops into the negatively biased mental representations

and, therefore, perpetuates the cycle of anxiety.

iii. The Emotional Processing Theory

According to the Emotional Processing Theory (Foa and Kozak, 1986), fear response is the result of the activation of a fear structure, which is represented in an associative network in long-term memory. This concept of fear structure is built on the work of Lang (1979). According to Lang (1979), a fear structure is a cognitive representation comprising three types of elements: stimulus (i.e., information about the feared stimuli), response (i.e., cognitive, behavioral, and bodily reactions to this stimulus), and meaning information (information that links these stimuli and responses elements together). The concept of emotional processing is based on the work of Rachman (1980) who defined it as a necessary process for emotional disturbances to be absorbed and argued that successful emotional processing appears when the anxious individuals is confront with a feared stimulus without experiencing anxiety.

According to Foa and Kozak (1986), fear reduction is achieved through the incorporation of information that is incompatible with the information stored in the fear structure. They suggested that three conditions must be fulfilled for emotional processing to occur: (1) the activation of the fear network, demonstrated by high initial fear during exposure to threatening stimuli; (2) within-session habituation (i.e., decrease in the level of fear during one session of exposure to the feared stimuli); and (3) between-session habituation (i.e., gradual decreases in fear responses across different sessions of exposure to the feared stimuli).

According to this model, one can infer that the inhibition of detailed

processing of threatening stimuli is the core deficit of anxiety, which is reflected in avoidance of threatening stimuli (Mogg, Bradley, Bono, & Painter, 1997). Threat-related biases among anxious individuals would characterize later stages of processing and are essentially featured as attentional avoidance of threat stimuli.

1.2.4. Summary and Integration

Although all of the eleven cognitive models of anxiety discussed above take into account the phenomenon of attentional bias for threatening stimuli, they present strong variability in the way they consider the causal nature of the relation between such biases and anxiety.

For only one of them, attentional bias for threatening stimuli appears as a core tenant of the **development of anxiety**. Bar-Haim et al. (2007) probably formulated the strongest claim about the causal nature of the relation between attentional bias for threat and anxiety. As we developed before, these researchers (p. 17) have stated that *“high-trait anxiety or different anxiety disorders may stem from a bias in the resources allocation system, that is, a tendency to allocate resources even to stimuli evaluated as only mildly threatening by the preattentive evaluation system”*. This clearly suggests that attentional bias for threat is not an epiphenomenon or a by-product of anxiety, but rather a factor involved in the etiology of anxiety.

Alongside this strong claim, several models are in line with the hypothesis that attentional bias for threat may be causally involved in **the maintenance of the disorder**. For instance, Williams et al. (1997, p. 309) suggested that *“the tendency to allocate attention to threat may prolong any episode of emotional disorder.”* A congruent point of view was enounced by Eysenck and al. (2007) through their

attention control theory. The position held by the cognitive-motivational model of anxiety (Mogg & Bradley, 1998) is in the same line. According to Mogg and Bradley (1998), an attentional bias towards mild threat may be considered as a maintenance factor of anxiety: If initial allocation of attention to threat is followed by avoidant behaviors, extinction to CS+ aborts and anxiety is maintained. Congruently, according to the Foa and Kozak's model (1986) attentional bias for threat stimuli, but only attentional avoidance, is a core maintenance factor of anxiety disorder.

Although they are both specifically dedicated to social anxiety, both Rapee and Heimberg (1997) and Clark and Wells (1995) models are clearly in line with the hypothesis that attentional bias for threat are involved in the maintenance of the disorder. For instance, Rapee and Heimberg (1997, p. 741) state that *“distortions and biases in the processing of social/evaluative information lead to heightened anxiety in social situations and, in turn, help to maintain social phobia”*.

In contrast, however, several models have formulated that attentional bias for threat is a by-product of an appraisal process impaired in anxiety disorder or sensitized by elevated arousal threat caused by anxiety. For instance, according to Öhman (1996) attentional bias is a consequence of a feature detection system sensitized by elevated arousal that automatically detect biologically prepared or high intense stimuli. According to Matthews and Mackintosh (1998), attentional biases for threat are the result of a Threat Evaluation System that strengthens activation of threat-related attributes. In the same vein, according to Beck and Clark (1997), attentional bias for threat results from an initial threat appraisal process which favors the process of threat-related material, and in turn lead to the activation of cognitive, physiological and behavioral anxious response. Considered together, these models share the feature that anxious individuals are more likely to value a stimulus as more

threatening than it actually is, even when the true threat value of the stimulus is mild. However, it should be noted that some studies provided evidence against this latter proposal. For instance, it has been reported that socially anxious individuals do not show better detection of threatening facial expression (e.g., Schofield, Coles, & Gibb, 2007) or stronger biases to evaluate facial expression more negatively (Philippot & Douilliez, 2005).

Finally, although a great care was taken to describe phenomenological features of attentional bias for threat and mechanisms underlying these features, the integrative model of Cisler and Koster (2010) does not specify any causal nature of the relation between attentional bias and anxiety. However, this later model takes into account the different features of the attentional bias and suggests that these features are more than merely descriptive. Indeed, this model probably formulates the strongest proposal for the underlying process of each feature of the attentional bias for threat.

In the same vein, in addition to their divergence about the causal nature of the relation between attentional bias for threat and anxiety, all the previous models also exhibit divergences about the features of attentional bias for threat that they postulated to be involved in the maintenance of the disorder. For instance, while several models postulated that vigilance for threat may be involved in the maintenance of anxiety (e.g., Mogg & Bradley, 2002; Rapee and Heimberg, 1997), others have proposed that the critical mechanism through which attentional bias for threat operates as a maintenance factor is delayed disengagement from threat (e.g., Eysenck et al., 2007) or attentional avoidance of threat (e.g., Foa and Kozak, 1986).

1.3. What is attentional bias for threat: A cause or a by-product?

Some prominent cognitive theories of anxiety pose that attentional bias for threatening stimuli is related to the maintenance (e.g., Rapee and Heimberg, 1997) or the installation of the disorder (e.g., Bar-Haim et al., 2007). In contrast, others argue that attentional bias for threat is merely a by-product of anxiety (Beck & Clark, 1997). In this section, we will review to what extent these claims are supported by empirical evidence.

1.3.1. The nature of the association: Strong and consistent

In order to investigate the causal nature of the relation between attentional bias for threat and anxiety disorders, we will first examine the strength of this relation. Indeed, at the very least, if we claim that there is a causal relation between attentional bias and anxiety (regardless of the direction), there must be an association between these two variables.

As we already mentioned above, there is a wide range of studies showing that anxious individuals exhibit an attentional bias for threat-related material, therefore suggesting that there is an association between anxiety disorder and attentional bias for threat. Bar-Haim et al. (2007) conducted a meta-analysis on 172 studies investigating these two variables. This meta-analysis included only studies in which attentional bias was measured using either the emotional Stroop task, the probe detection/discrimination task, or the spatial cueing task involving threatening and neutral stimuli. Bar-Haim and his collaborators reported that anxious individuals exhibit a medium sized attentional bias towards threatening stimuli, in comparison to neutral stimuli (i.e., average effect size of Cohen's $d = .45$). In contrast, non-anxious individuals do not show such effect (i.e., average effect size of Cohen's $d = .01$).

Further, the difference between anxious and non-anxious is medium sized (i.e., average effect size of Cohen's $d = .41$), suggesting that the attentional bias is stronger in anxious individuals than in the non-anxious ones. All together, these results clearly bear that there is an association between attentional bias for threatening stimuli (over neutral stimuli) and anxiety.

These effects are similar for all three tasks included in the meta-analysis (i.e., for the emotional Stroop task, average effect size of Cohen's $d = .49$; for the dot-probe task, average effect size of Cohen's $d = .37$; for the spatial cueing task; average effect size of Cohen's $d = .43$). Although results are less clear for the attentional blink paradigm (see the previous point dedicated to this task), studies using the visual search task paradigm have robustly reported that, in comparison to control participants, anxious individuals exhibited attentional bias for threatening stimuli (e.g., Rinck et al., 2003). In sum, these data are consistent with the notion that this effect occurs through different paradigms and suggest the robustness and reliability of this phenomenon.

Furthermore, Bar-Haim et al. (2007) found that the attentional bias appears similarly in different anxiety disorders. Indeed, in their meta-analysis, the studies they integrated included sample of specific phobia (e.g., spider-phobia), high-trait anxious individuals, Post-Traumatic Stress Disorder, Obsessive Compulsive Disorder, panic disorder, Generalized Anxiety Disorder, Social Phobia with medium sized average Cohen's d for each anxiety disorder, ranging from .36 to .59. These effect sizes suggest that attentional bias is a robust phenomenon occurring across different anxiety disorders.

1.3.2. Is there a temporal precedence of attentional bias for threat on anxiety?

Beyond these strictly correlational evidences, the temporal precedence of attentional bias on the onset of anxiety can be investigated by prospective or longitudinal studies. However, to our knowledge, no study to date has investigated whether attentional bias for threat during childhood is a significant predictor of anxiety vulnerability or anxiety disorder in adulthood.

Regarding prospective studies, it has been reported that attentional bias for threatening stimuli is a vulnerability factor for developing anxiety in response to stress. In one study, it has been reported that attentional bias for threatening stimuli at baseline, assessed using the emotional Stroop task, predicted anxiety and dysphoria in participants learning of a cancer test result eight weeks later (MacLeod & Hagan, 1992). In addition, attentional bias was a significantly stronger predictor of emotional responses than self-reported measures did at baseline. However, one cannot exclude that participants were already under stress when they performed the emotional Stroop task. It remains possible that their attentional bias for threatening stimulus was influenced by their high-level of anxiety due to the waiting of their medical results. To overcome these limitations, a series of studies have replicated this effect among participants who were non-anxious at baseline within different context of stress (e.g., Pury, 2002; van den Hout, Tenney, Huygens, Merckelbach, & Kindt, 1995). All of these studies have used the emotional Stroop task and reported that the amount of emotional Stroop interference was the unique predictor of later anxiety (for a non-replication, see Jansson & Najström, 2009).

Congruently, studies using other experimental paradigms have produced similar results. For instance, it has been reported that attentional bias for threatening words at a dot-probe task was a better predictor of subsequent physiological reactivity

to stressors (i.e., cardiovascular change) than self-report measures of anxiety (Egloff, Wilhelm, Neubauer, Mauss, & Gross, 2002). Similarly, van Bockstaele, Verschuere, Koster, Tibboel, de Houwer, & Combres (2011a) have observed that attentional bias for threat at baseline significantly predicted change in heart rate in response to the presentation of a spider among spider-fearful individuals, whereas self-reported measure of fear for spider predicted avoidance behavior. Additionally, a recent study demonstrated that attentional bias for threatening stimuli at baseline predicted salivary cortisol responses to both laboratory and natural real-life stressor four months later better than self-reported measures of anxiety and neuroticism (Fox, Cahill, & Zougkou, 2010). This cortisol-related effect has been replicated (Pilgrim, Marin, & Lupien, 2010).

To sum up, these results are consistent with the hypothesis that attentional bias for threat is causally involved in the etiology of anxiety disorder. At a theoretical level, these findings are consistent with the formulation of Bar-Haim et al. (2007) that high-trait anxiety or different anxiety disorders may stem from a tendency to allocate resources to threatening stimuli.

1.3.3. Is there a temporal precedence of anxiety on attentional bias for threat?

In contrast to the previous point, there is also evidence in favor of the alternative explanation, that is a temporal precedence of anxiety on the onset of attentional bias for threatening stimuli, suggesting that attentional bias for threat is a consequence of anxiety. For instance, several classical conditioning studies, in which a neutral stimulus (CS+) is paired with an unconditioned stimulus and a second neutral (CS-) is never paired with this latter, have shown that learning fear through

this procedure leads to an attentional bias for CS+ relative to the CS- following the fear conditioning (e.g., Koster et al., 2004; Lee, Lim, Lee, Kim, & Choi, 2009; Van Damme, Crombez, Eccleston, & Goubert, 2004). These studies indicate that attentional bias for threatening stimuli does not necessarily precede fear.

Between the conceptualizations of attentional bias as a by-product of anxiety and the reversed one, another line of research has assessed attentional bias before and after a successful psychological treatment that did not target the reduction of attentional bias. One of the earliest such studies was conducted by Foa and McNally (1986). Using a dichotic listening task before and after exposure and response prevention treatment among 11 patients who suffered from obsessive-compulsive disorder, they reported that attentional bias for threat decreased after treatment. However, their sample was very small and they did not include a control group.

Using a modified Stroop task, Watts, McKenna, Sharrock, and Trezise (1986) found similar findings among spider phobics following exposure, as compared to spider phobics in a waiting-list group. Three separate studies replicated this effect (e.g., Lavy & van den Hout, 1993; Lavy, van den Hout, Arntz, 1993; van den Hout, Tenney, Huygens, & de Jong, 1997). In contrast, Thorpe and Salkovskis (1997) did not observe such effect. However, their treatment only consisted of a one-session exposure, in comparison to no-treatment group. One cannot exclude the potentially limited impact of the single treatment's session as an explanation.

Similar findings were observed among patients treated for generalized anxiety disorder (GAD). Although they observed no significant difference between groups at post-treatment, Mathews, Mogg, Kentish, and Eysenck (1995) reported decreased attentional bias for threat at 3-month follow-up. Congruently, Mogg, Bradley, Millar, and White (1995) reported that patients treated for GAD who received a cognitive

behaviour therapy showed decreased interference in a modified Stroop task from pretreatment to posttreatment. Further, patients' symptoms and bias were also retested 20 months after initial testing. It has been observed that reduction in attentional bias for threat predicted reduction in anxiety not only after treatment, but also over the 20-month period.

Regarding PTSD, results are less clear. Indeed, one study reported that successful treatment did not differentially affect attentional bias to trauma-related words on a modified Stroop task from pre- to posttreatment, in comparison to a supportive therapy or a waiting-list group (Devineni, Blanchard, Hickling, and Buckley, 2004). Moreover, attentional bias for threat did not predict clinical status at posttreatment or at 3-month follow-up. However, as noted by Tobon, Ouimet, and Dozois (2011), one limitation of this study is the high rate of comorbidity present in their sample (i.e., 44% had a major depression) and it has been shown that depression attenuates the interference effect of anxiety-related stimuli in the modified Stroop task (e.g., Bradley, Mogg, Milar, & White, 1995). In addition, it should also be noted that their sample did not exhibit attentional bias for threatening stimuli before treatment. In contrast, El Khoury-Malhame et al. (2011) found that attentional bias for threatening stimuli, assessed using both the modified Stroop task and dot-probe task, diminished after treatment among patients suffering from PTSD. Moreover, change in the dot-probe task (i.e., decreased vigilance for threat) positively correlated with decreased anxiety.

Similar findings were observed among patients treated for social phobia. Mattia, Heimberg, and Hope (1993) reported decreased attentional bias for threat, using an emotional Stroop task, from baseline to posttreatment (either pharmacological or psychological). Congruently, Lundh and Öst (2001) reported that

a total of 75 % of the patients from their sample who were classified as treatment responders on the basis of a reduced score for social anxiety exhibited a significant decrease in attentional bias for social threat words from baseline to post-treatment. Pishyar, Harris, and Menzies (2008) reported similar findings using the dot-probe detection task. However, it should be noted that the effect size for group (treatment vs. waiting-list) $\times$ time (baseline vs. post-treatment) $\times$ stimulus type (social threatening vs. neutral) of this latter studies (i.e., Cohen's $d = .1.96$) was sensitively higher than studies using the modified Stroop task (i.e., Cohen's $d = .95$ for Mattia et al., 1993; Cohen's $d = .93$ for Lundh & Öst, 2001). These results suggest that the probe detection task is more sensitive to clinical change than the modified Stroop task in social phobia.

Summing all these studies together, 11 out of 13 significantly demonstrated that attentional bias was significantly reduced at posttreatment, and that the phenomenon occurred across different anxious disorders and using different attentional tasks (i.e., dichotic listening, modified Stroop, probe detection). Several of these studies have included a control group, suggesting that the changes are not necessarily a consequence of a test-retest effect. These studies relatively consistently demonstrated that attentional bias (x) is reduced when anxiety (y) is reduced. However, uncertainty still remains about the causal relation. On the one hand, one position is that, because reduced anxiety leads to reduced attentional bias for threat, these results suggest that attentional bias for threat may be a by-product of anxiety. On the other hand, the fact that decreased anxiety leads to decreased attentional bias for threat ($\Delta y \rightarrow \Delta x$) does not imply that attentional bias for threat has no impact on anxiety ($x \rightarrow y$). As we mentioned above, a number of studies have relatively consistently reported that attentional bias for threat significantly predicts

physiological and self-reported responses during both laboratory and natural real-life stressor among participants who were non-anxious at baseline (e.g., Pury, 2002; van den Hout et al., 1995). Therefore, one cannot exclude that the causal path of attentional bias for threat on anxiety is not strictly linear and that attentional bias for threat operates as a vulnerability factor or as a maintaining factor of anxiety. To overcome this uncertainty, only an experimental approach can serve adequately to test the hypothesis that variation on one process causally determines variation on a second one.

1.3.4. Experimental manipulation of attentional bias for threat

The required test of the hypothesis that individual differences in attentional bias for threat can causally impact on vulnerability to anxiety can be provided only by studies designed to systematically manipulate attention for threat, in order to assess consequent change in emotional vulnerability.

i. Attentional bias for threat as vulnerability factor of anxiety

Harris and Menzies (1998) were among the first to adopt such experimental approach. Using a modified version of the dot-probe detection task, they induced an attentional bias either toward or away from spider-relevant words in a non-clinical sample. Participants were randomly assigned to one of two attention bias induction conditions. In each condition, they saw word pairs comprising a spider-relevant word and a neutral word. In the attention-toward-threat condition, the probe always replaced the spider-relevant words. In contrast, in the attention-away-from threat

condition, the probe always replaced the neutral words. After the attention bias induction, the former group was faster in identifying probes replacing novel spider-relevant words, whereas the latter group was faster in identifying probes replacing neutral words. Nevertheless, there was no generalization to a different attentional task (i.e., Stroop task) and to self-reports of anxiety. However, their manipulation procedure only included 40 trials.

In a well-known study, MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) manipulated attention bias towards general anxiety words. They screened a large pool of participants and selected those who were in the middle third of the distribution of a self-report measure of trait-anxiety. Using a dot-probe detection task, MacLeod and colleagues trained participants to attend either to neutral or to threatening stimuli. In the attend-to-threat condition, probes appeared in the position of threat words (e.g., bomb, dead, nausea, sad) on 93% of the trials, whereas in the attend-to-neutral condition, probes appeared in the position of the neutral words (e.g., curve, league, journal, aisle) on 93% of the trials. The task comprised 672 trials. After completing the training, participants were presented with a laboratory stressor that involved solving a series of unsolvable anagrams and were told that their videotaped performance would be shown in classes should they perform particularly well or poorly. Consistent with prediction, participants developed differential attention bias to novel threat stimuli in accordance with their respective training contingency. Moreover, relative to those trained to attend to neutral material, participants trained to attend to threat material reported more anxiety and negative mood after performing the stressful anagram task. This result suggests that selective attention for negative information increases anxiety reactivity to an experimental stressor.

Although these results were consistent with the hypothesis that an attention bias towards threat cues confers a vulnerability to heightened negative emotional affectivity in response to stressor, an alternative explanation is that differences in anxiety reflect more a direct effect of the training task on participants' mood rather than differential vulnerability to stress between groups. To test this alternative explanation, MacLeod et al. (2002, Study 2) instructed participants to report their levels of anxiety and depression, not only after the stressor, but also prior the training, during the training and prior the stressor. The groups did not differ in their levels of anxiety or depression during the training procedure or prior the stressor. The differences between the groups only appeared during the stressor, reflecting the creation of a differing affective vulnerability to emotional stressors that endures, at least over a short period, after attending to threat cues.

Eldar, Ricon, and Bar-Haim (2008) replicated this finding in non-anxious 7-12-year-old children using a modified dot-probe task with naturalistic pictures of angry and neutral facial expressions. In addition to group differences in self-reported anxiety following stress induction, this study showed that, relative to children trained to attend away from threat, those trained to attend toward threat showed a higher frequency of anxious behaviour as coded from video tapes recorded during the stress episode.

Considered together, these studies provide a stronger support than the correlational ones for the hypothesis that individual differences in attentional bias for threat can causally impact on vulnerability to anxiety through response to subsequent stressor. Moreover, these findings are consistent with the statement of Bar-Haim et al. (2007) that anxiety disorder may stem from attentional bias.

ii. Attentional bias for threat as a maintenance factor of anxiety

Over the last four years, based on the experimental rationale of MacLeod et al. (2002), several studies have examined the hypothesis that individual differences in attentional bias for threat can causally impact on the maintenance of anxiety disorder.

Amir, Weber, Beard, Bomyea, and Taylor (2008) examined whether attention bias retraining can modify attention bias and emotional reactivity in individuals with high-level of social anxiety. Using an adaptation of the dot-probe discrimination task, these researchers examined the effects of a single attention training session designed to reduce attentional bias toward threatening faces (i.e., disgust). In that study, investigators trained attentional allocation by including a contingency between the location of the nonthreat stimuli (i.e., neutral faces) and the probe. The probe appeared in the same location as the nonthreat cues (i.e., neutral face) in 95% of the trials and in the same location as the threatening face (i.e., disgust face) in 5% of the trials. In the control training, there was no contingency between the probe and the cues (50%-50%). Relative to those who completed the control training, the individuals who underwent attention training reported reduced anxiety in response to an impromptu speech. Moreover, blind raters judged the speeches of those in the attention training group more positively than the speeches of those in the control group. Further, the authors included an assessment of attentional bias for threatening stimuli, which was an emotional spatial cueing task including socially threatening and neutral words, before and after the training. They observed that participants who underwent attention training exhibited a significant decreased on latencies for invalid threatening trials, suggesting an improvement in the ability to disengage attention from threat. Further, the use of spatial cueing task with words rather than a dot-probe

task with faces demonstrated that changes in attention generalized to a different measure of attention bias and to a different type of stimulus. They also found that changes in attentional biases for threat mediated the effects of the training on anxiety reactivity, and the decrease in anxiety, in turn, improved speech performance.

Similarly, Li, Tan, Quian, and Liu (2008) have observed that a 7-day of attention training toward positive faces diminished self-reported fear of social interaction among a sample of highly socially anxious university students, relative to those who completed a no-contingency attention training task. Using a probe discrimination task before and after the training, they observed that attention training decrease attentional vigilance for threat. However, they found no significant group differences on two other measures of social anxiety.

Such procedure was also used as a prophylactic intervention reducing anxiety and stress vulnerability in individuals who are bound to face stressful naturalistic circumstances. See, MacLeod, & Bridle (2009) followed Singaporean students while preparing to immigrate to Australia for tertiary education. This transition has been established as a highly stressful for these students (e.g., Babiker, Cox, & Miller, 1980). During the 16 days prior to departure from Singapore, these participants completed 14 days of an internet-delivered version of a training version of the dot-probe. See and his colleagues showed that students who were trained to attend to non-threat words reported reduced trait anxiety scores and attenuated state anxiety responses to the subsequent naturalistic stressor, relative to those who underwent a no-contingency training task.

Hazen, Vasey, and Schmidt (2009) found similar findings among a sample of severe worriers. They reported that those who underwent a five-session training in which they were trained to attend to non-threat words exhibited a significant decrease

in anxiety and depression, relative to those who were in a no-contingency training task. Although their methodology was partially different, Hayes, Hirsch, and Mathews (2010) reported results that are congruent with those for Hazen et al. (2009).

Najmi and Amir (2010) examined the effect of attentional bias modification among individuals with subclinical obsessive-compulsive symptoms. Participants in the active group showed a significant reduction in attention bias for threat and completed significantly more steps when approaching their feared objects compared with participants in the no-contingency training group. Moreover, the pre- to posttraining change in attention bias mediated the association between the active training and performance when approaching the feared objects.

Considered together, the above results suggest that attentional bias for threatening stimuli may be involved in the maintenance of subclinical level of anxiety. Regarding individuals diagnosed as presenting an anxiety disorder, several studies were realized and produced convergent findings.

In a sample of 29 individuals seeking treatment for generalized anxiety disorder, Amir, Beard, Burns, and Bomyea (2009) examined the effects of an eight-session attention training program using a modified dot-probe discrimination task on participants' attentional allocation toward threat-relevant information (i.e., words) and on symptoms of anxiety. Results indicated that patients who were trained to repeatedly direct their attention away from threat displayed a significant decrease in vigilance for threat as assessed by the dot-probe task and a decrease in anxiety as indicated by both self-reported and interviewer-rated measures, relative to those who underwent the no-contingency control training. Moreover, changes in the dot-probe task from baseline to post-training mediated the impacts of attention training on decreased interviewer-rated score of anxiety. Further, 50 % of participants who were

trained to attend towards non-threat no longer met diagnostic criteria for generalized anxiety disorder at post-assessment relative to 13% of control participants.

Similarly, Schmidt, Richey, Buckner, and Timpano (2009) observed that individuals with generalized social phobia who completed eight-sessions of attention training toward neutral faces over a 4-week period exhibited a significantly greater reduction in social anxiety and trait anxiety, when compared to individuals who completed a control condition. At post-assessment, 72% of patients in the active training no longer met diagnostic criteria for generalized social phobia, relative to 11% of patients in the control training. At a 4-month follow-up, clinical gains of those who underwent the active training were maintained. However, they did not include an independent measure of attentional bias for threat before and after the training. Therefore, it remains unclear whether the effects of attention training on social anxiety result from change in attentional bias.

To overcome this limitation, Amir, Beard, Taylor, Klump, Elias, Burns, and Chen (2009) realized a study presenting the same design but including an independent measure of attentional bias for threat, which was a modified Posner task including neutral and threatening words, before and after the training. Consistent with the results of Schmidt et al. (2009), they reported that attention training reduced self-reported and clinician interviewer-rated social anxiety, relative to those who underwent the no-contingency control training. At post-assessment, 50% of patients in the active training no longer met diagnostic criteria for generalized social phobia, relative to 14% of patients in the control training. Symptoms reduction of patients who underwent the active training was maintained during 4-month follow-up assessment. Further, they observed that participants who underwent attention training exhibited a significant decrease on latencies for invalid threatening trials, suggesting

an improvement in the ability to disengage attention from threat. Further, the use of spatial cueing task with words rather than a dot-probe task with faces demonstrated that changes in attention generalized to a different measure of attention bias and to a different type of stimulus. They also found that changes in attentional biases for threat mediated the effects of the training on decreased social anxiety symptoms.

Regarding specific phobia disorder, results are less obvious. For instance, Reese, McNally, Najmi and Amir (2010) assigned spider fearful participants to either an attentional bias reduction training condition or to a no-contingency control condition. They found that the training condition was successful in reducing attentional bias for spider-related stimuli. Nevertheless, both the training group and the control group showed similar decreases in self-reported spider fear and behavioural avoidance of a spider. More recently, Van Bockstaele, Verschuere, Koster, Tibboel, De Houwer, and Combres (2011b) investigated the effects of attentional training towards or away from spiders on self-reported, implicit, physiological and behavioural measures of spider fear among spider fearful participants. They reported that the training procedure was successful in inducing an attentional bias towards spiders in one group and away from spiders in the other group. However, for both attentional training conditions, self-reported and implicit spider fear as well as physiological fear responses decreased after training.

Recently, Hakamata et al. (2010) conducted a meta-analysis on 12 studies on attention training among social anxiety and generalized anxiety and trait anxiety (see studies mentioned above). Analyses revealed a significant benefit of attention training on anxiety, with a medium effect size ($d = .61$, $p < .001$, 95% CI = .42-.81). They also estimated the fail-safe n to 54, thereby estimating to 54 the number of unpublished studies with effect sizes of zero needed to reduce the aggregated effect below significance. Considered together, these studies provide a strong support for the

hypothesis that individual differences in attentional bias for threat can causally impact on the maintenance of anxiety (with the exception of specific phobia). Further, they are clearly in line with some cognitive models of anxiety that state that attentional bias for threat is involved in the maintenance of the disorder (e.g., Eysenck & al., 200; Rapee & Heimberg, 1997). However, it should be noted that, after the removal of three possible outliers with particularly large effect size (experiment 1 and 2 of Mathews & Macleod, 2002; Schmidt et al., 2009), the overall effect size is reduced but remains medium ($d = .36$, $p < .001$, 95% CI = .15-.57). Unfortunately, the estimated fail-safe n dropped to 7, suggesting that replications are clearly needed to ensure the reliability of the attention training procedure.

1.4. Future directions

Although the above review is consistent with the hypothesis that change in attention bias leads to change in anxiety, especially for social anxiety and generalized anxiety disorder, several issues need further examination.

1.4.1. Disengagement from threat or reengagement to non-threat?

A major issue is that there is uncertainty regarding the mechanisms that mediate the reduction of anxiety via attentional training procedure. According to Amir et al. (2008), the improvement in the ability to disengage attention from threatening stimuli mediates the reduction of emotional reactivity to stressor. As mentioned above, studies showed that anxious participants are no faster to respond to probes replacing threat as compared to non-threat cues. However, they are slower to respond

to probes that appear opposite to threat cues as compared to non-threat cues, implying difficulties in disengaging attention from threat (e.g., Amir et al., 2003; Fox et al., 2001). Hence, disengagement difficulty would be the underlying process mediating attentional bias for threat in the probe detection and probe discrimination paradigms.

An alternative account is based on results of MacLeod et al. (2002) and Li et al. (2008) and postulates that the development of a counter-bias during training, in which attention is trained to be oriented towards non-threat cues, constitutes the explanatory mechanism. For instance, Li et al. (2008) have observed that training socially anxious individuals to focus on positive faces reduces bias toward threatening faces, and also increases attentional bias towards non-threat cues. The therapeutic benefits of attention training would thus result from orienting attention towards non-threat cues. In other words, the critical component of attentional training would be the reallocation of attention towards non-threat rather than the disengagement from threat.

Alternatively, one cannot exclude the possibility that both processes (disengagement from threat and attention allocation to non-threat) are necessary for attentional training to be effective. Indeed, it could be argued that attention allocation to non-threat is only possible if one can disengage from threat.

1.4.2. Does reducing attentional bias for threat involve improvement in top-down control?

Several issues remain regarding the cognitive mechanisms underlying attention training. Indeed, it has been formulated that attention training may be efficient by increasing executive attentional control, which may inhibit threat

processing.

Executive attention network is defined as the function that enables an individual to resolve conflicts among responses and involves the top-down control of attention. Further, as we mentioned above, several cognitive models of anxiety posit that reduced top-down control may result in a difficulty to disengage attention from threatening stimuli (i.e., Eysenck et al., 2007; Cisler and Koster, 2010).

In accordance with this hypothesis, Koster, Baert, Bockstaele, and De Raedt (2010) found that attention training influences late (1500 ms) rather than early (30 or 100 ms) stages of threat processing. Congruently, in an event-related brain potentials (ERP) experiment, Eldar and Bar-Haim (2010) found that training attention away from pictures of angry faces in trait-anxious individuals reduced P2 and P3 amplitudes¹ and increased N2 amplitude in response to the onset of these stimuli compared to placebo training. They interpreted these data as implying that attention training involves top-down executive attention control rather than early orienting of attention. Consistent with these findings, Browning, Holmes, Murphy, Goodwin, and Harmer (2010) also showed that prefrontal cortical regions mediate attention training among healthy participants.

Similarly, Dandeneau, Baldwin, Baccus, Sakellaropoulou, and Pruessner (2007) developed a different attention bias modification procedure based on a visual search task. The task requires individuals to repeatedly identify the location of a smiling face among a matrix of rejecting (i.e., frowning) faces. These authors (Study 3b) found

¹ Most ERP components are referred to by a letter indicating polarity (positive or negative), followed by a number indicating either the latency in milliseconds or the component's ordinal position in the waveform. Thus, for instance, a negative peak that is the first substantial peak in the waveform and often occurs about 100 milliseconds after a stimulus onset is often called the N100 (indicating its latency) or N1 (indicating that it is the first peak and is negative).

that such procedure completed daily for one week by a group of telemarketers led to higher self-esteem, lower cortisol levels, lower self-reported stress, higher self-confidence, and improved work performance relative to both a control-group trained to search a five-petaled flower among a matrix of seven-petaled flowers (thereby controlling for the search process) and an exposure condition that controlled for the exposure to frowning faces (i.e., desensitization). The authors interpreted their results as specifically implying improvement in *the ability to inhibit automatic prepotent response*. However, their study did not include any such measurement.

In a recent study, Klumpp and Amir (2010) randomly allocated moderately socially anxious individuals to one of three different attention training conditions: (1) training to attend away from threat, (2) attend to threat, or (3) a control condition in which there was no contingency between cues and probe. After a single-session of training, individuals who were trained to attend to threat and those trained to attend away from threat reported less anxiety in response to an impromptu speech compared to individuals in the control condition. Klumpp and Amir concluded that training in either direction (toward or away from threat) bolsters top-down executive attentional control in ways that may foster the ability to control ones' anxiety. However, their study did not include any such measurement, therefore it remains unclear whether the Amir and Klumpp's effect effectively result from increased executive attention control. Unfortunately, this work has not yet been replicated.

In contrast to the hypothesis that changes in attentional bias involve changes in executive process, recent evidence have formulated that attentional bias for threatening stimuli may also result from the original impairment of the orienting process for non-emotional stimuli (e.g., Jongen, Smulders, Ranson, Arts, Krabbendam, 2007; Moriya & Tanno, 2009). The orienting network is defined as the

ability to select information from sensory input (that includes disengagement, shift, and engagement; Posner & Petersen, 1990). Similar predictions may be inferred from some cognitive models of anxiety presented above (e.g., Öhman, 2005). Previous research specifically focused on the attentional disengagement in the orienting network and have indicated that impaired attentional disengagement was related to negative affect (Compton, 2002). Further, regarding neuroanatomy, the orienting system is associated with parietal sites, particularly the superior parietal lobe and the temporoparietal junctions (Fan et al., 2005). Regarding threat processing, one of the important roles of the parietal cortex is the detection of salient new stimuli. For instance, Luo et al. (2007) have reported that emotional saliencies are associated with increased activity in the parietal cortex. As developed by Moriya and Tanno (2009), abnormal activity in parietal cortex might prevent anxious people from inhibiting attention to salient emotional stimuli. Therefore, one cannot exclude that attention training may lead to a change in the orienting process for non-emotional stimuli, which, in turn, may lead to improvement in the ability to inhibit attention toward salient emotional stimuli.

To sum up, it remains unclear whether change in attentional bias for threatening stimuli requires change in executive control or in orienting process.

1.4.3. More than merely the impact on self-report

Although some researchers have assessed the impact of attention training on anxiety by including behavioral measures of fear (e.g., Amir et al., 2008; Reese, McNally, Najmi, & Amir, 2010), few studies have addressed the effects of attention

training on physiological measures of anxiety. To our knowledge, only two studies have examined the effects of attention training on physiological responses to stressors.

Dandeneau et al. (2007), measuring hormonal response rather than a traditional measure of psychophysiology, found that attention training lowered cortisol release in response to stress. However, this study was conducted among non-anxious participants. Further, the experimental manipulation of this study involved a procedure based on a visual search task rather than a dot-probe task. In contrast, Van Bockstaele et al. (2011b) did not find any effect of attention training on skin conductance and heart rate in response to pictures of spiders among spider phobics. It should be noted, however, that this study did not evidence effects of training on any other measures of anxiety.

Regarding social anxiety and generalized anxiety disorder, with the exception of some studies that included a behavioral measure of anxiety (e.g., Amir et al., 2008), researchers have relied on self-report measures and diagnostic interviews to assess the impact of attention training. As MacLeod, Koster, and Fox (2009a) argued, the completion of self-report measures involves judgment and inferences, giving rise to the possibility that a cognitive manipulation might affect questionnaire scores even when emotional experience itself is unaffected. Moreover, as Lang (1968; 1993) and Bradley and Lang (2000) have argued, emotional response is not only expressed through language. Emotions are expressed in three different responses systems: 1) overt behaviors (e.g., avoidance), 2) language (i.e., self-report measures), and 3) physiological responses (e.g., skin conductance). Future research should address the impact of attentional retraining on these different response systems.

1.4.4. What about the installation of vulnerability to anxiety?

As we already mentioned, only one model explicitly states that anxiety disorder may stem from attentional bias (i.e., Bar-Haim et al., 2007). At an empirical level, we reviewed the few studies that have examined the hypothesis that individual differences in attentional bias for threat can causally impact on vulnerability to anxiety through modified response to subsequent stressor. Although MacLeod et al. (2002) and Eldar et al. (2008) reported evidence in favor of this hypothesis, it remains unclear how this effect occurs. For instance, both studies included a probe discrimination task as a measure of attentional bias for threat, which is less than ideal for distinguishing among subcomponents of attentional biases (i.e., difficulties to disengage from threatening stimuli vs. facilitated attention orientation for threatening stimuli). To address this issue, researchers could administer, for instance, a modified version of the Posner paradigm as an independent measure of attention bias before and after training.

Moreover, it remains unclear whether participants who are trained to attend to specific threatening stimuli (e.g., reject faces) show more anxiety during social exclusion specifically, or whether they would also exhibit other changes in mood.

1.5. Conclusion

As we reviewed, some prominent cognitive models of anxiety disorders have argued that attentional bias for threatening stimuli is causally involved in the etiology (i.e., Bar-Haim et al., 2007) and the maintenance (e.g., Rapee and Heimberg, 1997; Williams et al., 1997) of the disorder. A wealth of studies provides empirical support for these claims.

First, we reported the demonstration of an association between attentional bias for threat and anxiety, through different experimental behavioural paradigms and across different anxiety disorders. This research reveals, regardless of the direction, a relation between attentional bias for threat and anxiety. Secondly, beyond this strictly correlational demonstration, we reported some prospective studies. However, on the one hand, it has been reported that attentional bias for threatening stimuli is a vulnerability factor for developing anxiety in response to stress, suggesting that attentional bias for threat may be causally involved as a vulnerability factor in the etiology of anxiety disorder. On the other hand, there is also evidence in favor of the alternative explanation of a temporal precedence of anxiety on the onset of attentional bias for threatening stimuli, suggesting that attentional bias for threat may be a consequence of anxiety (i.e., classical conditioning).

Overcoming these uncertainties about the causal nature of this relation can only be accomplished by studies designed to systematically manipulate attention for threat, in order to assess consequent changes in emotional vulnerability. Such studies consistently provided empirical support for this hypothesis (e.g., MacLeod et al., 2002). At a theoretical level, these findings are consistent with the statement of Bar-Haim et al. (2007) that anxiety disorders may stem from attentional bias. Similar empirical support was also provided by studies designed to systematically manipulate attention for threat among anxious patients, thereby providing support for the hypothesis that individual differences in attentional bias for threat can causally impact on the maintenance of anxiety (with the exception of spider-phobia). These findings are clearly in line with the cognitive models of anxiety that state that attentional bias for threat is involved in the maintenance of the disorder (e.g., Eysenck & al., 200; Rapee & Heimberg, 1997).

Considered all together, these findings suggest a causal impact of attentional bias on the maintenance of anxiety. However, while the meta-analysis of Hakamata et al. (2010) clearly supports the idea that reducing attentional bias for threat in social anxiety and generalized anxiety disorder diminishes anxiety, we pointed several issues for further investigation. First, we noted that it remains unclear whether the impact of such procedure comes from change in the ability to disengage from threat, or from the ability to re-allocate attention to non-threat, or both simultaneously. Second, we noted that, although Eysenck et al. (2007) and Cisler and Koster (2010) postulated that top-down attention control underlies attentional bias for threat, uncertainty abounds regarding whether changes in such processes are required for reducing attentional bias for threatening stimuli. Third, we also noted that attention training research has mainly relied on self-report measures and diagnostic interviews to assess the impact of attention training, thereby constituting a limitation for understanding how change in attentional bias for threat impacts on anxiety. Finally, we formulated some recommendations for future research examining how attentional bias for threat may be involved, not only as a maintenance factor, but also as a vulnerability factor in the etiology of the disorder.

Empirical Section

Chapter 2

Overview of the empirical section

In the General Introduction, we have extensively discussed the causal nature of attentional bias for threatening stimuli in the etiology and the maintenance of anxiety. At a theoretical level, some prominent cognitive models of anxiety disorders state that attentional bias for threatening stimuli is causally involved in the etiology (i.e., Bar-Haim et al., 2007) and the maintenance of the disorder (e.g., Rapee and Heimberg, 1997; Williams et al., 1997). Empirical research provides empirical support for these claims. First, studies clearly demonstrated an association between attentional bias for threat and anxiety, through different experimental behavioral paradigms and across different anxiety disorders (e.g., Bar-Haim et al., 2007), suggesting that, there is a relation between attentional bias for threat and anxiety. Secondly, beyond this strictly correlational demonstration, we reviewed some prospective studies. However, on one hand, it has been reported that attentional bias for threatening stimuli is a vulnerability factor for developing anxiety in response to stress, suggesting that attentional bias for threat may be causally involved in the etiology of anxiety disorder (e.g., Pury, 2002; van den Hout, Tenney, Huygens, Merckelbach, & Kindt, 1995). On other hand, there is also evidence in favor of the alternative explanation of a temporal precedence of anxiety on the onset of attentional bias for threat, suggesting that attentional bias is a by-product of anxiety (e.g., Van Damme, Crombez, Eccleston, & Goubert, 2004).

Overcoming the uncertainty about the causal nature of this relation can only be provided by studies designed to systematically manipulate attention for threat. Such studies consistently provided empirical support for such causal relation (e.g., MacLeod et al., 2002). At a theoretical level, these findings are consistent with the statement of Bar-Haim et al. (2007) that anxiety disorder may stem from attentional

bias. Similar empirical support was also provided by studies designed to systematically manipulate attention for threat among anxious patients (for a review, see the meta-analysis of Hakamata et al., 2010). These findings provide support for the hypothesis that individual differences in attentional bias for threat can causally impact on the maintenance of anxiety (with the exception of more circumscribed fear, such as in phobia).

On the basis of the theoretical and empirical backgrounds described in the theoretical section, we pointed out several fundamental issues.

2.1. Is the malleability of attentional bias for threat a replicable effect?

As we developed in the General Introduction, Hakamata et al. (2010) conducted a meta-analysis of 12 studies on attention training in population characterized by social anxiety or generalized anxiety. The results suggest that replications are clearly needed to establish the reliability of the attention training effect. Further, some recent studies have failed to replicate the beneficial effects of attention training procedure (e.g., Boettcher, Berger, and Renneberg, in press; Reese et al., 2010; Van Bockstaele, et al., 2011b). For instance, Boettcher et al. (in press) did not report any beneficial effects from an internet-based attention training procedure designed for socially anxious individuals, in comparison to a no-contingency training procedure. Moreover, participants who were trained to attend to non-threat did not show any change in attentional bias for threat. Although one cannot exclude that the internet-based deliverance may be an explanation of the null-results (e.g., participants may be exposed to interruptions and diversions while completing the training task, difference in monitor size), it suggests that some uncertainty remains

regarding the efficacy of attention training as a novel treatment for anxiety.

Considered together, these findings raise doubt about the involvement of attentional bias for threat in the maintenance of anxiety disorder. Using an experimental design similar to previous attention training studies, one of the primary questions of the present dissertation is to ensure the reliability of these effects. Our main prediction is that training anxious individuals to attend to non-threatening stimuli should decrease anxiety symptoms.

Based on the theoretical backgrounds and previous empirical studies, we can consequently formulate the following hypothesis:

Hypothesis 1: Training anxious individuals to attend to non-threatening stimuli should lead to more decrease in anxiety than a no-contingency training

2.2. Generalisability to emotional reactivity and to information processing

In the General Introduction, we have drawn attention to the limitation that researchers have seldom included behavioral measures of anxiety reduction and few have taken physiological measures of anxiety reduction. To our knowledge, only two studies have examined the effects of attention training on physiological responses to stressors. Measuring hormonal response, Dandeneau et al. (2007), found that attention training lowered cortisol release in response to stress. However, this study was conducted among non-anxious participants. Further, the experimental manipulation of this study involved a procedure based on a visual search task rather than a dot-probe task. In contrast, Van Bockstaele et al. (2011b) did not find any

effect of attention training on skin conductance and heart rate in response to pictures of spiders among spider phobics. It should be noted, however, that this study did not show effects of training on any other measures of anxiety.

Regarding social anxiety and generalized anxiety disorder, with the exception of some studies that included a behavioral measure of anxiety (e.g., Amir et al., 2008), researchers have relied on self-report measures and diagnostic interviews to assess the impact of attention training. As MacLeod et al. (2009a) argued, the completion of self-report measures involves judgment and inferences, giving rise to the possibility that a cognitive manipulation might affect questionnaire scores even when emotional experience itself is unaffected. Moreover, as Lang (1968; 1993) and Bradley and Lang (2000) have pointed out, emotional response is not only expressed through language. Emotions are expressed in three different responses systems: 1) overt behaviors, 2) language, and 3) physiological responses.

Further, Rapee and Heimberg (1997) predicted that, in social situations, attentional bias for threat may lead to negative evaluation which, in turn, results in physiological, cognitive, and behavioral components of anxiety. Subsequently, according to their model, these activations retroactively loops into the negatively biased mental representations and, therefore, perpetuate the cycle of anxiety. Therefore, one can infer that, if attentional bias for threat maintains anxiety, attention training should target all systems --verbal, behavioral, and physiological. We can consequently formulate the following hypothesis:

Hypothesis 2: Training anxious individuals to attend to non-threatening stimuli should reduce self-report, behavioral, and physiological measures of anxiety whereas a no-contingency training should not.

Nevertheless, as such, these expected observations cannot sustain the conclusion that this emotional change can be unambiguously attributed to the selective attentional processing resulting from the training. As argued by MacLeod et al. (2009a), this conclusion requires that studies confirm predicted changes on a task that reliably measures the mediating cognitive process. Moreover, MacLeod et al. (2009a) also argue that the magnitude in change in the mediating process should predict the magnitude of improvement on the clinical measures.

To address these requirements, in all studies of the present thesis, we included an independent measure of attentional bias for threat. We can consequently state the following hypothesis:

Hypothesis 3: Training anxious individuals to attend to non-threatening stimuli should lead to changes on an independent measure of attentional bias for threatening stimuli whereas those in a no-contingency training should not.

2.3. Which components of attention bias are involved in the maintenance of anxiety?

The previous attention training results do not allow to clearly specify which components of attention is causally involved in the maintenance of anxiety. As

pointed by Cisler and Koster's (2010) model, attentional bias towards threat may comprise facilitated attention to threat, delayed disengagement from threat, and attentional avoidance of threat. According to Mogg and Bradley (1998), an attentional bias towards threat may be considered as a maintenance factor of anxiety because if the initial allocation of attention to threat is followed by avoidant behaviors, extinction to conditioned stimulus aborts and anxiety is maintained. Hence, according to the Foa and Kozak's model (1986), only attentional avoidance is a core maintenance factor of anxiety disorders. In contrast, others have proposed that the critical mechanism through which attentional bias for threat operates as a maintenance factor is delayed disengagement from threat (e.g., Eysenck et al., 2007).

Two differential approaches may be extracted from these models. According to the first, training anxious individuals to attend to threat should lead to decrease anxiety. In contrast, the second predicts that training anxious individuals to attend to non-threat should decrease anxiety. In order to be consistent with previous attention training studies (e.g., Amir et al., 2008), we can consequently state the following hypothesis:

Hypothesis 4: Training anxious individuals to attend to non-threatening stimuli should decrease anxiety more strongly than both training anxious individuals to attend to threat and to a no-contingency training.

Further, it remains unclear whether the impact of such procedure results from a change in the ability to disengage from threat or from the ability to re-allocate attention to non-threat. According to Amir et al. (2008, 2009), attention training reduces anxiety because it improves the ability to disengage attention threat.

However, an alternative account is based on results of MacLeod et al. (2002) and Li et al. (2008). According to this explanation, the development of a counter-bias during training, in which attention is trained to be oriented towards non-threat cues, constitutes the active mechanism. The findings of Amir et al. (2008) leads us to formulate the following hypothesis:

Hypothesis 5: Training anxious individuals to disengage from threat should lead to decrease anxiety whereas those trained to re-engage attention to non-threat should not.

2.4. Does improvement in executive control mediate reduction in delayed disengagement from threat?

In the General Introduction, we raised the issue of the involvement of executive control in the maintenance of attentional bias for threat. Indeed, it has been formulated that attention training may be efficient by increasing executive control, which would inhibit threat processing. Further, several cognitive models of anxiety posit that reduced top-down control may result in a difficulty to disengage attention from threatening stimuli (i.e., Eysenck et al., 2007; Cisler and Koster, 2010). Some attention training studies support this notion (e.g., Browning et al., 2010; Eldar & Bar-Haim, 2010; Klumpp & Amir, 2010; Koster et al., 2010). For instance, Browning et al. (2010) showed that prefrontal cortical regions mediate attention training among healthy participants.

They all concluded that attention training bolsters top-down executive

control in ways that may foster the ability to control's one anxiety. However, as these studies did not include executive control measurement, it remains unclear whether their effects really result from increased executive control.

In contrast to the hypothesis that changes in attentional bias involve changes in executive processes, recent evidence have also formulated that attentional bias for threatening stimuli may also result from the original impairment of the orienting process for non-emotional stimuli (e.g., Jongen, Smulders, Ranson, Arts, Krabbendam, 2007; Moriya & Tanno, 2009). The orienting network is defined as the ability to select information from sensory input (that includes disengagement, shift, and engagement; Posner & Petersen, 1990). Similar predictions may be inferred from some cognitive models of anxiety presented above (e.g., Öhman, 2005). However, no empirical data speaks to this hypothesis.

To sum up, it remains unclear whether changes in attentional bias for threatening stimuli requires change in executive control or in orienting process. This rationale leads us to formulate the following hypothesis:

Hypothesis 6: Training anxious individuals to attend to non-threat stimuli should lead to improvement in executive attentional control that mediates the reduction of delayed disengagement from threat, whereas a no-contingency training should not.

2.5. Attentional bias for threat, not only a maintenance factor, but also a vulnerability factor

As developed before, only one cognitive model of anxiety explicitly stated that anxiety disorder may stem from attentional bias (i.e., Bar-Haim et al. (2007). At an empirical level, we reviewed the few studies that have examined the hypothesis that individual differences in attentional bias for threat can causally impact on vulnerability to anxiety through a modified response to subsequent stressor. Although MacLeod et al. (2002) and Eldar et al. (2008) reported evidence in favor of this hypothesis, it remains unclear how this effect occurs. For instance, these two studies included a probe discrimination task as a measure of attentional bias for threat, which is less than ideal for distinguishing among subcomponents of attentional biases (i.e., difficulties to disengage from threatening stimuli vs. facilitated attention orientation for threatening stimuli).

To address these requirements, in all studies of the present thesis, we included an independent measure of attentional bias for threat. We can consequently state the following hypotheses:

Hypothesis 7: Training to attend to threatening stimuli should lead to an increase in delayed disengagement from threat, which in turn should lead to an increased reactivity to emotional stressors, whereas those trained to a no-contingency training should not.

2.6. Conclusion and rationale of the empirical part

The aim of this chapter was to present a general overview of the hypotheses raised in the present dissertation. Our main interest is to elucidate the mechanism underlying the requirement of attentional bias for threatening stimuli in the

maintenance of anxiety. The previous five questions, as explained in detail above, were examined in different empirical studies that are described in the next seven chapters.

Because of methodological concerns (e.g., more control in the stimuli selection) and in order to interpret our data with most of the previous research in the field, we have chosen to only focus on one type of population in our studies: Individual with a clinical diagnosis of social anxiety. Moreover, social anxiety is a common and incapacitating disorder that has been associated with seriously impaired career, academic, and general social functioning (e.g., Katzelnick et al., 2001; Schneier et al. 1994). For instance, individuals with social anxiety are more likely to have a job below their actual level of educational attainment, and to believe that their supervisors do not think they fit with the work environment (Bruch, Fallon, & Heimberg, 2003). Regarding epidemiological data, social anxiety has a lifetime prevalence of 12.1% and is the fourth most common psychopathological disorder (Kessler et al., 2005b).

The first two studies describe replications. We have performed a **first study** to replicate previous results about the effects of training individuals to attend to non-threatening stimuli (Hypothesis 1) among a sample of non-treatment seeking socially anxious individuals (e.g., Amir et al., 2008, 2009; Li et al., 2008). Using an independent measurement of attentional bias, we also examined whether decrease in social anxiety is related to change in disengagement from threatening stimuli (Hypothesis 3). The **second study** explored these hypotheses (Hypotheses 1 & 3) among a treatment seeking single-case individual. Using an attention training procedure based on a modified dot-probe task, we examined whether such procedure enabled a social phobic client to reduce attentional biases and to transfer this rehabilitation to daily functioning. Efficacy of the attention training was assessed at

the cognitive, behavioral and ecological levels. Using a Bayesian probabilistic approach, the case's performances were compared to a normative sample before, after the treatment, at a 2-month follow-up, at a 6-month follow-up, as well as one year after the treatment.

In a **third study**, we examined whether training individuals with generalized social phobia to attend to non-threatening stimuli leads to larger decrease in anxiety than training to attend to threat, or to alternately attend to both (Hypothesis 4). Further, we assessed not only self-reported social anxiety, but also behavioral and physiological measures of social anxiety (Hypothesis 2).

In a **fourth study**, we crossed the presence/absence of disengagement from threat and allocation to non-threat in four different attention training conditions (Hypothesis 5). We assessed not only self-reported social anxiety, but also behavioral measures of social anxiety.

In the next two chapters, we have assessed whether change in attentional bias for threatening stimuli requires change in executive attentional control (Hypothesis 6). In a **fifth study**, we examined whether the effects of training socially anxious individuals to attend to non-threat leads to more improvement in executive attention control than those trained to attend to threat (Hypotheses 4 & 6). A limitation of this study was the lack of non-contingency training condition. In a **sixth study**, we specifically examined whether training to attend to non-threat improves inhibitory control (as compared to a no-contingency training), which in turn may lead to improvement in the ability to disengage from threat (Hypothesis 6).

The **seventh study** examined whether attentional bias for threat causally leads to emotional vulnerability to stressors. No previous study has directly examined the causal status of selective attentional bias in the development of anxiety in a social

rejection context (Hypothesis 7). Our study explicitly investigated this issue. We used an experimental design similar to MacLeod et al. (2002), which involved two consecutive experimental phases: an attentional bias induction phase and a stress phase. During the attentional bias induction, participants completed modified versions of a dot-probe task; for half of the participants the task was designed to induce a biased attentional response for faces expressing disgust, for the other half, the task induced no bias. Then, all participants were exposed to a task inducing social rejection. We predicted that training to attend to threatening stimuli should lead to increase in delayed disengagement from threat, which in turn should lead to increase reactivity to the social stressor.

Chapter 3

Is the malleability of attentional bias for threatening stimuli a replicable effect?

An investigation among socially anxious individuals

(Study 1)

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Abstract

Attention training programs, in which probes replace non-threatening cues, reduce attentional bias for threat and social anxiety. However, some uncertainty abounds regarding the efficacy of attention training as a novel treatment for social anxiety. The primary issue of the present paper was to ensure the reliability of these effects. Individuals ($n = 36$) with a high-level of social anxiety were randomly allocated to one of the two training conditions. In a treatment condition, they had to attend to neutral faces, while in a control condition, there were no contingency between probes and cues. Attentional bias for threat and self-report social anxiety were assessed before and after the training. Participants trained to attend to neutral cues demonstrated a significant greater reduction in social anxiety as well as a decreased difficulty to disengage from threat. Further, mediational analyses indicated that improvement in the ability to disengage attention from threat mediates the impacts of attention training on change in social anxiety. The present data are consistent with recent developments in cognitive bias modification demonstrating that the attention bias for threatening stimuli can be manipulated and that these modifications are related to emotional changes.

Keywords: Attention training, cognitive bias modification, social anxiety, replication, attentional bias

3.1. Introduction

Social anxiety is a common and incapacitating disorder that has been associated with seriously impaired career, academic, and general social functioning (e.g., Katzelnick et al., 2001; Schneier et al. 1994). For instance, individuals with social anxiety are more likely to have a job below their actual level of educational attainment, and to believe that their supervisors do not think they fit with the work environment (Bruch, Fallon, & Heimberg, 2003). Regarding epidemiological data, social anxiety has a lifetime prevalence of 12.1% and is the fourth most common psychopathological disorder (Kessler et al., 2005b).

Regarding cognitive models of social anxiety, both Clark and Wells (1995) as well as Rapee and Heimberg (1997) have posited that biased information processing, such as attentional bias for threatening stimuli, may play a critical role in the maintenance of the disorder.

At an empirical level for people with social anxiety, these threatening stimuli include threatening facial expressions displaying anger or disgust, and words signifying social threat (e.g., *stupid*, *ostracism*). In probe detection and probe discrimination tasks, two stimuli (words or images), of different valences, are simultaneously displayed either side of a fixation point (usually 50% each) on a computer screen. Following a brief stimulus presentation (traditionally 500 ms), the stimuli disappear and a probe (e.g., a dot, a letter, an arrow) appears in a location previously occupied by one of the stimuli. Participants are asked to identify as fast as possible on a button indicating whether the right or left stimulus (or top or bottom) had been replaced by a probe (i.e., a probe

detection task), or indicate the type of probe displayed (i.e., a probe discrimination task). Studies consistently reported that individuals with social anxiety or social phobia respond faster to probes replacing threatening cues than to probes replacing neutral cues, thereby exhibiting an attentional bias for threat that is absent in nonanxious control individuals (e.g., Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2004).

Recent studies have attempted to dismantle this attentional bias to identify which attentional orientation component underlies it. Hence, attentional bias in the dot probe task may be triggered by different mechanisms. For instance, is the threatening material more effective at capturing anxious participants' attention (fast attentional engagement to threat), or is a delayed disengagement from this material? Most of these studies have used the modified Posner (1980) spatial cueing task in which a single threat (or non-threat) cue appears on either the left or right side of a computer screen, followed by a probe that either replaces the cue or appears on the other side of the screen (e.g., Amir, Elias, Klumpp, & Przeworski, 2003). These studies have shown that socially anxious participants are no faster to respond to probes replacing threat than non-threat cues, but they are slower to respond to probes that appear opposite to threat cues relative to non-threat ones. This pattern of results suggests that socially anxious participants have difficulty disengaging attention from threat (e.g., Amir, et al., 2003), rather than being faster to engage attention to threat.

Attentional bias for threat has clinical consequences. Its re-emergence predicts the return of anxiety at follow-up among patients treated for generalized anxiety (Mogg, Bradley, Millar, & White, 1995) and social phobia (Lundh & Öst, 2001). Moreover, threat-related bias experimentally influences vulnerability to anxiety (MacLeod,

Rutherford, Campbell, Ebssworthy, & Holker (2002). Using a modified dot-probe detection task in which there was a contingency between cues and probes, MacLeod and colleagues trained non-anxious participants to attend either to neutral or to threatening stimuli. The task comprised 672 trials in which pairs of words (one threatening and one neutral) appeared on a computer screen. In the attend-to-threat condition, probes replaced threat words, whereas in the attend-to-neutral condition, probes replaced neutral words. Participants pushed a button as soon as they detected the probe. Relative to those trained to attend to neutral material, participants trained to attend to threat material reported more anxiety and negative mood after performing a stressful anagram task.

Over the last four years, based on the experimental rationale of MacLeod et al. (2002), several studies have examined the hypothesis that individual differences in attentional bias for threat can causally impact on the maintenance of social anxiety disorder. Regarding individuals with a primary diagnosis of generalized social anxiety disorder, Schmidt, Richey, Buckner, and Timpano (2009) have observed that training individuals to attend to neutral faces when simultaneously presented with threatening and neutral faces, led to a significant reduction in social anxiety and trait anxiety, in comparison to a control group. At a 4-month follow-up, the treatment group had improved further on measures of anxiety. Amir, Beard, Taylor, Klump, Elias, Burns, and Chen (2009) have replicated these results.

Regarding non-treatment seeking sample of high socially anxious individuals, Li, Tan, Quian, and Liu (2008) have observed that 7-days of attention training toward positive faces diminished attentional bias for negative faces. Moreover, this training reduced self-reported fear of social interaction. Further, using a probe discrimination task

before and after the training, they observed that attention training decrease attentional vigilance for threat. Similarly, Amir, Weber, Beard, Bomyea, and Taylor (2008) trained, in a single-session, individuals with speech anxiety. In a treatment condition, they had to attend to neutral faces, while in a control task, there were no contingency between probes and cues. As compared to the latter condition, the former reduced anxiety in response to an impromptu speech. Blind raters judged the speeches of those in the non-threat attention training group more positively than those of the control group. Further, using a modified Posner paradigm after attention training, these authors observed that the improvement in the ability to disengage attention from threat mediated the effects of the training on anxiety reactivity, and that this decrease in anxiety, in turn, improved speech performance.

However, although these clinical studies suggest that reducing attentional bias for threat diminishes anxiety, some recent data suggest that the efficacy and the reliability of the attention training procedure may be more complicated than it is commonly depicted. For instance, Boettcher, Berger, and Renneberg (in press) recently failed to replicate that attention training lead to more clinical improvement than the non-contingency placebo training. Moreover, participants who were trained to attend to non-threat did not show any change in attentional bias for threat.

Moreover, Hakamata et al. (2010) conducted a meta-analysis on 12 studies on attention training among social anxiety and generalized anxiety. They revealed a significant benefit of attention training on anxiety, with a medium effect size ($d = .61$, $p < .001$, 95% CI = .42-.81). They also estimated the fail-safe n to 54, thereby estimating to 54 the number of unpublished studies with effect sizes of zero needed to reduce the

aggregated effect below significance. However, it should be noted that, after the removal of three possible outliers with particularly large effect size (experiment 1 and 2 of Mathews & Macleod, 2002; Schmidt et al., 2009), the overall effect size is reduced but remains medium ($d = .36$, $p < .001$, 95% CI = .15-.57). Unfortunately, the estimated fail-safe n dropped to 7, suggesting that replications are clearly needed to establish the reliability of this effect.

Moreover, with the exception of the studies of the Amir's group (Amir et al., 2008; 2009), previous studies either included a probe discrimination task as an independent measure of attentional bias or did not integrate such measurement. As suggested by Yiend (2010), this task provides little information about the mechanisms behind the bias. Hence, attentional bias in the dot probe task may be triggered by different mechanisms. For instance, is the threatening material more effective at capturing anxious participants' attention (fast attentional engagement to threat), or is a delayed disengagement from this material, or a combination of both (e.g., Koster, Crombez, Verschuere, & De Houwer, 2004; 2006; Salemink, van den Hout, & Kindt, 2007). Moreover, most of these studies did not compute mediational analyses examining whether change in attentional biases mediated the impacts of attention training on symptoms change. As argued by MacLeod, Koster, and Fox (2009a, p.94), in order to strengthen the conclusion that symptoms change results from cognitive change elicited by the training, one should demonstrate that the magnitude of assessed symptoms change is related to the magnitude of observed cognitive change across individuals.

Considered together, the previous points suggest that some uncertainty abounds regarding the efficacy of attention training as a novel treatment for social anxiety. Using

an experimental design similar to previous attention training studies, the primary issue of the present paper was to ensure the reliability of these effects. Our main prediction was that training socially anxious individuals to attend to non-threatening stimuli would decrease maintenance of social anxiety symptoms. Further, we also predicted that attention training impacts on the ability to disengage attention from threat, and that improvement in this ability mediates the decreased in social anxiety.

3.2. Method

3.2.1. Participants

We recruited 36 individuals from a large university community. They were selected using the total score of the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987) that assesses a range of social interaction and performance situations that individuals with social phobia may fear and/or avoid. A total of 203 volunteers responded to our invitation to take part in an investigation of the mechanisms underlying vigilance among shy people (and therefore not as a therapeutic study). Individuals who were in the upper-quartile were invited to take part in the experiment; their characteristics are displayed in Table 1. We obtained written informed consent from each participant.

In addition, all participants had to fulfill several inclusion criteria: (a) no current substance abuse or dependency, (b) no current heart, respiratory, neurological problems or use of psychotropic medications, (c) no current psychological or psychiatric treatment and (d) normal or corrected-to-normal vision. Each participant was tested individually in a quiet room and all sessions were completed in the same laboratory. Participants

received compensation (5 euros and a lottery ticket) for their participation. The study conformed to the ethical standards of the American Psychological Association.

Table 1. *Participants' Characteristics and Changes in Self-reported Measures as a Function of Condition and Time (Standard Deviations in Parentheses).*

Measure	Attention Training Group		Control Training Group	
	Baseline	Post-training	Baseline	Post-training
BDI-II	15.29 (9.06)	14.24 (9.65)	13.32 (8.05)	11.53 (8.38)
STAI-Trait	54.12 (6.29)	50.71 (6.26)	53.37 (6.09)	55.11 (5.81)
LSAS	82.94 (12.60)	71.76 (13.68)	80.79 (15.32)	82.32 (17.10)
Age	21.00 (3.69)		20.47 (2.59)	
% of female	64.7 %		68.4 %	
Years of Education	15.31 (1.89)		14.53 (1.74)	
n	17		19	

Note. BDI-II is Beck Depression Inventory-II; STAI-T is Spielberger-Trait Anxiety Inventory; LSAS is Liebowitz Social Anxiety Scale.

3.2.2. Materials

Attention bias modification stimuli. We randomly selected 70 faces (35 men, 35 women) from the Karolinska Emotional Directed Faces database (Lundqvist, Flykt, & Öhman, 1998), which is a standardized set of emotional expressions. All picture were

adjusted to exclude interference if background stimuli (hair, clothing) so that only the face was presented. The faces displayed either threatening (i.e., disgust) or neutral facial expressions. An illustration is shown on Figure 1. We chose disgust faces as threat cues for several reasons. First, disgust conveys a message of aversion or rejection (e.g., Rozin, Lowery, & Ebert, 1994), a central concern of individuals with social phobia (American Psychiatric Association, 1994). Second, previous studies have found that socially anxious individuals exhibit an attentional bias toward disgust faces (Pishyar et al., 2004). Finally, previous studies supporting the effectiveness of attention training programs in reducing attentional bias towards threat cues in social anxiety have used faces expressing disgust as threatening stimuli. We thus used disgust faces to remain consistent with previous work.

Attention bias assessment stimuli. The stimuli used for the attention bias assessment task (modified Posner task) were eight social threat words (e.g., *stupid*, *humiliation*, *embarrassed*) and eight neutral words (e.g., *book*, *radiator*, *procession*). These proportions were based on previous studies on attentional bias in social anxiety (e.g., Amir et al., 2003). Words types were matched for frequency and usage in French (Lambert & Chesnet, 2001; New, Pallier, Ferrand, & Matos, 2001). There was no significant difference in word length between social threat and neutral words, $t(14) = .44$, $p = .67$, $d = .23$. We used words, rather than faces, in the assessment trials in order to show that the effects of training with one type of stimulus can be generalized to another type of stimulus.

3.2.3. Measures

Questionnaires. Participants were asked to complete the Trait-Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Beck Depression Inventory (BDI-II; Beck, Steer, and Brown, 1996) at the beginning of the first training session. Participants were selected according to their responses on the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987).

The STAI-Trait is a 20-item self-report questionnaire assessing anxiety trait vulnerability. Bruchon-Schweitzer and Paulhan (1993) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alphas in the current sample were .78 at baseline and .79 at post-training.

The BDI is a 21-item self-report measure of the symptoms of depression. Beck, et al. (1996) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alphas in the current sample were .87 at baseline and .91 at post-training.

The LSAS is a 24-item scale that measures the anxiety induced by, and the avoidance of, social interaction and performance situations. Yao et al. (1999) as well as Heeren, Maurage, et al. (in press) reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alphas in the current sample were .83 at baseline and .84 at post-training.

Measure of attention bias. For assessing the effects of training on attention to threat cues, participants were asked to complete an independent measure of attention bias at baseline and after training. We used a modified version of the Posner spatial cueing task very similar to that reported in Amir et al. (2003, 2008). Words were presented in lowercase white letters against a black background. Each word was 3.27° in width x .85°

in height. The target was 0.56° in width x 0.57° in height. The participants viewed the monitor at a distance of 60 cm.

Socially threatening or neutral cue words appeared in one of two locations on the computer screen (i.e., rectangles located to the right or left of a central fixation cross), thereby directing attention to one of two screen locations (i.e., right or left). After 600 ms, the cue word disappeared, and participants were instructed to detect a probe (“*”) that immediately appeared in one of the two locations. The probe remained onscreen until the participant responded, and response latencies were recorded from the onset of the probe to the button press. The inter-trial interval from the target offset to the next fixation cross was 1650 ms. On some trials, the cue word was valid (i.e., the probe appeared in the same location as the cue word). On other trials, the cue word was invalid (i.e., the probe appeared in the location opposite to the cue word).

Participants performed 192 experimental trials, two thirds of which were validly cued ($128 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions} \times 4 \text{ repetitions}$), one sixth were invalidly cued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$), and one sixth were uncued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$). The decision to use these proportions was based on previous research that used the same proportions (Stormark, Nordby, & Hugdahl, 1995). Trial order was randomized for each participant.

Participants completed four practice trials (including four neutral words) prior to the experimental trials. During the practice trials, participants received feedback regarding the accuracy of their response. Feedback was not provided during the experimental trials. In previous research using this task (e.g., Amir et al., 2003), socially anxious participants showed significantly longer response latencies on invalid cued social

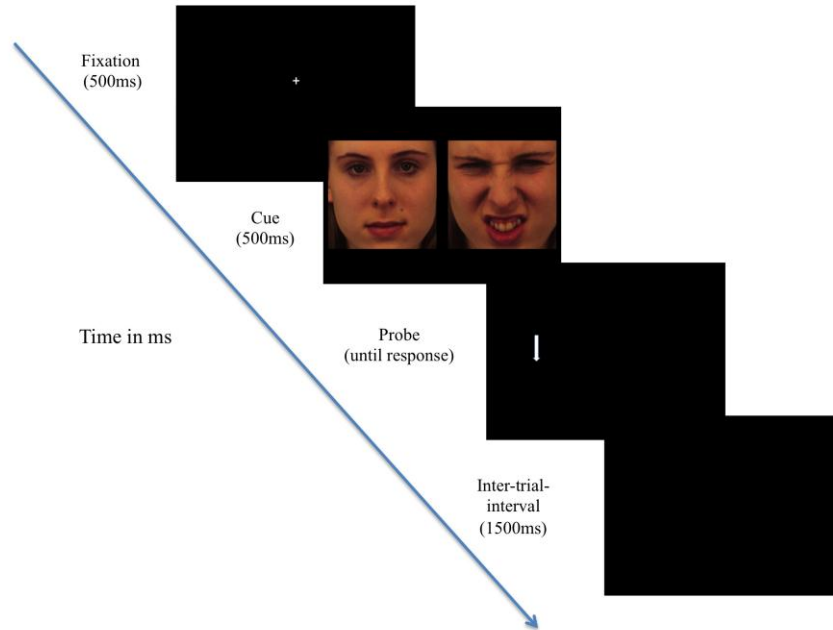
threat trials compared to non-anxious controls, suggesting that an attentional bias may be due to difficulty in disengaging from threatening stimuli.

3.2.4. Attention bias modification

Attentional bias was modified using a standard probe discrimination task, which was modified to train participants either to attend primarily to non-threat cues, or to attend equally to threat and neutral cues. For both conditions, a fixation cross appeared for 500-ms followed either by two facial expressions, a disgust face and a neutral face, presented for 500 ms. Then a probe appeared (i.e., a white arrow), pointing either up or down. The probe remained onscreen until the participant indicated the direction of the arrow by pressing the corresponding button. The inter-trial interval was 1500 ms. An illustration of the task is set on Figure 1.

In the attend-to-non-threat condition, a neutral and a threatening face appeared followed by an arrow in the location previously occupied by the non-threatening face on 95% of the trials. In the control condition, there was no contingency between the face cues and probes.

Figure 1. Trial depicting the sequence of the attention training task.



Participants completed 560 trials in one block. Each of the 70 threatening faces was presented four times, paired with a non-threatening face of the same individual, in positions that represented all combinations of the locations and probe types. This procedure was repeated 2 times (i.e., $560 = 70 \text{ stimuli} \times 2 \text{ positions} \times 2 \text{ arrow directions} \times 2 \text{ repetitions}$). The instructions were presented on the computer and were identical for both conditions. Each face was 9.69° in width $\times$ 7.10° in height. The target was 0.95° in width $\times$ 3.32° in height. The participants viewed the monitor at a distance of 60 cm.

3.2.5. General Procedure

The procedure consisted of two sessions of attention bias modification, including one day between the two sessions. Participants were randomly assigned to one of the two training conditions. Using a computerized randomization system, the participants and the experimenters were blind to condition. Participants first completed a demographic questionnaire and self-report assessment. Next, they completed the modified Posner spatial cueing task, which provided a baseline index of attention bias. Participants then completed the two attention-training sessions. After completing the training, participants again completed the modified Posner spatial cueing task to examine the influence of attention training on an independent measure of attention bias. Next, participants again filled in the self-report assessment. At the end of the procedure, participants were fully debriefed.

3.3. Results

3.3.1. Data Analyses

To assess for the effect of training on attentional bias, we computed a 2 (Groups: Attention training, Control training) x 2 (Time: Pre-training, Post-training) x 2 (Cue Validity: valid, invalid) x 2 (Word Type: threat, neutral) analysis of variance (ANOVA) with repeated measurement on the last three factors. Higher order interactions were followed up with simple lower order interaction and main effects as appropriate. To assess for changes in self-reported measurement, we computed separate 2 (Groups: Attention training, Control training) x 2 (Time: Pre-training, Post-training) ANOVAs with Time as a within-subject factor, Condition as between-subjects factor, and scores as the dependent variables. We followed up significant interactions with between and

within-group simple effects analyses (*t*-tests) as appropriate. For all analyses, we applied Greenhouse-Geisser corrections when necessary (Mauchley's Sphericity Test < .05).

3.3.2. Group Equivalence

Preliminary analyses indicated no differences among the groups at baseline on STAI-Trait, $t(34) = .76, p > .21, d = .24$, BDI-II, $t(34) = .69, p > .49, d = .24$, LSAS, $t(34) = .45, p > .65, d = .15$. Both groups were similar in terms of age, $t(34) = .50, p > .62, d = .17$, gender, $\chi^2(1, N = 36) = .06, p > .81$, and level of education, $\chi^2(1, N = 36) = 1.72, p > .42$. Data are displayed in Table 1.

3.3.3. Compliance monitoring of the training task

The output of the attention modification task was investigated to check compliance with the task instructions (errors and outliers). Participants made very few errors on the training task ($M = 1.04\%$, $SD = .21$) and there were few outliers, response latencies over 2.5 standard deviations below or above each participant's mean, ($M = 1.46\%$, $SD = .11$). Both conditions did not differ with regard to the number of erroneous responses or outliers (all $ps > .40$). Further, these results also suggest that participants were compliant to the attention modification task.

3.3.4. Independent measure of attentional bias

Data reduction. Before the main analyses, response latency data from the attention bias assessments were prepared following recommendations from Radcliff (1993). First, trials with incorrect responses were excluded (.52 % of the data). Second, latencies less than 100 ms or greater than 2000 ms were eliminated (.45% of trials with

correct responses). Third, response latencies over 2.5 standard deviations below or above each participant's mean were discarded as outliers (1.2 % of the remaining trials). At baseline, both groups did not differ significantly in error rates, $t(34) = .03$, $p > .97$, $d = .01$.

Change in attentional bias. The ANOVA revealed a significant Group x Time x Word Type x Validity interaction, $F(1, 34) = 8.33$, $p < .01$, $\eta_p^2 = .19$. To follow-up this four-way interaction, we computed separate Group x Time x Validity ANOVAs for social threat and neutral words. For the neutral words, the Group x Time x Validity interaction was not significant, $F(1, 34) = .22$, $p > .62$, $\eta_p^2 < .01$. For threat words, the three-way interaction was significant, $F(1, 34) = 15.53$, $p < .001$, $\eta_p^2 = .32$. To follow-up this interaction, we conducted separate Group x Time ANOVAs for valid and invalid threat trials. For valid trials, the interaction was not significant, $F(1, 34) = 0.02$, $p = .88$, $\eta_p^2 < .01$. For invalid threat trials, analyses revealed a significant Time x Condition interaction, $F(1, 34) = 29.83$, $p < .001$, $\eta_p^2 = .47$.

Although both groups did not differ in their performance at baseline, $t(34) = .54$, $p = .60$, $d = .18$, a comparison Student t -test computed on reaction times to threat invalid trials at post-training showed a significant difference between groups, $t(34) = 4.54$, $p < .001$, $d = 1.56$. Participants from the Control Condition showed no significant difference from baseline to after bias induction, $t(18) = 2.06$, $p = .07$. For participants from the Attention training condition, there was a significant decrease in reaction times for invalid threat trials from baseline to post-training, $t(16) = 6.66$, $p < .001$. Data are displayed in Table 2.

Table 2. Means of Response Latencies in milliseconds by Group on the Spatial Cueing Task (Standard Deviations in Parentheses).

Trials		Condition			
		Attention Training		Control Training	
Validity	Material	Baseline	Post-training	Baseline	Post-training
Valid	Neutral	364.95 (37.78)	326.72(40.38)	389.95 (50.01)	359.67 (67.71)
	Threat	368.97 (33.21)	335.53 (43.28)	387.15 (51.53)	350.73 (64.67)
Invalid	Neutral	421.42 (57.04)	411.01 (46.21)	423.19 (70.99)	432.14 (80.20)
	Threat	410.54 (46.73)	367.58 (44.32)*	421.43 (57.04)	442.45 (51.57)

Note. “*” indicates a significant difference between pre- and post- training in that group according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons.

* $p < .01$.

3.3.5. Self-report assessment

For the LSAS, analyses revealed a main effect of Time, $F(1, 34) = 16.20$, $p < .01$, $\eta_p^2 = .30$, as well as a significant Group x Time interaction, $F(1, 34) = 28.19$, $p < .01$, $\eta_p^2 = .41$. Although the groups did not differ in their scores at baseline, $t(34) = .46$, $p > .05$, $d = .02$, comparison Student *t*-tests computed on the score at post-training revealed a significant difference between groups, $t(34) = 2.05$, $p < .05$, $d = .70$. Participants from control training showed no difference from baseline to post-training, $t(18) = .77$, $p = .45$.

In contrast, participants who were in attention training condition reported a significant decrease in social anxiety from baseline to post-training, $t(16) = 9.37, p < .001$. Data are shown in Table 1.

For the STAI-Trait, analyses only revealed a significant Group $\times$ Time interaction, $F(1, 34) = 16.51, p < .001, \eta_p^2 = .33$. Although both groups did not differ in their score at baseline, $t(34) = .36, p > .71, d = .12$, a comparison Student t -test computed on their score at post-training showed a significant difference between groups, $t(34) = 2.19, p < .05, d = 0.75$. Further, participants from the Control Condition showed no significant difference from baseline to post-training, $t(18) = 2.00, p = .07$. For participants from the Attention training condition, there was a significant decrease Trait-anxiety from baseline to post-training, $t(16) = 3.69, p < .001$. Data are shown in Table 1.

For the BDI-II, the ANOVA only revealed a main effect of Time, $F(1, 34) = 10.66, p < .01, \eta_p^2 = .24$. The Group $\times$ Time interaction was not significant, $F(1, 34) = .70, p > .40, \eta_p^2 = .02$. For both conditions, scores decreased from baseline to post-training. Data are shown in Table 1.

3.3.6. Mediation Analyses

To examine whether the effects of the attention training task on change in self-reported assessment of anxiety were mediated by changes in the ability to disengage attention from social threat, we performed mediational analyses following the procedure of MacKinnon, Fairchild, and Fritz's (2007).

This procedure tests the product of the coefficients for the effects of (a) the independent variable (contrast coded: Attention training = +1, Control training = -1) to

the mediator (change in reaction times for invalid threat trials from pre-treatment to post-treatment) (alpha), and (b) the mediator to the dependent variable when the independent variable is taken into account (beta). This procedure is a variation of the Sobel (1982) test that accounts for the non-normal distribution of the alpha–beta path through the construction of asymmetric confidence intervals (MacKinnon et al., 2007).

First, we examined whether the impact of training condition on change in LSAS score was mediated by change in attention bias. Consistent with a statistically significant mediation, the 95% confidence interval of the indirect path (alpha–beta) did not contain zero (lower limit = .44, upper limit = 6.03). The same conclusion was supported by the results of the Sobel test, $Z = 2.11$, $p < .03$ (two-tailed). These results indicate that improvement in the ability to disengage attention from threat mediates the impacts of attention training on change in social anxiety score in LSAS.

Second, we examined whether the impact of training condition on change in STAI-trait score was mediated by change in attention bias. Inconsistent with a statistically significant mediation, the 95% confidence interval of the indirect path (alpha–beta) contains zero (lower limit = -0.83, upper limit = 1.47). The same conclusion was supported by the results of the Sobel test, $Z = .27$, $p = .79$ (two-tailed).

These findings are consistent with the hypothesis that attention training had an indirect effect on reduction in social anxiety through reduction in attention bias.

3.4. Discussion

The primary purpose of the present study was to replicate the effect of attention training among a non-treatment seeking sample of socially anxious individuals. Consistent with previous research (e.g., Amir et al., 2009; Li et al., 2008), participants trained to attend to non-threat cues reported reductions in self-reported social anxiety as well as trait-anxiety from baseline to post-training. Participants in the comparison condition showed no such reductions.

Consistent with our predictions, participants who were trained to attend-to-non-threat exhibited, after training, a significant reduction in latency for identifying probes during invalid threat trials. Those from the control training group showed no such reductions. As we mentioned above, previous work (e.g., Amir et al., 2003) showed that reaction time for invalid social threat is related to the capacity to disengage attention from socially threatening stimuli. We may therefore conclude that the processing bias may be modified by the experimental manipulation as intended. However, one cannot exclude that the attention training may or may not have trained disengagement of attention (versus training in not paying attention to the stimuli in the first place, thus no engagement to begin with and no need for disengagement). Future studies should further investigate this issue.

Furthermore, the present study included an independent measure of attention bias which is a spatial cueing task with words rather than a dot-probe task with faces and demonstrated that changes in attention generalized to a different measure of attention bias and to a different type of stimulus. This observation suggests that the experimental procedure exerts a general impact on the selective processing of the categories of information from which the present training stimuli were drawn. However, one could

speculate that there might have been even smaller differences in attentional bias for threat if the pre-post measure had involved face stimuli, since face stimuli might have been harder to disengage from (more potent than words). Future studies should further examine this possibility.

We conducted mediational analyses to address the second recommendation of MacLeod et al. (2009a) to evaluate the mediation of attentional change on the impact of attention training on symptom change. The results of these analyses are consistent with the notion that attention training has an indirect effect on social anxiety symptoms through decreased difficulty to disengage attention from social threatening stimuli. These observations support the conclusion that the self-reported anxiety change observed in this study can be attributed to the selective attentional processing elicited by the training. Hence, this finding converges with previous studies suggesting that the critical process of attention training in social anxiety may be the training of attentional disengagement from threat (Amir et al., 2008, 2009).

In relation to the cognitive models of social phobia, the present data support the notion that selective attention to threatening social stimuli may play a causal role in the maintenance of social anxiety (Clark, 1999; Clark & Wells, 1995; Rapee & Heimberg, 1997). Furthermore, Fox, Russo, Bowles, and Dutton (2001) propose that the ability to disengage from threat cues may serve as a protective factor from anxiety reactivity, whereas an inability to effectively disengage from threat may serve to maintain or increase anxiety. They postulate that the tendency to dwell on threat cues may contribute to maladaptive rumination. Consistent with these notions, the present data revealed that training socially anxious individuals to improve their ability to disengage from social

threat cues clearly led to a significant reduction in anxiety. Future research is needed to evaluate the possibility that the disengagement training is efficient because it disrupts maladaptive rumination.

At a clinical level, the present data are consistent with recent developments in cognitive bias modification (e.g., Hakamata et al., 2010) demonstrating that the attention bias for threatening stimuli can be manipulated and that these modifications are related to emotional changes. However, although the decrease is relatively small, it should be noted that depressive symptoms significantly decreased from baseline to post-training for both condition. With respect to the nature of these tasks, it could be that both conditions have improved a more general executive functioning, which is known to be involved in depressive symptoms (e.g., Castaneda, Tuulio-Henriksson, Marttunen, Suvisaari, Lönnqvist, 2008; Philippot & Brutoux, 2008). Further, it has been demonstrated that increasing executive functioning is related to decreased depressive symptoms (e.g., Baeken et al., 2009; Heeren, van Broeck, & Philippot, 2009). In the same vein, it should be noted that the decrease in STAI-Trait score from baseline to post-training in the control condition was marginally significant ($p = .07$). In striking contrast, there was no effect of the control training on social anxiety. Further, mediational analyses revealed that the indirect effect on reduction in social anxiety through reduction in attention bias only occurred for participants who were in the attention training condition. Considered together, that suggests that training to attend to non-threat faces more specifically impacted on social anxiety than on depressive symptoms or trait-anxiety.

The present study has limitations. First, we used a double-session design and did not collect follow-up data. As such, one cannot determine whether group differences

were long-lasting or simply a transient effect. Second, we used only self-reported measure of mood and anxiety. As MacLeod et al. (2009, p. 90-91) argued, attention-training-induced changes in selective information processing might exert an impact on self-report measures without actual changes in the symptoms of interest. In other words, induced changes in information processing might directly influence the decision-making processes underlying the formulation of responses to self-report assessment. It is to be noted that a few studies have shown that attentional training effects in social anxiety are not limited to self-report but that they extend to behavior responses (e.g., Amir et al., 2008). Future research should incorporate physiological and behavioral measures of anxiety. Finally, recent findings have pointed out that attention training is more effective following explicit instructions about the contingency between cues and probes (Krebs, Hirsch, & Mathews, 2010). Unfortunately, there was no such manipulation in the present paper and participants were not informed about the potential therapeutic nature of the training task, which prevents us to draw any conclusion on this question. However, at debriefing interview, a vast majority of the participants from ours studies who receive the contingency training reported that they believe they had been assigned to the non-contingency-training.

3.5. Rationale for the transition from Study 1 to Study 2

As we developed in the General Introduction, Hakamata et al. (2010) conducted a meta-analysis of 12 studies on attention training in population characterized by social anxiety or generalized anxiety. Their results suggest that replications are clearly needed to establish the reliability of the attention training effect. Further, some recent studies have failed to replicate the beneficial effects of attention training procedure (e.g., Boettcher, Berger, and Renneberg, in press; Reese et al., 2010; Van Bockstaele, et al., 2011b). Considered together, these findings raise doubt about the involvement of attentional bias for threat in the maintenance of anxiety disorder. Using an experimental design similar to previous attention training studies, one of the primary questions of the present dissertation was to ensure the reliability of these effects. Our main prediction was that training anxious individuals to attend to non-threatening stimuli should decrease anxiety symptoms. In Study 1, consistent with our prediction, we found that participants who were trained to attend-to-non-threat exhibited, after training, a significant reduction in latency for identifying probes during invalid threat trials. Those from the control training group showed no such reductions. These findings suggest that the impact of attention training on the malleability of attentional bias for threatening stimuli in social phobia is replicable.

However, no study to date has examined the adaptation of an attention training approach within a single-case design in a normal clinical setting. For practitioners, this issue is a decisive one. Indeed, although results from randomized controlled trials clearly suggest the efficacy of attention training for social phobia, a critical issue for attention

training research is to establish its efficacy beyond the laboratory. Such evidence would demonstrate that the clinical efficiency of attention training is not merely due to a statistical group effect. This last point is critical for therapist who would implement attention training in their practice. Thus, the present paper focuses on the malleability of attentional bias for threat in a single case compared to a matched normative sample of healthy controls. To be consistent with previous experimental works (e.g., See et al., 2009), we delivered the attention training at one session per day over 14 days. We predicted that attention training would result in improvements in attentional bias and mental health in a client currently experiencing social phobia.

Chapter 4

A Bayesian Case-controls Exploration of the Malleability of Attentional Bias for Threat in Social Phobia (Study 2)

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Abstract

Recent studies have demonstrated that training social phobics to attend to non-threat is related to short-term (Amir et al., 2008) as well as long term emotional changes (e.g., Schmidt et al., 2009). However, to date, no study has examined the adaptation of this attention bias modification procedure into a single-case design for clinical social phobia. Using an attention training procedure based on a modified dot-probe task, the present single-case study examined whether such procedure enabled a social phobic client to reduce attentional biases and to transfer this rehabilitation to daily functioning. Efficacy of the attention training was assessed at the cognitive, behavioral and ecological levels. Using a Bayesian probabilistic approach, case's performances were compared to a normative sample before, after the treatment, at a 2-month follow-up, at a 6-month follow-up, as well as one year after the treatment. The results suggested the efficacy of the rehabilitation program on the attentional bias for threat cues and the generalization of these beneficial effects to daily life during the two and six month follow-up. A significant decrease in both subjective and behavioral anxiety during speech performance was also observed. However, a set back of the clinical condition of the client was observed at the one year follow up.

Keywords: cognitive bias modification, social phobia, probe detection task, attentional bias, attention training, single-case

4.1. Introduction

Across recent years, evidence has accumulated that anxious individuals, regardless of their type of anxiety, appear to demonstrate attentional biases towards threat (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007). For people with social phobia, these cues include threatening facial expressions displaying anger or disgust, and words signifying social threat (e.g., *humiliation*). In probe detection and probe discrimination tasks, individuals with social anxiety or social phobia respond faster to probes replacing these cues than to probes replacing neutral cues, thereby exhibiting an attentional bias for threat that is absent in nonanxious control individuals (e.g., Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2004). Recent studies have attempted to dismantle this bias to identify which attention component underlies it. Most of these studies used the modified Posner (1980) spatial cueing task, in which a threat (or non-threat) cue appears on either the left or right side of a computer screen, followed by a probe that either replaces the cue or appears on the other side of the screen (e.g., Amir, Ellias, Klumpp, & Przeworski, 2003; Fox, Russo, Bowles, & Dutton, 2001). These studies show that anxious participants are not faster to respond to probes replacing threat than non-threat cues, but they are slower to respond to probes that appear opposite to threat cues relative to non-threat ones. This pattern of results suggests that anxious participants have difficulty disengaging attention from threat (e.g., Amir et al., 2003), rather than being faster to engage attention to threat.

Attentional bias for threat has clinical consequences. First, its re-emergence predicts return of anxiety at follow-up among patients treated for generalized anxiety

(Mogg, Bradley, Millar, & White, 1995) and social phobia (Lundh & Öst, 2001). Second, threat-related bias causally influences vulnerability to social anxiety (Heeren, Peschard, & Philippot, 2011). Such findings have led researchers to investigate whether experimentally reducing the attentional bias for threat (attention training) can reduce social anxiety. Based on the landmark study by MacLeod and colleagues (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002), researchers have used a modified version of the dot-probe paradigm (MacLeod, Mathews, & Tata, 1986) to experimentally reduce attentional bias for threat. In the original version of the dot-probe paradigm, participants viewed two stimuli (e.g., a threatening word/photograph and a neutral word/photograph) presented on a computer screen for approximately 500 ms. Immediately after the pictures had disappeared, a probe replaced one of the stimuli. Participants were requested to respond to the probe as quickly as possible. An attentional bias for threat is demonstrated when participants are faster to respond to the probe when it replaces a threatening stimulus than when it replaces a nonthreatening stimulus, thereby implying that the participant's attention was directed to the location occupied by the threatening stimulus. In attention training, researchers typically modify the original task so that the probe nearly always replaces the neutral stimulus, thereby redirecting subjects' attention to nonthreat cues.

Li, Tan, Qian, and Liu (2008) observed that, in comparison to a control condition, a 7 days of attention training toward positive faces diminished attentional bias for negative faces and reduced self-reported fear of social interaction in individuals with social phobia. Similarly, Amir, Weber, Beard, Bomyea, and Taylor (2008) compared socially phobic individuals who completed a single session of attention training toward

neutral faces to those who completed a control task in which there was no contingency between the probe and the cues. Relative to those who completed the control task, the individuals who underwent attention training reported reduced anxiety in response to an impromptu speech. Moreover, blind raters judged the speeches of those in the attention training group more positively than the speeches of those in the control group. Further, the authors found that changes in attentional biases for threat mediated the effects of the training on anxiety reactivity, and the decrease in anxiety, in turn, improved speech performance.

Likewise, Schmidt, Richey, Buckner, and Timpano (2009) observed that individuals with social phobia who completed eight sessions of attention training toward neutral faces over a 4-week period exhibited a significantly greater reduction in social anxiety and trait anxiety, when compared to individuals who completed a control condition. At a 4-month follow-up, the training group had improved further on measures of anxiety. Using a similar design, Amir, Beard, Taylor, Klump, Elias, Burns, and Chen (2009) recently replicated these results.

Taken together, these studies suggest that reducing attentional bias for threat can reduce social anxiety. However, no study to date has examined the adaptation of an attention training approach within a single-case design in a normal clinical setting. Regarding practitioners, this issue is a decisive one. Indeed, although results from randomized controlled trials clearly suggest the efficacy of attention training for social phobia, a critical issue for attention training research is to establish its efficacy beyond the laboratory. This observation should emphasize that the clinical efficiency of attention training is not merely due to a statistical group mean effect (i.e., the effect of attention

training may occur in low-powered statistical design). This last point is critical for therapist who would implement attention training in their practice. Thus, the present paper focuses on the malleability of attentional bias for threat in a single case compared to a matched normative sample of healthy controls. To be consistent with previous experimental work (e.g., See, MacLeod, & Bridle, 2009), we delivered the attention training at one session per day over 14 days. We predicted that attention training would result in improvements in attentional bias and mental health in a client currently experiencing social phobia.

4.2. Design and data analysis

An A-B design (Barlow & Hersen, 1984) with follow-up was implemented. During the baseline period, the therapist met the client weekly in order to administer and collect measures. Following baseline, attention training was delivered at one session per day over a 14-days-period. After the training, outcomes were assessed. Finally, the client returned to the clinical center two months, six months, and one year after the final training session for assessment of outcomes.

The statistical recommendations for single-case design of Crawford, Garthwaite, and Porter (2010) were followed. A statistical Bayesian approach was used. There has been an explosion of interest in Bayesian statistical methods over the last decades. The main reason of this is the development of numerical techniques, notably Markov Chain Monte Carlo (MCMC) methods that have solved many of the remaining computational problems formally associated with the application of Bayesian analyses. MCMC methods make inferences by generating a large number of observations from the distribution of the

data (for a review, see Andrieu, De Freitas, Doucet, &, Jordan, 2003). The essential difference between the classical and the Bayesian approaches is that the classical approach treats parameters as *fixed* but unknown whereas, in the Bayesian approach, parameters are treated as *random* variables and hence has probability distribution.

The single-case adaptation of Bayesian methods from Crawford and Garthwaite (2007) was used. First, this procedure provides a Bayesian hypothesis test. It estimates the probability that a member of the normative sample would exhibit a larger difference than the single case, in either direction. Second, this procedure also provides a point estimate of the effect size (Z_{CC}) for the difference between the case and the normative sample (Crawford, Garthwaite, & Howell, 2009). Finally, the Bayesian point estimate and 95% confidence interval for the abnormality of the case's score are reported. The point estimate of the abnormality of the case's score is the Bayesian estimated percentage of the normative sample that would obtain a score lower/higher than the case and the interval estimate quantifies the uncertainty over this percentage. Data analysis were made using SingleBayes_ES.exe (Crawford et al., 2010). This program implements Bayesian methods for comparison of a single case's score to scores obtained in a normative sample.

4.3. Participants

4.3.1. Case report

BJ was a right-handed 64-year-old woman, who is unmarried and lived alone in Belgium at the time of testing. She was a retired computer-engineer. At the time of

testing, she worked as a volunteer with mentally handicapped person. She came to the Psychology Department Emotional Consulting Center of the Université catholique de Louvain in Belgium with a complaint of fear of negative evaluation during social interaction and avoidance of social interaction. She had (a) no current substance abuse, (b) no current or past heart, respiratory, neurological problems, (c) no current or past use of psychotropic medications, (d) was not currently engaged in any form of psychological or psychiatric treatment, and (e) had corrected-to-normal vision. We obtained written informed consent for publishing her data.

4.3.2. Normative sample

In order to compare the performance of BJ to a normative sample, a matched group was constituted by pairing BJ to participants matched for age ($\pm$ 12 months), gender, education level as well manual laterality, but showing a low-level of social anxiety. We recruited 11 females. They were administrated the attention bias assessment task (see above), Trait Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), the Beck Depression Inventory (BDI-II; Beck et al., 1996), the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987), the Mini Mental State Examination (MMSE; Crum, Anthony, Basset, & Folstein, 1993), the Attention Self-Assessment (ASA; Coyette, Arno, Leclercq, Seron, Van der Linden, & Grégoire, 1999), and the Mini International Neuropsychiatric Interview (MINI; Lecrubier, Weiller, Bonora, Amorin, & Lépine, 1994). Their characteristics, as well as those of BJ, appear in Table 1. In addition to the absence of social phobia diagnostic, all participants: (a) had no current substance abuse, (b) no current or past heart, respiratory, neurological problems,

(c) no current or past use of psychotropic medications, (d) were not currently engaged in any form of psychological or psychiatric treatment, and (e) had normal or corrected-to-normal vision. Each participant was tested individually in a quiet room. Participants received compensation (12.5 euros and a lottery ticket) for their participation. We conducted the study in accordance with the ethical standards of the American Psychological Association. We obtained written informed consent from each participant.

4.4. Pre-rehabilitation assessment

4.4.1. Attention bias assessment

Materials. The stimuli used for the attention bias assessment task (modified Posner task) were eight disgust (four males and four females) and eight neutral facial expressions (four males and four females). They were selected from the Karolinska Emotional Directed Faces database (Lundqvist, Flykt, & Öhman, 1998), which is a standardized set of emotional expressions. All pictures were adjusted to exclude interference in background stimuli (hair, clothing) so that only the face was presented.

Measure of attention bias. For assessing the effects of training on attention to threat cues, BJ was asked to complete a measure of attention bias at baseline and after bias modification. We used a modified version of the Posner spatial cueing task with proportions identical to that reported in Amir et al. (2008). Faces were positioned 4 cm from the top/bottom of the screen, 8 cm from the ipsi-lateral edge, 22.5 cm from the contro-lateral edge, and centered vertically. Each face was 7.5 cm tall by 7.5 cm wide. Disgust or neutral faces appeared in one of two locations on the computer screen (i.e.,

rectangles located to the right or left of a central fixation cross), thereby directing attention to one of two screen locations (i.e., right or left). After 600 ms, the cue face disappeared, and participants were instructed to detect a probe (“*”) that immediately appeared in one of the two locations. The probe remained onscreen until the participant responded, and response latencies were recorded from the onset of the probe to the button press. The inter-trial interval from the target offset to the next fixation cross was 1650 ms. On some trials, the cue was valid (i.e., the probe appeared in the same location as the face). On other trials, the cue was invalid (i.e., the probe appeared in the location opposite to the cue face). Participants performed 192 experimental trials, two thirds of which were validly cued ($128 = 8 \text{ identities} \times 2 \text{ facial expressions} \times 2 \text{ positions} \times 4 \text{ repetitions}$), one sixth were invalidly cued ($32 = 8 \text{ identities} \times 2 \text{ facial expressions} \times 2 \text{ positions}$) and one sixth were uncued ($32 = 8 \text{ identities} \times 2 \text{ facial expressions} \times 2 \text{ positions}$). The decision to use these proportions was based on previous research that used the same proportions (Stormark, Nordby, & Hugdahl, 1995). Trial order was randomized for each participant. Participants completed four practice trials (including four neutral faces different from those used during the task) prior to the experimental trials. During the practice trials, participants received feedback regarding the accuracy of their response. Feedback was not provided during the experimental trials. Participants sat approximately 30 cm from the computer screen. In previous research using this task (e.g., Amir et al., 2003), socially anxious participants showed significantly longer response latencies on invalid cued social threat trials compared to non-anxious controls, suggesting that an attentional bias may be due to difficulty in disengaging from threatening stimuli.

4.4.2. Cognitive evaluation

To ensure that BJ does not show any general cognitive impairment, a cognitive formal testing was done. At the Mini Mental State Examination test (Crum, Anthony, Basset, & Folstein, 1993), assessing general cognitive processing (i.e., memory, spatio-temporal orientation, gnosis, praxia, and language), she scored 30/30 showing no difficulty. As shown in Table 1, there was no significant difference between BJ and the normative sample.

An ecological measurement of attentional functioning in everyday life, the Attention Self-Assessment (ASA; Coyette, Arno, Leclercq, Seron, Van der Linden, & Grégoire, 1999), was also administrated. The QAA contains 59 questions that assess different aspects of attention (processing speed, tonic alertness, focused attention, divided attention, vigilance, attentional slips, and questions about working memory quality) in everyday situations (e.g., conversation, watching television, reading, personal information). BJ scored 7/354, clearly indicating a good level of general attentional functioning. As shown in Table 1, there was no significant difference between BJ and the normative sample.

Table 1. *Descriptive characteristics of the single-case to normative controls.*

	Normative sample		Bayesian probability		Bayesian estimated percentage		Estimated effect size
	<i>M</i>	<i>SD</i>	Case's score	Probability (two-tailed)	Point	95% CI	<i>Z_{CC}</i>
Age	63.72	1.90	64	.89	55.48%	33.63 - 76.99	.15
Year of education	18.82	1.60	20	.50	75.19%	52.04 - 91.83	.74
BDI	9.82	1.60	10	.45	54.19%	31.46 - 75.91	.11
STAI-Trait	35.27	8.91	42	.24	75.69%	52.60 - 92.14	.76
ASA	9.09	4.42	7	.33	33.03%	13.87 - 56.51	.47
MMSE	20.91	.30	30	.39	61.02%	37.76 - 81.54	.30

Note. BDI = Beck Depression Inventory; STAI-Trait = Trait Anxiety Inventory; ASA = Attention Self-Assessment; MMSE = Mini Mental State Examination

4.4.3. Psychopathological self-report assessment

BJ completed the Trait Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983), the Beck Depression Inventory (BDI-II; Beck et al., 1996), the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987).

The STAI-Trait is a 20-item self-report questionnaire assessing anxiety trait vulnerability. Bruchon-Schweitzer and Paulhan (1993) have reported good psychometric and structural properties of the French adaptation of the scale. BJ scored 42/80, showing a low to medium level of anxiety. As shown in Table 1, there was no significant difference between BJ and the normative sample.

The BDI is a 21-item self-report measure of the symptoms of depression. Beck, Steer, and Brown (1998) have reported good psychometric and structural properties of the French adaptation of the scale. BJ scored 10/63, showing the presence of low-level depressive symptoms. As shown in Table 1, there was no significant difference between BJ and the normative sample.

The LSAS is a 24-item scale that measures the anxiety induced by, and the avoidance of, social interaction and performance situations. Yao et al. (1999) and Heeren et al. (in press) have reported good psychometric and structural properties of the French adaptation of the scale. BJ scored 97/144, showing a high-level of social anxiety. As shown in Table 2, there was a significant difference between BJ and the normative sample.

4.4.4. Semi-structured interview

BJ was also administered the Mini International Neuropsychiatric Interview (MINI; Lecrubier, Weiller, Bonora, Amarin, & Lépine, 1994), a semi-structured interview assessing DSM-IV (American Psychiatric Association, 1994) axis I disorders. One assessor administered the MINI to BJ and all control participants. He had over three years of CBT training and one year of intensive training on using the MINI to make reliable diagnoses. Responses of BJ on the MINI confirmed the current diagnosis of Generalized Social Anxiety Disorder. A second independent assessor with at least three years of CBT training rated a randomly selected portion of 40% of the interviews. A strict overlapping between the two ratings was observed.

4.4.5. Ecological measurement

Speech task. In order to assess ecological responses of fear evaluation, we administered a speech task to assess self-report and behavioral responses to a social stressor at baseline, post-training, and follow-up assessment. BJ and control participants began the task, sitting in a chair 30 cm from a computer screen. A set of instructions then appeared and displayed a list of five topics that were widely discussed in the national media at the time of data collection (i.e., global warming, the AH1N1 vaccination program, wearing of the Islamic veil in high-school, alcohol prohibition among minors, the come-back of a former Prime Minister on the national political scene). They were asked to choose one of the five topics. The next screen informed participants that they would have to make a 2-min speech about their chosen topic and that their performances would be video-recorded. They were given 2 minutes to prepare and a sheet of paper to write down their notes; however, they were told that they would not be allowed to use

these notes during the speech. After participants had prepared their speech, they were directed to stand in front of a video camera in another room. Just before starting the speech, the experimenter asked participants to rate their level of situational anxiety, from 0 (not anxious) to 100 (extremely anxious), using Subjective Units of Discomfort Scale (SUDS; Wolpe, 1958). The participant then performed the speech while being videorecorded. Speech performance was rated by two judges with at least three years of CBT training. Speech ratings were scored by the same raters at baseline, post-training, and follow-up. They were blind to clinical condition. The rating scheme was the Behavioral Assessment of Speech Anxiety (BASA; Mulac & Sherman, 1974), which includes 18 molecular categories (e.g., having a clear voice, searching for the words). The total score of these categories has shown excellent concurrent validity with experts' ratings of speech anxiety (Mulac & Sherman, 1974). Inter-rater reliability of the total score was high (BJ and controls, $r = .85$, $p < .05$), suggesting that a mean score of the two raters may be computed.

4.5. Treatment

4.5.1. Rationale

Attention training procedure was based on a standard probe discrimination task, which was modified to train participants to attend primarily to non-threat cues. A fixation cross appeared for 500-ms followed either by two facial expressions, a disgust face and a neutral face, presented for 500 ms. Then a probe appeared (i.e., a white arrow), pointing either up or down. The probe remained onscreen until the participant indicated the

direction of the arrow by pressing the corresponding button. The inter-trial interval was 1500 ms. The rationale was that a neutral and a threatening face appeared followed by an arrow in the location previously occupied by the non-threatening face on 95% of the trials.

BJ completed 560 trials in one block. Each of the 70 threatening faces was presented four times, paired with a non-threatening face of the same individual, in positions that represented all combinations of the locations and probe types. This procedure was repeated 2 times (i.e., $560 = 70 \text{ stimuli} \times 2 \text{ positions} \times 2 \text{ arrow directions} \times 2 \text{ repetitions}$). The instructions were presented on the computer and were identical for each session. Faces were positioned 4 cm from the top/bottom of the screen, 8 cm from the ipsi-lateral edge, 22.5 cm from the contro-lateral edge, and centered vertically. Each face was 7.5 cm tall by 7.5 cm wide.

The attentional training procedure lasted 14 days in total. Over that period, BJ completed a 40 minutes training session every day. The computer program was installed on a laptop computer and the training was realized at home.

4.5.2. Materials

We randomly selected 70 face pairs without hairlines (35 men, 35 women) from the Karolinska Emotional Directed Faces database (Lundqvist, Flykt, & Öhman, 1998), which is a standardized set of emotional expressions. There were different from those used during the assessment task. The faces displayed either threatening (i.e., disgust) or neutral facial expressions. We chose disgust faces as threat cues for several reasons. First, disgust conveys a message of aversion or rejection (e.g., Rozin, Lowery, & Ebert, 1994),

a central concern of individuals with social phobia (American Psychiatric Association, 1994). Second, previous studies have found that socially anxious individuals exhibit an attentional bias toward disgust faces (Pishyar et al., 2004). Finally, previous studies supporting the effectiveness of attention training programs in reducing attentional bias towards threat cues in social anxiety have used faces expressing disgust as threatening stimuli. We thus used disgust faces to remain consistent with previous work.

4.6. Results

4.6.1. Measure of attentional bias

Data reduction. Before the main analyses, response latencies from the attention bias assessment were prepared following recommendations from Radcliff (1993). First, trials with incorrect responses were excluded (2.12 % of the data). Second, latencies less than 100 ms or greater than 2000 ms were eliminated (.02% of trials with correct responses). Third, response latencies over 2 standard deviations below or above each participant's mean were discarded as outliers (less than .01 % of the remaining trials). At baseline, BJ did not differ significantly from the normative sample in error rates, $t(10) = .98$, $p = .35$ (two-tailed), nor in outliers, $t(10) = .07$, $p = .94$ (two-tailed).

Change in attentional bias. At baseline, as shown in Table 2, it was estimated that 94.81% of the control population would obtain latencies for invalid threat trials lower than BJ (95% CI = 80.28% to 99.78%). The score meets the criteria for a deficit; that is, the null hypothesis, that the score is an observation from the control population, is rejected ($p = .05$, one-tailed). There were no such differences between BJ and normative

controls regarding other type of trials. As mentioned above, reaction times for invalid threat trials is related to the capacity to disengage attention from threat.

At post-treatment, it was estimated that 22.38 % of the control population would obtain latencies for invalid threat trials lower than BJ (95% CI = 6.68% to 45.20%). Consistently, the null hypothesis, that the score is an observation from the control population, was not rejected ($p = .22$, one-tailed). Similar results were found at 2-month follow-up (Bayesian point estimate of percentage = 45.20, $p = .45$, one-tailed) and at 6-month follow-up (Bayesian point estimate of percentage = 53.27, $p = .47$, one-tailed). However, at one-year follow-up, it was estimated that 95.27% of the control population would obtain latencies for invalid threat trials lower than BJ (95% CI = 81.35% to 99.83%). The score meets the criteria for a deficit; that is, the null hypothesis, that the score is an observation from the control population, is rejected ($p < .05$, one-tailed).

Table 2. *Case-controls score on social anxiety measures.*

Normative sample			Bayesian probability			Bayesian estimated percentage		Estimated effect size
	<i>M</i>	<i>SD</i>	Time	Case's score	Probability (one-tailed)	Point	95% CI	<i>Z_{CC}</i>
LSAS	26.55	17.15	Baseline	97	< .01	99.85	98.72 – 100	4.11
			Post-training	59	.05	95.07	80.93 – 99.81	1.91
			2-month	54	.08	92.29	75.18 – 99.39	1.61
			6-month	49	.11	11.93	68.21 – 98.25	1.31
			1-year	81	< .01	99.40	95.41 – 99.99	3.20
BASA	28	17.96	Baseline	101	< .01	99.85	98.63 – 100	4.07
			Post-training	73	.02	98.13	89.59 – 99.99	2.51
			2-month	50	.13	86.59	66.05 – 97.72	1.22
			6-month	55	.09	90.97	72.83 – 99.09	1.50
			1-year	90	< .01	99.60	96.71 – 100.00	3.45
SUDS	15	7.07	Baseline	85	< .01	99.99	100 – 100	9.90
			Post-training	35	.01	98.90	92.78 – 99.99	2.83
			2-month	25	.10	89.72	70.77 – 98.76	1.41
			6-month	27	.07	93.24	76.98 – 99.56	1.69
			1-year	70	< .01	99.99	99.99– 100.00	7.78

Note. LSAS = Liebowitz Social Anxiety Scale; BASA = Behavioural Assessment of Speech Anxiety; SUDS = Subjective Units of Discomfort Units. A bold font emphasizes a significant difference between BJ and the normative sample.

Table 3. *Case-controls performance on the Posner Spatial Cueing Task.*

Normative sample			Bayesian probability		Bayesian estimated percentage		Estimated effect size	
Condition	<i>M</i>	<i>SD</i>	Time	Case's score	Probability (one-tailed)	Point	95% CI	<i>Z</i> _{CC}
Valid	628.08	198.71	Baseline	548.72	.40	35.52	15.75 – 58.94	.40
Neutral			Post-training	478.72	.24	24.42	7.92 – 47.50	.75
			2-month	499.72	.28	27.52	9.94 – 50.86	.65
			6-month	531.42	.33	32.58	13.54 – 56.06	.49
			1-year	581.32	.41	41.33	20.38 – 64.45	.24
Valid	18.82	1.60	Baseline	491.27	.21	21.22	6.01 – 43.86	.87
Disgust			Post-training	487.68	.21	20.75	5.75 – 43.31	.89
			2-month	501.29	.23	22.56	6.79 – 45.40	.82
			6-month	564.51	.32	32.22	13.27 – 55.69	.50
			1-year	541.27	.28	28.44	10.58 – 51.83	.87
Invalid	9.82	1.60	Baseline	777.19	.45	55.24	32.42 – 76.80	.14
Neutral			Post-training	491.27	.14	13.57	2.33 – 34.13	1.22
			2-month	590.78	.26	25.71	8.74 – 48.90	.71
			6-month	575.33	.24	23.71	7.48 – 46.71	.78
			1-year	630.19	.31	31.23	12.55 – 54.70	.53
Invalid	35.27	8.91	Baseline	884.42	.05	94.81	80.28 – 99.78	1.87
Disgust			Post-training	531.42	.22	22.38	6.68 – 45.20	.83
			2-month	662.67	.45	45.20	23.62 – 68.01	.13
			6-month	651.09	.47	53.27	30.64 – 75.13	.09
			1-year	892.23	.04	95.27	81.35 – 99.83	1.93

Note. A bold font emphasizes a significant difference between BJ and the normative sample.

4.6.2. Change in social anxiety

LSAS. At baseline, as shown in Table 3, it was estimated that 99.85% of the control population would obtain a score lower than BJ (95% CI = 98.72% to 100%). The score meets the criteria for a deficit; that is, the null hypothesis, that the score is an observation from the control population, is rejected ($p < .01$, one-tailed). Similar difference was found at post-treatment (Bayesian point estimate of percentage = 95.07, $p < .05$, one-tailed). At 2-month and 6-month follow-up assessments, the null hypothesis, that the score is an observation from the normative sample, was not rejected ($p > .05$, one-tailed). At one-year follow-up, however, the null hypothesis was rejected ($p < .01$, one-tailed).

Semi-Structured Interview. At baseline and post-treatment, BJ met the DSM-IV criteria of Specific Social Phobia on the MINI. At both 2-month-follow-up and 6-month-follow-up, she did not meet the criteria Specific Social Phobia. However, at one-year follow-up, she met the criteria.

4.6.3. Change in responses to ecological stressor

SUDS. As shown in Table 3, it was estimated that 99.99% of the control population would score lower than BJ and the null hypothesis, that the score is an observation from the control population, was rejected ($p < .05$, one-tailed). Similar difference was found at post-treatment (Bayesian point estimate of percentage = 98.90%, $p < .05$, one-tailed). However, at both 2-month and 6-month follow-up assessment, the null hypothesis, that the score is an observation from the normative sample, was not

rejected (respectively, $p = .10$ and $p = .07$, one-tailed). At one-year follow-ups, the null hypothesis was rejected ($p < .05$, one-tailed).

BASA. As shown in Table 3, it was estimated that 99.85% of the control population would obtain a score lower than BJ and the null hypothesis, that the score is an observation from the normative sample, was rejected ($p < .01$, one-tailed). Similar difference was found at post-treatment ($p < .02$, one-tailed). However, at both 2-month and 6-month follow-up, the null hypothesis, that the score is an observation from the normative sample, was not rejected ($p = .13$ and $p = .09$, respectively). Again, at one-year follow-ups, the null hypothesis was rejected ($p < .05$, one-tailed).

4.7. Discussion

The primary purpose of this study was to examine whether an attention training procedure could be successfully applied, in a regular clinical setting, for a client with social phobia. In accordance to our prediction, the results of this single-case study suggest that individuals who suffer from social phobia may benefit from an attention training procedure, at least up to six months post-treatment

First, as compared to the normative sample, BJ exhibited, after training, shorter latencies to identify probes during invalid threat trials. As mentioned above, previous works have shown that reaction time for invalid threat trials is related to the capacity to disengage attention from socially threatening word (e.g., Amir et al. 2003). We may therefore infer that training targeted the difficulty in disengaging attention from threat. This finding is consistent with previous account noting that difficulty in disengaging from

disgust face may play a causal role in the maintenance of clinical social phobia (e.g., Buckner, Maner, & Schmidt, 2010). Furthermore, the present design included an independent measure of attention bias which is a spatial cueing task rather than a dot-probe task. That demonstrated that changes in attention generalized to a different measure of attention bias and to a novel set of stimulus. This observation suggests that the training exerts a general impact on the selective processing of the categories of information from which the present training stimuli were drawn.

Second, our study showed that the attention training program had a beneficial effect transferred to some of the client's daily life situation. At 2-month and 6-month follow-up, significant improvement was evidenced in the ecological situation of speech (i.e., behavioral and subjective responses). BJ also reported that certain changes had taken place regarding her social anxiety, as disclosed in the LSAS score. In addition, regarding criteria of Social Phobia, the MINI semi-structured interview revealed the absence of DSM-IV diagnosis of Social Phobia at 2-month and 6-month follow-up. These findings revealed that, in the present case, improvement in the ability to disengage attention from threat first occurred, and that this beneficial effect then transferred to the client's daily life.

At a clinical level, this study adds to a small but growing empirical literature revealing the efficacy of computerized attention training procedures in reducing clinical symptoms in individuals who suffer from social phobia (Amir et al., 2008, Amir et al., 2009, Li et al., 2008; Schmidt et al., 2009). Although the extent of training is modest, totaling no more than a 30-minute period per day over 14 days, and minimal therapist contact, clinical benefits occurred on measures of subjective and behavioral anxiety

during a speech performance as well as on self-reported measures of social phobia. Further, the 6-month follow-up assessment revealed maintenance of these benefits. However, these benefits disappeared at one-year follow-up. One cannot exclude that environmental factors (e.g., events, stress, work) have engendered that return of fear. However, it should be noted that the present study is the first one including a follow-up assessment more than 4 month after treatment (e.g., Schmidt et al., 2009). In that way, it remains difficult to interpret the relapse of BJ at one-year follow-up. In order to solve this issue, future randomized controlled trials should include a one-year follow-up assessment. Future studies might also examine the benefit of including boosting sessions between the 6-month and the one-year follow-up.

Importantly, the convergence of the clinical measures across the different times of assessment should be noted. This finding is critical because it suggests that the benefits of attention training during the two and six month follow-up were not merely the mirror of error measurement or bias due to self-report assessment. In addition, consistent with a central tenet of several cognitive models of social anxiety that information-processing biases may cause the disorder, social anxiety symptoms decreased when attentional bias for threat disappeared and the relapse occurred when attentional bias reappeared. This latter observation is clearly consistent with previous account noting that the reemergence of attentional biases for threat after a behavioral therapy predicts the return of anxiety at follow-up among patients treated for generalized anxiety (Mogg et al., 1995) and social phobia (Lundh & Öst, 2001).

The present study has limitations. First, one cannot exclude that the improvement may be attributed to spontaneous recovery. Second, because of clinical

constraints, the person who administered the training was not blind to the hypothesis of the present study. We could therefore not completely protect against a Rosenthal effect (e.g., Rosenthal & Rosnow, 1997), that one's beliefs and expectations can have influence on the phenomenon under investigation. Finally, given recent evidence that anxious individuals, regardless of their type of anxiety, appear to demonstrate attentional biases towards threat (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007), future experiments should examine whether the result underlying the current study generalizes to other anxiety disorders.

In conclusion, the present findings suggested the efficacy of the rehabilitation program on the attentional bias for threat cues and the generalization of these beneficial effects to daily life during the two and six month follow-up. A significant decrease in both subjective and behavioral anxiety during speech performance was also observed. Although a set back of the clinical condition of the client was observed at the one year follow up, the present data suggest that attention training might be a suitable clinical intervention for clinical social phobia.

4.8. Rationale for the transition from Study 2 to Study 3

In Study 2, through an ABA single-case designed study, the efficacy of the attention training procedure was observed *in a treatment-seeking client with social phobia*. At 2-month and 6-month follow-up, significant improvement was evidenced in the ecological situation of delivering a speech (i.e., behavioral and subjective responses). The client also reported changes regarding her social anxiety, as disclosed in the self-reported measure of social anxiety. Regarding criteria of Social Phobia, the diagnostic interview revealed the absence of DSM-IV diagnosis of Social Phobia at 2-month and 6-month follow-up. However, these benefits disappeared at one-year follow-up. One cannot exclude that environmental factors (e.g., events, stress, work) have engendered that return of fear. Moreover, it should be noted that Study 2 is the first study including a follow-up assessment more than 4 month after treatment (e.g., Schmidt et al., 2009). In that way, it remains difficult to interpret the relapse at one-year follow-up. In order to solve this issue, future randomized controlled trials should include a one-year follow-up assessment. Future studies might also examine the benefit of including boosting sessions between the 6-month and the one-year follow-up.

Moreover, in Study 2, we have drawn attention to the important limitation that researchers have seldom included ecological measures of anxiety reduction. Further, as we pointed out in the General Introduction, researchers have seldom included behavioral measures of anxiety reduction and few have taken physiological measures of anxiety reduction. To our knowledge, only two studies have examined the effects of attention training on physiological responses to stressors. Measuring hormonal response,

Dandeneau et al. (2007), found that attention training lowered cortisol release in response to stress. However, this study was conducted among non-anxious participants. Further, the experimental manipulation of this study involved a procedure based on a visual search task rather than a dot-probe task. In contrast, Van Bockstaele et al. (2011b) did not find any effect of attention training on skin conductance and heart rate in response to pictures of spiders among spider phobics. It should be noted, however, that this study did not show effects of training on any other measures of anxiety.

Regarding social anxiety and generalized anxiety disorder, with the exception of some studies that included a behavioral measure of anxiety (e.g., Amir et al., 2008), researchers have relied on self-report measures and diagnostic interviews to assess the impact of attention training. As MacLeod et al. (2009a) argued, the completion of self-report measures involves judgment and inferences, giving rise to the possibility that a cognitive manipulation might affect questionnaire scores even when emotional experience itself is unaffected. Moreover, as Lang (1968; 1993) and Bradley and Lang (2000) have pointed out, emotional response is not only expressed through language. Emotions are expressed in three different responses systems: 1) overt behaviors, 2) language, and 3) physiological responses. To our knowledge, no previous studies on attention training in individuals with social anxiety disorder have included all three measures of Lang's three systems.

At a more fundamental level, uncertainty remains regarding the mechanisms that mediate the reduction of emotional vulnerability via attention training. In a recent study, Klumpp and Amir (2010) randomly allocated moderately socially anxious individuals to one of three different attention training conditions: (1) training to attend away from

threat, (2) attend to threat, or (3) a control condition in which there was no contingency between cues and probe. After a single-session of training, individuals who were trained to attend to threat and those trained to attend away from threat reported less anxiety in response to an impromptu speech compared to individuals in the control condition. Klumpp and Amir concluded that training in either direction (toward or away from threat) bolsters executive control in ways that may foster the ability to control's one anxiety. However, this study did not include behavioral or physiological measures of anxiety.

In Study 3, we randomly assigned individuals with social anxiety disorder to one of three conditions: 1) attend to positive stimuli, 2) attend to threat stimuli, or 3) attend to both in alternating blocks (a control condition). In the control condition, participants viewed alternating blocks of attend-to-threat trials and attend-to-positive trials. In addition, we assessed the effects of these procedures on self-report, behavioral, and physiological measures of anxiety.

If attention training works by correcting an attentional bias for threat, then only those participants who receive the attend to positive training should demonstrate reductions in anxiety on self-report, behavioral, and physiological measures. If, however, as Klumpp and Amir have argued, attention training is effective because of increased attentional control regardless of the direction of attention, then participants in either the attend to threat or attend to positive conditions should demonstrate reductions in anxiety on self-report, behavioral, and physiological measures whereas the subjects in the control condition should not.

Chapter 5

Attention Training Toward and Away from Threat in Social Phobia: Effects on Subjective, Behavioral, and Physiological Measures of Anxiety (Study 3)

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Abstract

Social phobics exhibit an attentional bias for threat in probe detection and probe discrimination paradigms. Attention training programs, in which probes always replace nonthreatening cues, reduce attentional bias for threat and self-reported social anxiety. However, researchers have seldom included behavioral measures of anxiety reduction, and have never taken physiological measures of anxiety reduction. In the present study, we trained individuals with generalized social phobia ($n = 57$) to attend to threat cues (attend to threat), to attend to positive cues (attend to positive), or to alternately attend to both (control condition). We assessed not only self-reported social anxiety, but also behavioral and physiological measures of social anxiety. Participants trained to attend to nonthreatening cues demonstrated significantly greater reductions in self-reported, behavioral, and physiological measures of anxiety than did participants from the attend-to-threat and control conditions.

Keywords: cognitive bias modification, social phobia, probe detection task, attentional bias, attention training, social anxiety.

5.1. Introduction

Most cognitive models of anxiety propose that selective attention to threat contributes to the development and maintenance of emotional disorders (e.g., Mathews & MacLeod, 1994). Indeed, individuals with social phobia, when compared to nonanxious controls, consistently demonstrate an attentional bias for threatening cues (e.g., facial expressions of anger or disgust, words such as *humiliation*) in probe detection and probe discrimination tasks (e.g., Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2004). Attentional biases for threat also decline following successful cognitive-behavioral treatment of social phobia (Pishyar, Harris, & Menzies, 2008). Moreover, the reemergence of attentional biases for threat predicts the return of anxiety at follow-up among patients treated for generalized anxiety (Mogg, Bradley, Millar, & White, 1995) and social phobia (Lundh & Öst, 2001). Such findings have led researchers to investigate whether experimentally reducing the attentional bias for threat (attention training) can reduce social anxiety. Based on the landmark study by MacLeod and colleagues (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002), researchers have used a modified version of the dot-probe paradigm (MacLeod, Mathews, & Tata, 1986) to experimentally reduce attentional bias for threat. In the original version of the dot-probe paradigm, participants viewed two stimuli (e.g., a threatening word/photograph and a neutral word/photograph) presented in two areas of a computer screen for approximately 500 ms. Immediately after the pictures disappeared, a probe replaced one of the stimuli. Participants responded to the probe as quickly as possible. An attentional bias for threat was demonstrated when participants were faster to respond to the probe when it replaced

a threatening stimulus than when it replaced a nonthreatening stimulus, thereby implying that the participant's attention was directed to the location occupied by the threatening stimulus. In attention training, researchers typically modify the original task such so that the probe nearly always replaces the neutral stimulus, thereby redirecting subjects' attention to nonthreat cues.

Li, Tan, Qian, and Liu (2008) observed that, in comparison to a control condition, 7 days of attention training toward positive faces diminished attentional bias for negative faces and reduced self-reported fear of social interaction in individuals with social phobia. Similarly, Amir, Weber, Beard, Bomyea, and Taylor (2008) compared socially phobic individuals who completed a single session of attention training toward neutral faces to those who completed a control task in which there was no contingency between the probe and the cues. Relative to those who completed the control task, the individuals who underwent attention training reported reduced anxiety in response to an impromptu speech. Moreover, blind raters judged the speeches of those in the attention training group more positively than the speeches of those in the control group. Further, the authors found that changes in attentional biases for threat mediated the effects of the training on anxiety reactivity, and the decrease in anxiety, in turn, improved speech performance. Likewise, Schmidt, Richey, Buckner, and Timpano (2009) observed that individuals with social phobia who completed eight sessions of attention training toward neutral faces over a 4-week period exhibited a significantly greater reduction in social anxiety and trait anxiety, when compared to individuals who completed a control condition. At a 4-month follow-up, the training group had improved further on measures

of anxiety. Using a similar design, Amir, Beard, Taylor, Klump, Elias, Burns, and Chen (2009) recently replicated these results.

Taken together, these studies suggest that reducing attentional bias for threat can reduce social anxiety. However, although some researchers have assessed the impact of attention training on anxiety by including behavioral measures of fear (e.g., Amir et al., 2008; Reese, McNally, Najmi, & Amir, 2010), few studies have addressed the effects of attention training on physiological measures of anxiety. To our knowledge, only two studies have examined the effects of attention training on physiological responses to stressors. Dandeneau, Baldwin, Baccus, Sakellaropoulou, and Pruessner (2007), measuring hormonal response rather than a traditional measure of psychophysiology, found that attention training lowered cortisol release in response to stress. In contrast, Van Bockstaele et al. (2011b) did not find any effect of attention training on skin conductance and heart rate in response to pictures of spiders among spider phobics. However, regarding social anxiety, with the exception of some studies which included a behavioral measure of anxiety (e.g., Amir et al., 2008) researchers have relied on self-report measures and diagnostic interviews to assess the impact of attention training on social anxiety. As MacLeod, Koster, and Fox (2009a) argued, the completion of self-report measures involves judgment and inferences, giving rise to the possibility that a cognitive manipulation might affect questionnaire scores even when emotional experience itself is unaffected. Moreover, as Lang (1968; 1993) and Bradley and Lang (2000) have argued, emotional response is not only expressed through language. Emotions are expressed in three different responses systems: 1) overt behaviors (e.g., avoidance), 2) language (i.e., self-report measures), and 3) physiological responses (e.g., skin conductance). To our

knowledge, no previous studies on attention training in individuals with social anxiety disorder have included all three measures of Lang's three systems.

Further, at a more fundamental level, uncertainty remains regarding the mechanisms that mediate the reduction of emotional vulnerability via attention training. In a recent study, Klumpp and Amir (2010) randomly allocated moderately socially anxious individuals to one of three different attention training conditions: (1) training to attend away from threat, (2) attend to threat, or (3) a control condition in which there was no contingency between cues and probe. After a single-session of training, individuals who were trained to attend to threat and those trained to attend away from threat reported less anxiety in response to an impromptu speech compared to individuals in the control condition. Klumpp and Amir concluded that training in either direction (toward or away from threat) bolsters executive control in ways that may foster the ability to control's one anxiety. However, this study did not include behavioral or physiological measures of anxiety.

In the present double-blind experiment, we randomly assigned individuals with social anxiety disorder to one of three conditions: 1) attend to positive stimuli, 2) attend to threat stimuli, or 3) attend to both in alternating blocks (a control condition). In the control condition, participants viewed alternating blocks of attend-to-threat trials and attend-to-positive trials. We assessed the effects of these procedures on self-report, behavioral, and physiological measures of anxiety.

If attention training works by correcting an attentional bias for threat, then only those subjects who receive the attend to positive training should demonstrate reductions in anxiety on self-report, behavioral, and physiological measures. If, however, as

Klumpp and Amir have argued, attention training is effective because of increased attentional control regardless of the direction of attention, then subjects in either the attend to threat or attend to positive conditions should demonstrate reductions in anxiety on self-report, behavioral, and physiological measures whereas the subjects in the control condition should not.

5.2. Method

5.2.1. Overview and General Procedure

Participants came to the laboratory for six visits. At the baseline visit, participants completed two self-report measures of social anxiety, a probe discrimination task that assessed attentional bias for threat, and a stressful speech task during which we recorded behavioral and physiological responses. We then randomly assigned participants to receive one of the three attentional training conditions: Attend to threat stimuli, attend to positive stimuli, or control. Neither the participant nor the experimenter was aware of the assigned training condition. Each training was delivered in 4 sessions over 4 consecutive days. Immediately after the final training session, participants repeated the assessment of self-reported social anxiety, the probe discrimination task, and the stressful speech task. Finally, participants returned to the laboratory two weeks after the final training session for assessment of self-reported social anxiety and debriefing.

5.2.2. Participants

We recruited 60 Caucasian individuals with a primary DSM-IV (American Psychiatric Associations, 1994) diagnosis of Generalized Social Phobia from the Université Catholique de Louvain community. A total of 213 volunteers responded to our invitation to take part in an investigation of the mechanisms underlying social interaction among shy people. As shown in Figure 1, 78 individuals met the initial eligibility criteria as assessed via a screening questionnaire and subsequently completed a structured interview to assess diagnostic eligibility. To confirm the diagnosis of Generalized Social Anxiety Disorder, we administered the social phobia section of the Mini International Neuropsychiatric Interview (MINI; Lecrubier, Weiller, Bonora, Amarin, & Lépine, 1998). One assessor administered the MINI to all participants. He had over three years of CBT training and one year of intensive training on using the MINI to make reliable diagnoses. A second independent assessor with at least three years of CBT training rated a randomly selected portion of the interviews (25%). Inter-rater agreement for the diagnosis was good ($\kappa = .86$). Fifteen of the 78 pre-selected volunteers did not meet criteria for social phobia and 3 refused to participate. The remaining 60 participants were included in the study; their characteristics appear in Table 1. In addition to a primary diagnosis of Generalized Social Anxiety Disorder, all participants: (a) had no current substance abuse, (b) no current or past heart, respiratory, neurological problems, (c) no current or past use of psychotropic medications, (d) were not currently engaged in any form of psychological or psychiatric treatment, and (e) had normal or corrected-to-normal vision. Each participant was tested individually in a quiet laboratory room. Participants received compensation (12.5 euros and a lottery ticket) for their participation. We conducted the study in accordance with the ethical standards of the

American Psychological Association. We obtained written informed consent from each participant.

5.2.3. Measures

Questionnaires. To characterize our participants, we asked them to complete the Trait Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Beck Depression Inventory (BDI-II; Beck Steer, & Brown, 1996) at the beginning of the first training session.

The STAI-Trait is a 20-item self-report questionnaire assessing anxiety proneness. Bruchon-Schweitzer and Paulhan (1993) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .89.

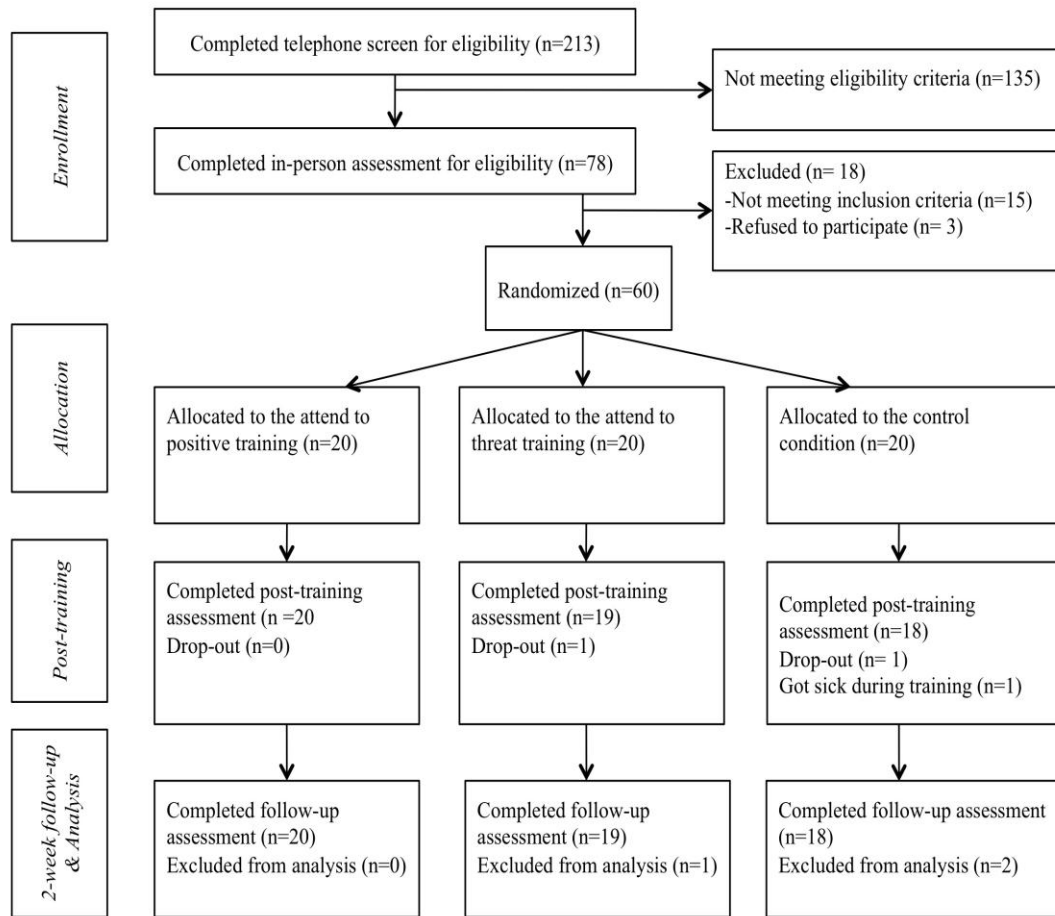
The BDI is a 21-item self-report measure of symptoms of depression. Beck et al. (1996) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .84.

Participants completed two self-report scales of social anxiety at baseline, post-training, and follow-up: the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987) and the Fear of Negative Evaluation scale (FNE; Watson & Friend, 1969). The LSAS is a 24-item scale that measures anxiety and avoidance of social interaction and performance situations. Yao et al. (1999) have reported good psychometric properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .91.

Table 1. *Participants Characteristics as a Function of Group Allocation (Standard Deviations in Parentheses).*

	Attend to Threat	Attend to Positive	Control
Age	22.16 (3.82)	22.00 (3.24)	21.44 (2.23)
% female	68.4%	50.0%	61.1%
Years of Education	15.94 (1.39)	15.78 (1.06)	16.22 (1.00)
BDI-II	11.37 (4.42)	9.80 (3.31)	9.50 (5.27)
STAI-T	33.52 (10.46)	28.70 (7.23)	34.00 (7.17)
FNE	22.68 (3.42)	22.55 (2.59)	23.50 (4.50)
LSAS	80.47 (18.70)	82.10 (18.16)	79.50 (18.44)

Note. Attend to Threat = training to attend to threatening material; Attend to Positive = training to attend to positive material; Control = alternating training to attend toward positive and threatening material; BDI-II is Beck Depression Inventory-II, STAI-T is Spielberger State-Trait Anxiety Inventory-Trait, FNE is Fear of Negative Evaluation scale; LSAS is Liebowitz Social Anxiety Scale.

Figure 1. *Flowchart depicting passage of participants through the study.*

The FNE is a 30-item self-report questionnaire that measures a person's apprehension about negative evaluation. Studies have reported good psychometric properties as well as structural validity of the French adaptation of the scale (Douilliez, Baeyens, & Philippot, 2008; Musa, Kostogianni, & Lépine, 2004). Cronbach's alpha in the current sample was .93.

Measure of attention bias for threat: Probe discrimination task. Participants completed a probe discrimination task modeled on the dot-probe detection task (MacLeod et al., 1986) at baseline and post-training. The task consisted of 96 trials delivered in one block. Each trial began with a central fixation cross which appeared on the screen for 500 ms. Immediately following the disappearance of the cross, a pair of faces appeared on the screen for 500 ms. One face appeared to the left of center screen, whereas the other face appeared to the right of center screen. Immediately following their disappearance, a probe (i.e., white arrow), pointing either up or down, replaced one of the faces. The probe remained on the screen until the participant indicated the direction of the arrow by pressing by a button. The inter-trial interval was 1500 ms. An attentional bias for threat was demonstrated by a significantly faster response when the probe appeared in the location previously occupied by a threatening face than when the probe appeared in the location previously occupied by a positive face. There were an equal number of trials in each condition as a function of emotional face location (left or right) and probe type (up or down arrow). Stimuli consisted of 24 face pairs generated from the FaceGen Modeller (Singular Inversions Inc, 2008) as described in the materials section (see below) and different from those used during the training procedure. The

same face pairs were used at baseline and at post-training. Each of the 24 face pairs appeared four times representing all combinations of the locations and probe types (96 trials = 24 faces pairs x 2 positions x 2 arrow directions). The same pairs of faces appeared in a different random order for each participant. Participants completed eight practice trials (including four men and four women neutral face pairs) prior to the experimental trials. During the practice trials, participants received feedback regarding the accuracy of their response. No feedback occurred during the experimental trials. Participants sat approximately 30 cm from the computer screen.

Speech task. We administered a speech task to assess self-report, behavioral, and physiological responses to a social stressor at baseline and post-training. Each participant began the task sitting in a comfortable chair 30 cm from a computer screen. We then attached the skin conductance electrodes and asked the participant to read the instructions that appeared on the screen. The first instruction read, “Calmly rest until another slide occurs” and appeared on the screen for 1 minute. Skin conductance was recorded during this 1 min baseline. The second set of instructions then appeared on screen and informed participants that they would have to make a 2-minute speech about a negative emotional experience and that their performance would be video recorded. Two different topics (a negative experience with a friend or a negative academic experience) were randomly counterbalanced between times of assessment. This instruction remained on the screen for 2 minutes and skin conductance was recorded during this time. The final set of instructions then appeared on the screen, asking the participant to wait for the experimenter. The experimenter then directed participants to stand in a designated area, in another room, in front of a video camera. Just before the speech, the experimenter

asked participants to rate their level of situational anxiety from 0 (not anxious) to 100 (extremely anxious) (Subjective Units of Discomfort Scale [SUDS]; Wolpe, 1958). The participant then performed the speech while being videorecorded.

Physiological response. Skin conductance reactivity (SCR) was measured with two Ag-AgCl electrodes attached to the volar surfaces of the medial phalanges of the middle and ring fingers of the nondominant hand. Grass skin conductance paste (with the recommended 0.05-M NaCl saturation; Grey & Smith, 1984) was the electrolyte. We used a BIOPAC MP150 unit running Acqknowledge 4.0.0 software (Biopac Systems, 2008) with one SCR 100B amplifier to collect SCR data. The SCR amplifier had a sensitivity of 5 $\mu\text{ohm/V}$, with a 10-Hz low-pass filter and a 0.05-Hz high-pass filter. Choice of electrode attachment and sampling was based on published research guidelines for skin conductance recording (Dawson, Schell, & Fillion, 1990).

SCR amplitudes were scored by subtracting the lowest from the highest value in the time window between one and one hundred-twenty seconds after the onset of the slide instructing participants that they would have to give a 2-min speech in front of video-camera. Choice of using this subtractive method, and therefore amplitude score, was based on published research guidelines for SCR (e.g., Kozak, Foa, & Steketee, 1988; Dawson et al., 1990). The Acqknowledge data file was scanned for movement or other artifacts. If a clear artifact was found, these data were omitted from analyses. In addition, for each participant, negative scores, which only occurred in less than 0.01% of the data, were taken as non-responses and, as recommended by Dawson et al. (1990), were set to 0.01.

Behavioral assessment. Speech performance was rated by two judges with at least three years of CBT training. Speech ratings were scored by the same raters at baseline and post-training. They were blind to training condition. The rating scheme was the Behavioral Assessment of Speech Anxiety (BASA; Mulac & Sherman, 1974), which includes 18 molecular categories (e.g., having a clear voice, searching for the words). The total score of these categories has shown excellent concurrent validity with experts' ratings of speech anxiety (Mulac & Sherman, 1974). Inter-rater reliability of the total score was high ($r = .81$, $p < .01$ at baseline; $r = .78$, $p < .01$ at post-training), suggesting that a mean score of the two raters may be computed. Internal consistency of the data in our study was good ($\alpha = .75$ at baseline; $\alpha = .79$ at post-training).

Attention training. Attention training consisted of the probe discrimination task described above, modified to promote either: (1) an attentional bias toward positive stimuli (AP), (2) an attentional bias toward threat stimuli (AT), or (3) both (i.e., a control condition that alternated between positive and threat). In the AP condition, the arrow appeared in the location previously occupied by the positive face on 80% of the trials. In the AT condition, the arrow appeared in the location previously occupied by the threatening face on 80% of the trials. In the control condition, two blocks of differing trial types (no break between blocks) were alternated. In the first block, the probe replaced the threatening face in 80% of the trials and the positive face in 20% of the trials. In the second block, the probe replaced the threatening face in 20 % of the trials and the positive face in 80 % of the trials. For each session, the switch occurred four times (i.e., after every 186 trials).

Participants completed 744 trials, delivered without break, per training session. Sixty-two threatening faces were paired with a positive face of the same individual (see Materials section below for details). Each pair was presented four times, representing all combinations of the locations and probe types, and this procedure was repeated 3 times (i.e., $744 = 62 \text{ face-pairs} \times 2 \text{ positions} \times 2 \text{ arrow's directions} \times 3 \text{ repetitions}$). Groups were exposed to the same face pairs although the order of presentation was randomly determined for each subject. The training task lasted around 40 minutes.

5.2.4. Materials

Eighty-six pairs of faces were used in the dot-probe testing and in the attention training tasks. The face pairs were created with FaceGen 3.1 software (Singular Inversions Inc., 2008) that is based on statistical modeling of a sample of real faces varying in ethnicity, age, and gender. To model faces, the software uses more than 100 dimensions, such as eye, mouth, or lip size. We generated 20 angry faces for both genders and for three ethnic groups (Caucasian, African, and Asian), resulting in 120 faces. We pretested these threatening faces (on a scale from *1 = absolutely not threatening* to *9 = absolutely threatening*) on 19 college students. We selected the 86 faces expressing anger most clearly. Among the selected faces, there were no ethnic group or gender differences in anger ratings.

We then generated positive stimuli by duplicating each angry face and manipulating the facial features to possess a 40% level of closed smile expression. We used mildly smiling faces because socially anxious individuals tend to interpret neutral faces as threatening (e.g., Somerville, Kim, Johnstone, Alexander, & Whalen, 2004;

Yoon & Zinbarg, 2008). We pretested these positive faces (on a scale from 1 = *absolutely not threatening* to 9 = *absolutely threatening*) on 17 college students. Pretest data confirmed that these faces were rated as positive.

Each face pair consisted of the same individual displaying either an angry or a light smile expression. Each picture was 11 cm high and 7.6 cm wide. Faces were separated by 11.5 cm from their centers. All stimuli appeared against a black background.

Regarding the percentage of faces from each race, for attention training: 49.33 % of the faces were Caucasian, 29.33% were African, and 21.33% were Asian. For the probe discrimination task: 51.62% were Caucasian, 22.58% were African, and 25.80% were Asian. Examples of faces used in the experiment are shown in Figure 2.

Figure 2. *Example of angry (100% angry; left) and happy (i.e., a 40% level of closed smile expression; right) faces used in the experiment.*



5.2.5. Data Analyses

To assess for changes in self-reported anxiety, we computed separate 3 (Time: baseline, post-training, follow-up) x 3 (Condition: AP, AT, Control) ANOVAs with Time as a within-subject factor, Condition as between-subjects factor, and LSAS and FNE scores as the dependent variables. We applied Greenhouse-Geisser corrections when necessary (Mauchley's Sphericity Test < .05). To assess for the effect of training on attentional bias and response to the stressful speech task, we computed separate 2 (Time: baseline, post-training) x 3 (Condition: AT, AP, Control) ANOVAs with Time as a within-subjects factor, Condition as a between-subjects factor, and reaction time in the probe-discrimination task, as well as subjective, behavioral, and physiological measures of emotional reactivity during the speech task as the dependent variables. We used Scheffe post-hoc tests to probe interactions.

5.3. Results

We lost three participants, one from the AT condition and two from the control condition. The AT participant and one control participant dropped out without explanation, whereas the other control participant got sick during training. All statistical analyses were conducted on the 57 remaining participants ($n_{AP} = 20$, $n_{AT} = 19$, $n_{Control} = 18$). Three participants (one from the AT condition and two from the AP condition) missed one training session. They were included in the analyses, but the number of training sessions was included as a covariate in all analyses.

5.3.1. Preliminary Analyses

There were no significant baseline differences among the groups on STAI-trait anxiety, $F(2, 56) = 1.85, p = .17, \eta_p^2 = .07$, symptoms of depression as measured by the BDI-II, $F(2, 56) = .99, p = .37, \eta_p^2 = .04$, or symptoms of social phobia as measured by the LSAS, $F(2, 56) = .06, p = .94, \eta_p^2 < .01$, and the FNE, $F(2, 56) = .37, p = .69, \eta_p^2 = .01$. Groups were similar in terms of age, $F(2, 56) = .28, p = .75, \eta_p^2 = .01$, gender, $\chi^2(2, N = 57) = 1.39, p = .49$, and years of education, $F(2, 56) = .69, p = .50, \eta_p^2 = .03$.

5.3.2 Independent measure of attentional bias: probe discrimination task

Data reduction. Latencies from trials with errors were excluded (less than 2 % of the data). Responses more than two standard deviations below or above the participant's mean were discarded as outliers (less than 1 % of the data). At baseline, the groups did not differ significantly in error rates, $F(2, 56) = .49, p = .62, \eta_p^2 = .01$. Similarly, groups did not differ significantly in error rates at post-training, $F(2, 56) = .31, p = .74, \eta_p^2 = .01$. Consistent with MacLeod and Mathews (1988), we calculated a d (or bias) score for each participant by subtracting the mean latency when the probe appeared in the same location as the threatening face from the mean latency when the probe and threatening face appeared at different locations (see Table 2). A positive bias score indicates faster detection of probes replacing threatening faces (i.e., attentional bias for threat). To test for group differences before training, we conducted a one-way ANOVA on the d values. Results indicate no significant differences between groups at pre-training, $F(2, 56) = .11, p = .89, \eta_p^2 < .01$. In addition, to test for an attentional bias for threat before training, we computed, for each group, separate one-sample- t -tests testing whether the d score at

baseline significantly differed from 0 (i.e., no attentional bias). Each group exhibited an attentional bias for threat at baseline [AT group: $t(18) = 2.31, p < .05$; AP group: $t(19) = 4.76, p < .01$, Control group: $t(17) = 1.91, p < .05$].

Change in attentional bias. The ANOVA revealed a significant Time x Condition interaction, $F(2, 53) = 8.08, p < .01, \eta_p^2 = .23$. Although the groups did not differ in their scores at baseline, a one-way ANOVA computed on the score at post-training revealed a significant difference among the groups, $F(2, 56) = 41.42, p < .01, \eta_p^2 = .61$. Scheffe post-hoc tests revealed that the AP group exhibited significantly less attentional bias for threat than did both the AT and Control groups, whereas there was no significant difference between the AT and Control groups. To examine within-subject effects, we ran follow-up paired-samples t tests on each group separately. In the AT condition, there was no significant change in attentional bias for threat from baseline to the post-training, $t(18) = .18, p = .86$. In the Control condition, there was no significant change in attentional bias for threat from baseline to the post-training, $t(17) = 1.12, p = .28$. In the AP condition, there was a significant decrease in attentional bias for threat from baseline to post-training, $t(19) = 8.38, p < .01$.

Table 2. Means of Probe Discrimination Latencies (in ms) and Attentional Bias Scores as a Function of Condition and Time (Standard Deviations in Parentheses).

	Attend to Threat		Attend to Positive		Control	
	Baseline	Post-training	Baseline	Post-training	Baseline	Post-training
Probe in locus of threat	563.28 (111.11)	442.15 (45.68)	563.30 (64.17)	415.76 (32.74)	567.78 (72.38)	444.94 (28.74)
Probe in locus of positive	532.78 (85.69)	408.92 (45.43)	534.61 (51.83)	438.08 (29.49)	544.45 (66.78)	406.15 (16.92)
Attentional bias score	30.50 (57.47)	33.28 (23.32)	28.71 (26.97)	-22.33 (13.53)*	23.34 (51.75)	38.79 (29.71)

Note. Attend to Threat = training to attend to threatening material; Attend to Positive = training to attend to positive material; Control = alternating training to attend toward positive and threatening material; Attentional bias score = the mean latency when the probe appeared in the same location as the threatening face from the mean latency when the probe and threatening face appeared at different locations. A positive bias score indicates faster detection of probes replacing threatening faces (i.e., attentional bias for threat). “*” indicates a significant difference between pre- and post-training in that group according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons.

* $p < .01$.

In addition, to further examine change in attentional bias for threat after the training, we computed separate one-sample-*t*-tests for each condition testing whether the *d* score at post-training significantly differed from 0 (i.e., no attentional bias). For both the AT and Control groups, the attentional bias persisted at post-training [AT group: $t(18) = 6.22, p < .01$, Control group: $t(17) = 5.53, p < .01$]. In striking contrast, the AP group exhibited an attentional bias for positive faces at post-training, $t(19) = -7.38, p < .01$. Data appear in Table 2.

5.3.3. Self-reported measures of Social Anxiety

For the LSAS, the ANOVA only revealed a significant Time x Condition interaction, $F(4, 106) = 5.04, p < .01, \eta_p^2 = .16$. Scheffe post-hoc tests revealed that, at post-training, both AP and Control participants reported significantly less anxiety than AT participants did, but there was no significant difference between AP and Control participants. At follow-up, AP participants reported significantly less anxiety than both AT and Control participants did. There was no significant difference between AT and Control participants. To examine within-subject effects, we ran follow-up paired-samples *t* tests on each group separately. AT participants showed no differences from baseline to both post-training, $t(18) = .78, p = .44$, and follow-up, $t(18) = 1.99, p = .10$. In contrast, AP participants reported significant decreases in social anxiety from baseline to both post-training, $t(19) = 5.55, p < .01$, and follow-up, $t(19) = 5.21, p < .01$. Control participants reported significant decreases in social anxiety from baseline to post-training, $t(17) = 3.02, p < .01$, but no significant difference from baseline to follow-up, $t(17) = 1.81, p = .09$. See Table 3.

For the FNE, the ANOVA only revealed a significant Time x Condition interaction, $F(4, 106) = 8.74, p < .01, \eta_p^2 = .25$. Scheffe post-hoc tests revealed that, at post-training, both AP and Control participants reported significantly less anxiety than AT participants did, but there was no significant difference between AP and Control participants. In contrast, at follow-up, AP participants reported significantly less anxiety than both AT and Control participants, but there was no significant difference between AT and Control groups. To examine within-subject effects, we ran follow-up paired-samples t tests on each group separately. AT participants showed no differences from baseline to both post-training, $t(18) = .51, p = .61$, and follow-up, $t(18) = .82, p = .42$. In contrast, AP participants reported significant decreases in social anxiety from baseline to both post-training, $t(19) = 7.31, p < .01$, and follow-up, $t(19) = 7.33, p < .01$. Control participants reported significant decreases in social anxiety from baseline to post-training, $t(17) = 3.09, p < .01$, but no significant difference from baseline to follow-up, $t(17) = 1.78, p = .07$. See Table 3.

5.3.4. Emotional responses to a speech task

Subjective response. For the SUDS rating provided during the speech task, the ANOVA revealed a significant Time x Condition interaction, $F(1, 53) = 14.46, p < .01, \eta_p^2 = .35$. Although the groups did not differ in their scores at baseline, $F(2, 56) = .45, p = .64, \eta_p^2 = .02$, a one-way ANOVA computed on the score at post-training revealed a significant difference between groups, $F(2, 56) = 16.67, p < .01, \eta_p^2 = .38$. Scheffe post-hoc tests revealed that both AP and Control participants reported significantly less elevated SUDS than AT participants did, but no significant differences between AP and

Control participants. To examine within-subject effects, we ran follow-up paired-samples t tests on each group separately. In the AT condition, there was no significant change in SUDS from baseline to the post-training, $t(18) = 1.49, p = .15$. In the AP condition, there was a significant decrease in SUDS from baseline to post-training, $t(19) = 7.19, p < .01$. In the Control condition, there was also a significant decrease in SUDS from baseline to post-training, $t(17) = 6.78, p < .01$. Data appear in Table 4.

Behavioral change. The ANOVA computed on the BASA scores revealed only a significant Time x Condition interaction, $F(2, 53) = 9.50, p < .01, \eta_p^2 = .26$. Although the groups did not differ in their scores at baseline, $F(2, 56) = .95, p = .39, \eta_p^2 = .03$, a one-way ANOVA computed on the score at post-training revealed a significant difference between groups, $F(2, 56) = 10.75, p < .01, \eta_p^2 = .30$. Scheffe post-hoc tests revealed that AP participants exhibited significantly less anxiety at post-training than both AT and control participants, but no significant difference between AT and Control participants. To examine within-subject effects, we ran follow-up paired-samples t tests on each group separately. In the AT condition, there was a significant increase in behavioral anxiety from baseline to post-training, $t(18) = 2.26, p = .04$. In the AP condition, there was a significant decrease from baseline to post-training, $t(19) = 3.42, p < .01$. In the control condition, there was no significant change from baseline to post-training, $t(17) = 1.86, p = .09$. Data appear in Table 4.

Table 3. *Changes in Self-reported measures of Social Anxiety as a Function of Condition and Time (Standard Deviations in Parentheses).*

	Attend to Threat			Attend to Positive			Control		
	Baseline	Post- training	Follow-up	Baseline	Post- training	Follow- up	Baseline	Post- training	Follow- up
LSAS	80.47 (18.70)	77.05 (25.03)	74.05 (21.18)	82.10 (18.16)	61.00 (16.90)*	51.05 (24.03)*	79.50 (18.44)	62.89 (22.80)*	71.22 (15.88)
FNE	22.68 (3.42)	22.32 (4.55)	22.11 (3.07)	22.55 (2.59)	19.55 (3.14)*	14.35 (5.10)*	23.50 (4.50)	19.67 (5.18)*	20.17 (3.28)

Note. Attend to Threat = training to attend to threatening material; Attend to Positive = training to attend to positive material; Control = alternating training to attend toward positive and threatening material; LSAS = Liebowitz Social Anxiety Scale; FNE = Fear of Negative Evaluation. “*” indicates a significant difference between pre- and post- training/follow-up in that group according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons.

* $p < .01$

Table 4. *Changes in emotional reactivity to speech performance as a Function of Condition and Time (Standard Deviations in Parentheses).*

	Attend to Threat		Attend to Positive		Control	
	Baseline	Post-training	Baseline	Post-training	Baseline	Post-training
SUDS	74.37 (14.76)	68.52 (10.24)	78.00 (14.64)	43.75 (19.01)**	78.28 (16.59)	36.56 (21.67)**
BASA	81.34 (18.27)	87.71 (13.94)*	78.58 (16.84)	63.62 (17.53)*	84.86 (12.29)	78.94 (16.15)
SCR	.12 (.05)	.11 (.13)	.13 (.11)	.02 (.04)**	.11 (.08)	.11 (.07)
(amplitudes in μ s)						

Note. Attend to Threat = training to attend to threatening material; Attend to Positive = training to attend to positive material; Control = alternating training to attend toward positive and threatening material; SUDS = Subjective Units of Discomfort Scale; BASA = Behavioral Assessment of Speech Anxiety; SCR = Skin conductance reactivity. “*” indicates a significant difference between pre- and post- training in that group according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons.

* $p < .05$; ** $p < .01$

Psychophysiological responses. Due to a leptokurtotic distribution of the data, we used a logarithmic transformation prior to analysis (Dawson et al., 1990). The ANOVA revealed a significant Time x Condition interaction, $F(1, 53) = 6.36, p < .01, \eta_p^2 = .19$. Although the groups did not differ in their scores at baseline, $F(2, 56) = .38, p = .68, \eta_p^2 = .01$, a one-way ANOVA computed on the score at post-training revealed a significant difference between groups, $F(2, 56) = 5.30, p < .01, \eta_p^2 = .17$. Scheffe post-hoc tests revealed that AP participants exhibited significantly less SCR at post-training than both AT and control participants did, but there was no significant difference between AT and control participants. To examine within-subject effects, we ran follow-up paired-samples t tests on each group separately. In the AT condition, there was no significant change from baseline to post-training, $t(18) = .360, p = .72$. In the AP condition, there was a significant decrease from baseline to post-training, $t(19) = 5.03, p < .01$. In the control condition, there was no significant change from baseline to post-training, $t(17) = .578, p = .57$. Data appear in Table 4.

5.3.5. Mediation Analyses

To examine whether changes in attentional bias mediated changes in self-report, behavioral, and physiological reactivity to the social stressor, we performed mediation analyses according to MacKinnon, Fairchild, and Fritz's (2007) procedure.

This procedure tests the product of the coefficients for the effects of (a) the independent variable (contrast coded: AP = +2, AT = -3, Control = +1) to the mediator (change in attentional bias from baseline to post-training) (alpha), and (b) the mediator to

dependent variable when the independent variable is taken into account (beta). This procedure is a variation on the Sobel (1982) test that accounts for the nonnormal distribution of the alpha–beta path through the construction of asymmetric confidence intervals (MacKinnon et al., 2007).

We first examined whether change in attentional bias mediated the impact of training condition on the dependent variables (change in scores from baseline to post-training for LSAS, FNE, SUDS, BASA, and SCR). Consistent with a statistically significant mediation, the 95% confidence interval of the indirect path (alpha–beta) did not contain zero (lower limit = .005, upper limit = 0.153; $r = .32$, $p < .05$) for SCR. Results from the Sobel test supported this conclusion, $Z = 1.93$, $p < .05$ (two-tailed). None of the other dependent variables showed significant mediation by change in attention bias.

Because all variables were measured at the same two points in time (baseline and pos-training), the direction of causality cannot be determined and alternative mediational models are possible. Hence, we also examined whether change in SCR mediated the impact of training condition on change in attentional bias. Inconsistent with a statistically significant mediation, the 95% confidence interval of the indirect path (alpha–beta) contained zero (lower limit = -38.74, upper limit = 2.69; $r = .32$, $p < .05$). The same conclusion was supported by the results of the Sobel test, $Z = 1.89$, $p = .09$ (two-tailed).

We also examined whether change in attentional bias from baseline to post-training mediated the impact of training condition on change from post-training to follow-up (for LSAS and FNE). Consistent with a statistically significant mediation, the 95% confidence interval of the indirect path (alpha–beta) did not contain zero (lower

limit = -2.12, upper limit = -0.04; $r = .19$, $p < .05$) for FNE. Results from the Sobel test supported this conclusion, $Z = 1.94$, $p < .05$ (two-tailed). Change in LSAS did not show significant mediation by change in attentional bias.

These findings suggest that a decrease in attentional bias for angry faces mediated the effects of attention training on change in physiological reactivity to a subsequent stressor from baseline to post-training and change in self-reported measures of apprehension about negative evaluation from post-training to follow-up.

5.4. Discussion

The primary purpose of this study was to answer two major questions. First, does attention training reduce physiological, self-report, and behavioral measures of anxiety in people with social phobia? Indeed, no previous attention training study involving participants with social phobia had included all three types of measure. Second, we sought to further examine whether attention training in any direction, regardless of valence, would result in reduced anxiety relative to a control condition, as found Klumpp and Amir (2010).

Consistent with previous studies (e.g., Dandeneau et al., 2007; Li et al., 2008), participants trained to attend to positive stimuli reported reductions in self-reported social anxiety from baseline to both post-training and 2-week follow-up. They also demonstrated reductions in self-reported anxiety, behavioral manifestations of anxiety, and physiological arousal in response to a speech task. Control training reduced only self-reported distress at post-training, and even this benefit dissipated by the two-week

follow-up. In contrast to Klumpp and Amir (2010), participants trained to attend to threatening stimuli showed no such reductions.

These results are consistent with previous studies showing that training socially anxious to attend to non-threat faces reduces emotional vulnerability to subsequent stressors (e.g., Amir et al., 2008), extending this finding to physiological responses. Moreover, our study is the first to involve assessment of emotional change in all three emotional response systems within one study of socially anxious individuals. Our results show that attention training produces beneficial effects across all systems -- verbal, behavioral, and physiological. This would suggest that attention training does indeed affect the emotional experience of anxiety and not simply the verbal report of anxiety.

This is consistent with previous studies of attention training among individuals reporting high-level of trait anxiety. Dandeneau et al. (2007) found that attention training lowered cortisol release in response to stress. In an electroencephalographic experiment, Eldar and Bar-Haim (2010) found that training attention away from pictures of angry faces in anxious individuals reduced P2 and P3 amplitudes and increased N2 amplitude in response to the onset of these stimuli compared to placebo training. They interpreted these data as implying that attention training involves top-down executive control rather than early orienting of attention. Consistent with these findings, Browning, Holmes, Murphy, Goodwin, and Harmer (2010) showed that prefrontal cortical regions mediate attention training. Taken together, these findings clearly support the notion that attention training does not merely affect the verbal report of anxiety.

Nevertheless, these observations cannot sustain the conclusion that this emotional change can be unambiguously attributed to the selective attentional processing produced

by the training. As argued by MacLeod et al. (2009a), this conclusion requires that researchers confirm the predicted changes on a task that reliably measures the mediating cognitive process. Moreover, MacLeod et al. (2009a) also argue that the magnitude in change in the mediating process predicts the magnitude of improvement on the clinical measures.

In the present study, participants in the AP group exhibited greater reduction in attentional bias than did those in the AT and control groups. Therefore, the experimental manipulation achieved the goal of diminishing attentional bias for threat.

Our data partly conform to MacLeod et al.'s (2009a) second requirement. Mediation analyses revealed that training-induced reductions in attentional bias for threat mediated reductions in self-reported fear of negative evaluation and physiological reactivity. However, these analyses failed to confirm that training-induced reductions in attentional bias for threat mediated reductions on the LSAS, SUDS, and BASA ratings. A central assumption of mediation analysis is that measurement of variables must be nearly error-free (MacKinnon, 2008). The SUDS and the BASA certainly cannot fulfill this latter condition. For example, although the internal consistency of the BASA ($\alpha = .73$) was good, it was less than ideal.

Consistent with certain cognitive models of social phobia, reduction in attentional bias mediated improvements on at least some measures of anxiety, suggesting that vigilance for threat is a causal factor in the maintenance of social anxiety (e.g., Clark, 1999; Clark & Wells, 1995; Rapee & Heimberg, 1997). Excessive attention to external threat cues (e.g., threatening faces) may render the environment more threatening than it actually is, thus promoting anxiety (e.g., Mogg & Bradley, 1998). As Buckner, Maner,

and Schmidt (2010) have suggested, attentional bias for threat may increase the tendency of socially anxious individuals to ruminate about memories of negative evaluation, further worsening their anxiety. Training anxious subjects to attend to nonthreatening cues may interrupt this vicious cycle, creating a snowballing cascade of patholytic social encounters that foster elimination of their social fears.

Our results suggest that processes mediating the impact of attention training on anxiety may be more complicated than commonly assumed. For example, we did not replicate the findings of Klumpp and Amir (2010) who found that training to attend towards and away from threat lowered anxiety in response to a speech. Their participants, however, were only moderately socially anxious, whereas ours had generalized social phobia. One cannot exclude the possibility that training to attend away from threat may benefit only highly anxious individuals. As argued by Koster, Baert, Bockstaele, and De Raedt (2010), this divergence can be explained if one assumes that high-anxious individuals (i.e., generalized anxiety disorder and social anxiety disorder) exhibit attentional biases to a wide range of mildly threatening cues (Mogg & Bradley, 1998). Therefore, as demonstrated by Amir et al. (2009) and Schmidt et al. (2009), training to attend away from threat may be helpful in anxiety disorders marked by these attentional biases towards mildly threatening cues. However, in accordance with theories of fear reduction predicting that attentive processing of threat is required to facilitate emotional processing (Foa & Kozak, 1986), training to attend to threat may be helpful in anxiety disorders driven by a narrow band of threat cues (e.g., specific social phobia).

We found that training to attend to threat did not worsen attentional bias for threat. Although such training can induce a vulnerability to experience anxiety (e.g.,

MacLeod et al., 2002; Eldar, Ricon, & Bar-Haim, 2008), these studies involved nonanxious participants. Training to attend to threat is unlikely to have much of an effect in participants who already exhibit an attentional bias for threat.

Importantly, we found that training away from threat fostered a bias favoring attention to positive stimuli rather than merely a reduction in the attentional bias for threat. However, because we used a probe discrimination task, we cannot determine whether the training affected attentional capture versus disengagement components of attention. Heeren, Lievens, and Philippot (in press) found that, in a single-session design, disengagement from threat is more important than allocation to non-threat. Perhaps after receiving extensive training, socially anxious people may learn to attend to non-threatening cues after first learning how to disengage from threatening ones.

At a clinical level, this study adds to a small but growing empirical literature revealing the efficacy of computerized attention training procedures in reducing clinical symptoms in individuals who suffer from social phobia (Amir et al., 2008, Amir et al., 2009, Li et al., 2008; Schmidt et al., 2009). Although the extent of training is modest, totaling no more than a couple of hours over four days, and no therapist contact, clinical benefits occurred on measures of subjective, behavioral, and physiological of anxiety during a speech performance as well as on self-reported measures of social phobia. Further, the 2-week follow-up assessment revealed continued self-reported benefits. However, the effect sizes were (e.g., $\eta_p^2 = .16$ for the LSAS) smaller than the effect sizes in previous studies. For instance, Amir et al. (2009) reported a much larger effect size on the LSAS (i.e., $\eta_p^2 = .42$) relative to ours. Amir et al. spaced their training sessions further apart than we did, and this may have boosted the effect of the training. Spaced

sessions produce more robust learning than massed sessions do (e.g., Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). Therefore, as See, MacLeod, and Bridle (2009) observed, spacing sessions may enhance their efficacy.

The present study has limitations. First, we used only skin conductance as an index of physiological reactivity. Future research should incorporate other measures, such as heart rate and cortisol release. Second, we used a probe discrimination task as a measure of attention bias. This task does not reveal whether reductions in attentional bias for threat resulted from improvements in early (i.e., attentional capture) or late (i.e., difficulties in disengaging from threat) components of attention. Third, we used faces for both assessment and training, and it would be desirable to also test whether training reduces attentional bias for lexical threat stimuli. Fourth, although both speech raters have at least three years of CBT training, they were not trained to use the BASA. On the other hand, the standardized character of the BASA renders it easy to use reliably. Finally, it should be noted that our sample was not ethnically diverse. All participants were French-speaking Belgian Caucasian individuals, limiting the generalisability of our results.

In conclusion, the present findings show that training social phobics to attend to positive stimuli reduces self-report, behavioral, and physiological measures of the disorder. Further, the study indicates that attentional biases for threat play a causal role in the maintenance of social phobia.

5.5. Rationale for the transition from Study 3 to Study 4

The primary purpose of Study 3 was to answer two major questions. First, does attention training reduce physiological, self-report, and behavioral measures of anxiety in people with social phobia? Indeed, no previous attention training study involving participants with social phobia had included all three types of measure. Second, we sought to further examine whether attention training in any direction, regardless of valence, would result in reduced anxiety relative to a control condition, as found Klumpp and Amir (2010).

Consistent with previous studies (e.g., Dandeneau et al., 2007; Li et al., 2008), participants trained to attend to positive stimuli reported reductions in self-reported social anxiety from baseline to both post-training and 2-week follow-up. They also demonstrated reductions in self-reported anxiety, behavioral manifestations of anxiety, and physiological arousal in response to a speech task. Control training reduced only self-reported distress at post-training, and even this benefit dissipated by the two-week follow-up. In contrast to Klumpp and Amir (2010), participants trained to attend to threatening stimuli showed no such reductions. These results are consistent with previous studies showing that training socially anxious to attend to non-threat faces reduces emotional vulnerability to subsequent stressors (e.g., Amir et al., 2008), extending this finding to physiological responses.

Moreover, our study is the first to involve assessment of emotional change in all three emotional response systems within one study of socially anxious individuals. Our results show that attention training produces beneficial effects across all systems --

verbal, behavioral, and physiological. This suggests that attention training does indeed effect upon the emotional experience of anxiety and not simply the verbal report of anxiety.

However, uncertainty remains regarding the mechanisms that mediate the reduction of emotional vulnerability via attention training. According to Amir et al. (2008), the improvement in the ability to disengage attention from threatening stimuli mediates the reduction of emotional reactivity to stressors (disengagement hypothesis). Studies show that anxious participants are no faster to respond to probes replacing threat as compared to non-threat cues. However, they are slower to respond to probes that appear opposite to threat cues as compared to non-threat cues, implying difficulties in disengaging attention from threat (e.g., Amir et al., 2003; Fox et al., 2001). Hence, disengagement difficulty would be the underlying process mediating attentional bias for threat in the probe detection and probe discrimination paradigms.

An alternative account is based on results of MacLeod et al. (2002) and Li et al. (2008). According to this explanation (the counter-bias hypothesis), the development of a counter-bias, in which attention is trained to be oriented towards non-threat cues, explains the effect of attention training. For instance, Li et al. (2008) have observed that training socially anxious individuals to focus on positive faces reduces bias toward threatening faces but increases attentional bias towards non-threat cues. The therapeutic benefits of attention training would thus result from orienting attention towards non-threat cues. In other words, the critical component of attentional training would be the reallocation of attention towards non-threat rather than the disengagement from threat.

Finally, one cannot exclude the possibility that both processes (disengagement from threat and attention allocation to non-threat) are necessary for attentional training to be effective. Indeed, it could be argued that attention allocation to non-threat is only possible if one can disengage from threat.

However, to date, paradigms used do not allow us to determine the process of change. Study 4 directly addresses this question by crossing the presence/absence of disengagement from threat and allocation to non-threat in four different attention training conditions. Participants diagnosed as having a generalized social phobia were randomly assigned to one of four attention training conditions: 1) disengaging attention from threat cues, 2) only attending to non-threat cues, 3) disengaging attention from threat cues and re-engaging it to non-threat cues, or 4) control condition (i.e., no contingencies between cues and probes).

If the disengagement hypothesis is true, participants who are trained to disengage their attention from threat cues, and those trained to disengage it from threat cues and re-engage it to non-threat cues, should show more reduction in anxiety than the two other groups. Indeed, these two conditions share the same process: attentional disengagement from threat cues. In contrast, if the counter-bias hypothesis is true, participants who are trained to engage attention to non-threat and those trained to disengage it from threat cues and re-engage it to non-threat cues should show more reduction in anxiety than the two other groups. Indeed, these two conditions share the same process: engagement of attention to non-threat cues. Finally, if attention training involves both disengagement from threat cues and the re-engagement to non-threat cues, we expect a significant decrease of anxiety for participants in that condition only.

Chapter 6

How Does Attention Training Work in Social Phobia: Disengagement from Threat or Re-engagement to Non-threat? (Study 4)

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Abstract

Social phobics exhibit an attentional bias for threat in probe detection paradigms. Attention training, whereby probes always replace non-threat in a display presenting both threat and non-threat, reduces attentional bias for threat and social anxiety. However, it remains unclear whether therapeutic benefits result from learning to disengage attention from threat or learning to orient attention towards non-threat. In this experiment, social phobics were randomly assigned to one of four training conditions: 1) disengagement from threat, 2) engagement towards non-threat, 3) disengagement from threat and re-engagement towards non-threat, and 4) a control condition. Effects were examined on subjective and behavioral responses to a subsequent stressor. Data revealed that training to disengage from threat reduces behavioral indices of anxiety. Engagement towards non-threat faces did not have effects in itself. These results support that the difficulty in disengaging attention from threat is a critical process in maintenance of the disorder.

Keywords: Attention training, Social Phobia, speech performance, cognitive bias modification, attentional bias

6.1. Introduction

Most cognitive models of anxiety propose that selective attention to threat cues contributes to development and maintenance of emotional disorders (e.g., Mathews & MacLeod, 1994). For people with social phobia, these cues include threatening facial expressions displaying anger or disgust, and words signifying social threat (e.g., humiliation). In probe detection and probe discrimination tasks, individuals with social anxiety or social phobia respond faster to probes replacing these cues than to probes replacing neutral cues, thereby exhibiting an attentional bias for threat that is absent in nonanxious control individuals (e.g., Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2004).

Recent studies have attempted to dismantle this bias to identify which attention component underlies it. Most of these studies used the modified Posner (1980) spatial cueing task, in which a threat (or non-threat) cue appears on either the left or right side of a computer screen, followed by a probe that either replaces the cue or appears on the other side of the screen (e.g., Amir, Elias, Klumpp, & Przeworski, 2003; Fox, Russo, Bowles, & Dutton, 2001). These studies showed that anxious participants are no faster to respond to probes replacing threat than non-threat cues, but they are slower to respond to probes that appear opposite to threat cues relative to non-threat ones. This pattern of results suggests that anxious participants have difficulty disengaging attention from threat (e.g., Amir et al., 2003), rather than being faster to engage attention to threat.

Attentional bias for threat has clinical consequences. Its re-emergence predicts return of anxiety at follow-up among patients treated for generalized anxiety (Mogg,

Bradley, Millar, & White, 1995) and social phobia (Lundh & Öst, 2001). Moreover, threat-related bias causally influences vulnerability to anxiety (MacLeod, Rutherford, Campbell, Ebbsworthy, & Holker (2002). Using a dot-probe detection task, MacLeod and colleagues trained non-anxious participants to attend either to neutral or to threatening stimuli. The task comprised 672 trials in which pairs of words (one threatening and one neutral) appeared on a computer screen. In the attend-to-threat condition, probes replaced threat words, whereas in the attend-to-neutral condition, probes replaced neutral words. Participants pushed a button as soon as they detected the probe. Relative to those trained to attend to neutral material, participants trained to attend to threat material reported more anxiety and negative mood after performing a stressful anagram task. This study provides causal evidence that selective attention to negative information increases anxiety reactivity to an experimental stressor.

Regarding social anxiety, Li, Tan, Quian, and Liu (2008) have observed that 7-days of attention training toward positive faces diminished attentional bias for negative faces. Moreover, such training reduced self-reported fear of social interaction. Similarly, Amir, Weber, Beard, Bomyea, and Taylor (2008) trained, in a single-session, socially phobic individuals either to attend to neutral faces or to a control task in which there were no contingency between probe and cues. As compared to the latter condition, the former reduced anxiety in response to an impromptu speech. Blind raters judged the speeches of those in the non-threat attention training group more positively than those of the control group. Further, using a modified Posner paradigm after attention training, these authors observed that improvement in the ability to disengage attention from threat mediated the effects of the training on anxiety reactivity, and that this decrease in anxiety, in turn,

improved speech performance. Likewise, Schmidt, Richey, Buckner, and Timpano (2009) have observed that training individuals with social phobia to attend to neutral faces led to a significant reduction in social anxiety and trait anxiety, in comparison to a control group. At a 4-month follow-up, the treatment group had improved further on measures of anxiety. Amir, Beard, Taylor, Klump, Elias, Burns, and Chen (2009) have replicated these results.

These studies suggest that reducing attentional bias for threat in social phobia diminishes emotional vulnerability to subsequent social stressors. However, uncertainty remains regarding the mechanisms that mediate the reduction of emotional vulnerability via attention training. According to Amir et al. (2008), the improvement in the ability to disengage attention from threatening stimuli mediates the reduction of emotional reactivity to stressors (disengagement hypothesis). As mentioned above, studies show that anxious participants are no faster to respond to probes replacing threat as compared to non-threat cues. However, they are slower to respond to probes that appear opposite to threat cues as compared to non-threat cues, implying difficulties in disengaging attention from threat (e.g., Amir et al., 2003; Fox et al., 2001). Hence, disengagement difficulty would be the underlying process mediating attentional bias for threat in the probe detection and probe discrimination paradigms.

An alternative account is based on results of MacLeod et al. (2002) and Li et al. (2008). According to this explanation (the counter-bias hypothesis), the development of a counter-bias during training, in which attention is trained to be oriented towards non-threat cues, constitutes an alternative explanation. For instance, Li et al. (2008) have observed that training socially anxious individuals to focus more on positive faces

reduces bias toward threatening faces but increases attentional bias towards non-threat cues. The therapeutic benefits of attention training would thus result from orienting attention towards non-threat cues. In other words, the critical component of attentional training would be the reallocation of attention towards non-threat rather than the disengagement from threat.

Finally, one cannot exclude the possibility that both processes (disengagement from threat and attention allocation to non-threat) are necessary for attentional training to be effective. Indeed, it could be argued that attention allocation to non-threat is only possible if one can disengage from threat.

However, to date, paradigms used do not allow us to determine the process of change. The present double-blind experiment addresses this question by crossing the presence/absence of disengagement from threat and allocation to non-threat in four different attention training conditions. Participants diagnosed as having generalized social phobia were randomly assigned to one of four attention training conditions: 1) disengaging attention from threat cues, 2) only attending to non-threat cues, 3) disengaging attention from threat cues and re-engaging it to non-threat cues, or 4) control condition (i.e., no contingencies between cues and probes).

If the disengagement hypothesis is true, participants who are trained to disengage their attention from threat cues, and those trained to disengage it from threat cues and re-engage it to non-threat cues, should show more reduction in anxiety than the two other groups. Indeed, these two conditions share the same process: attentional disengagement from threat cues. In contrast, if the counter-bias hypothesis is true, participants who are trained to engage attention to non-threat and those trained to

disengage it from threat cues and re-engage it to non-threat cues should show more reduction in anxiety than the two other groups. Indeed, these two conditions share the same process: engagement of attention to non-threat cues. Finally, if attention training involves both disengagement from threat cues and the re-engagement to non-threat cues, we expect a significant decrease of anxiety for participants in this condition only.

6.2. Method

6.2.1. Participants

We recruited 79 individuals with a primary DSM-IV (American Psychiatric Associations, 1994) diagnosis of Generalized Social Anxiety Disorder from the Université catholique de Louvain community. A total of 398 volunteers responded to our invitation to take part in an investigation of the mechanisms underlying social interaction among shy people. Eighty-nine individuals met the initial eligibility criteria assessed via a screening questionnaire (i.e., Liebowitz Social Anxiety scale, Liebowitz, 1987) and subsequently completed a structured interview to assess diagnostic eligibility. The Mini International Neuropsychiatric Interview (MINI; Lecrubier, Weiller, Bonora, Amorin, & Lépine, 1994), a structured interview assessing specific DSM-IV axis I disorders, was used for diagnostic eligibility. One clinical psychologist administered the MINI. A second independent clinical psychologist rated a randomly selected portion of the interview (15%). Inter-rater agreement for the diagnosis was good ($\kappa = .83$). Ten of the 88 pre-selected volunteers met criteria for other diagnoses than social anxiety disorder and one declined to participate. The remaining 79 participants only met the DSM-IV

diagnosis of Social Anxiety Disorder and were included in the study; their characteristics are displayed in Table 1. We obtained written informed consent from each participant.

In addition to the DSM-IV diagnosis of Social Anxiety Disorder, all participants had to fulfil several inclusion criteria: (a) no current substance abuse or dependency, (b) no current heart, respiratory, neurological problems or use of psychotropic medications, (c) no current psychological or psychiatric treatment and (d) normal or corrected-to-normal vision. Each participant was tested individually in a quiet room and all sessions were completed in the same laboratory. Participants received compensation (5 euros and a lottery ticket) for their participation. The study conformed to the ethical standards of the American Psychological Association.

6.2.2. Materials

Attention training stimuli. We randomly selected 70 face pairs without hairlines (35 men, 35 women) from the Karolinska Emotional Directed Faces database (Lundqvist, Flykt, & Öhman, 1998), which is a standardized set of emotional expressions. The faces displayed either threatening (i.e., disgust) or neutral facial expressions. We chose disgust faces as threat cues for several reasons. First, previous studies have found that socially anxious individuals exhibit an attentional bias toward disgust faces (Pishyar et al., 2004). Second, disgust conveys a message of aversion or rejection (e.g., Rozin, Lowery, & Ebert, 1994), a central concern of individuals with social phobia (American Psychiatric Association, 2000). Finally, previous studies indicating the effectiveness of attention training programs in reducing attentional bias toward threat cues in social anxiety have

used faces expressing disgust as threatening stimuli. We thus used disgust faces to remain consistent with previous work.

Table 1. *Participants' Characteristics as a Function of Group Allocation (Standard Deviations in Parentheses)*

	Disengage/Re-engage	Disengage	Re-engage	Control
n	20	22	18	19
Age	22.50 (5.75)	20.95 (2.34)	20.72(2.39)	21.89(2.18)
% female	70.00	63.90	50.00	78.90
Years of Education	10.50 (1.54)	9.91 (2.25)	11.22 (1.31)	10.37 (2.50)
BDI-II	12.80 (7.96)	12.86 (7.35)	17.33 (10.47)	13.68 (5.907)
STAI-T	34.80 (4.41)	35.36 (5.27)	37.39 (7.38)	34.00 (3.97)
LSAS	78.90 (16.18)	75.09 (16.18)	86.39 (22.678)	75.58 (12.33)

Note. BDI-II is Beck Depression Inventory-II, STAI-T is Spielberger State-Trait Anxiety Inventory-Trait; LSAS is Liebowitz Social Anxiety Scale.

Attention bias assessment stimuli. The stimuli used for the attention bias assessment task (modified Posner task) were eight social threat words (e.g., stupid, humiliation, embarrassed) and eight neutral words (e.g., book, radiator, procession). These proportions were based on previous studies on attentional bias in social anxiety (e.g., Amir et al., 2010). Words types were matched on frequency and usage in French (Lambert & Chesnet, 2001; New, Pallier, Ferrand, & Matos, 2001). There was no significant difference in word length between social threat and neutral words, $t(14) = .44$, $p > .66$, $d = .23$. We used words, rather faces, in the assessment trials in order to show that the effects of training with one type of stimuli can be generalized to another type of stimuli.

6.2.3. Measures

Questionnaires. Participants were selected according to their responses on the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987). Participants were also asked to complete the Trait Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Beck Depression Inventory (BDI-II; Beck Steer, & Brown, 1996) at the beginning of the first training session.

The LSAS is a 24-item scale that measures the anxiety induced by, and the avoidance of, social interaction and performance situations. Yao et al. (1999) have reported good psychometric properties of the French adaptation of the scale. Recently, the structural validity of the French version has been demonstrated (Heeren, Maurage,

Rossignol, Van Haelen, Peschard, Eechout, and Philippot, in press). Cronbach's alpha in the current sample was .91.

The STAI-Trait is a 20-item self-report questionnaire assessing anxiety trait vulnerability. Bruchon-Schweitzer and Paulhan (1993) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .84.

The BDI is a 21-item self-report measure of symptoms of depression. Beck, Steer, and Brown (1998) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .80.

Visual Analogue Scales. To assess level of negative mood and anxiety states at baseline, at post-training and during the stress phase, participants completed two visual analogue scales on a computer. Each scale consisted of a 740-pixel horizontal line. One was an anxiety scale anchored from *relaxed* to *anxious* and the other was a mood scale anchored from *happy* to *depressed*. Previous work on attention training has used similar scales (e.g., MacLeod et al., 2002). To complete these scales, participants used the mouse to move a cursor along the line corresponding to their current state. This yielded a score between 0 and 740 pixels, depending on which point on the line was selected. For each response, the presentation order of the scales and localization of the anchor label (i.e., from happy to relaxed vs. from relaxed to happy) were randomised.

Measure of attention bias. For assessing effects of training on attention to threat cues, participants were asked to complete an independent measure of attention bias at baseline and post-training. We used a modified version of the Posner spatial cueing task identical to that reported in Amir et al. (2008) and in Amir et al. (2010). Words were

presented in lowercase (5-8 mm in height) white letters against a black background in the center of the screen. Social threat or neutral cue words appeared in one of two locations on the computer screen (i.e., rectangles located to the right or left of a central fixation cross), thereby directing attention to one of two screen locations (i.e., right or left). After 600 ms, the cue word disappeared, and participants were instructed to detect a probe (“*”) that immediately appeared in one of the two locations. The probe remained onscreen until the participant responded, and response latencies were recorded from the onset of the probe to the button press. The inter-trial interval from the target offset to the next fixation cross was 1650 ms. On some trials, the cue word was valid (i.e., the probe appeared in the same location as the cue word). On other trials, the cue word was invalid (i.e., the probe appeared in the location opposite to the cue word).

Participants were exposed to 192 experimental trials, two thirds of which were validly cued ($128 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions} \times 4 \text{ repetitions}$), one sixth were invalidly cued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$), and one sixth were uncued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$). The decision to use these proportions was based on previous research (Posner, 1988; Stormark, Nordby, & Hugdahl, 1995). Trials were presented in a different random order for each participant.

Participants completed four practice trials (including four neutral words) prior to the experimental trials. During the practice trials, participants received feedback regarding the accuracy of their response. Feedback was not provided during the experimental trials. Participants sat approximately 30 cm from the computer screen. In previous research using this task (e.g., Amir et al., 2003), socially anxious participants showed significantly longer response latencies on invalid cued social threat trials

compared to non-anxious controls, suggesting that an attentional bias may be due to difficulty in disengaging from threatening stimuli.

Speech task. We administered a speech task to assess self-report and behavioral responses to a social stressor at baseline and post-training. Each participant began the task, sitting in a comfortable chair 30 cm from a computer screen. A set of instructions then appeared and displayed a list of five topics that were widely discussed in the national media at the time of data collection (i.e., global warming, the AH1N1 vaccination program, wearing of the Islamic veil in high-school, alcohol prohibition among minors, the come-back of a former Prime Minister on the national political scene). They were asked to choose one of the five topics. There were no significant choice differences in topics among conditions, $\chi^2(3, N = 79) = 15.44, p > .21$. The next screen informed participants that they would have to make a 2-min speech about their chosen topic and that their performances would be video-recorded. They were given 2 minutes to prepare and a sheet of paper to write down their notes; however, they were told that they would not be allowed to use these notes during the speech. After participants had prepared their speech, they were directed to stand in front of a video camera in another room. Just before starting the speech, the experimenter asked participants to rate their mood and level of situational anxiety using computerized visual analogue scales. The participants then performed the speech while being videorecorded.

Speech performance was rated by two independent judges blind to the hypotheses of the present study, who each had at least three years of CBT training. The rating scale was the Behavioural Assessment of Speech Anxiety (BASA; Mulac & Sherman, 1974), which includes 18 molecular categories (e.g., having a clear voice;

searching for the words). The total score of these categories has shown excellent concurrent validity with experts' ratings of speech anxiety (Mulac & Sherman, 1974). As the inter-rater reliability of the total score was high ($r = .94$), a mean score of the two raters was computed. Internal consistency of the present data was good ($\alpha = .79$).

6.2.4. Attention training

Attention training consisted of a standard probe discrimination task, modified to promote either: 1) the re-engagement to non-threat cues without disengagement from threat cues (Re-engage condition) 2) the disengagement from threat cues without re-engagement to non-threat cues (Disengage condition), 3) the disengagement of attention from threat cues and the re-engagement to non-threat cues (Disengage/Re-engage condition), or 4) control condition. According to the condition, a fixation cross appeared during 500-ms followed either by one or two facial expressions presented for 500 ms. Then a probe appeared (i.e., a white arrow), pointing either up or down. The probe remained onscreen until the participant indicated the direction of the arrow by pressing the corresponding button. The inter-trial interval was 1500 ms.

In the disengage condition, only one threatening face appeared, followed by an arrow in the location opposite to the threatening face on 95% of the trials. In the re-engage condition, a single non-threatening face was presented followed by an arrow in the location of the non-threatening face on 95% of the trials. In the Disengage/Re-engage condition, a neutral and a threatening face appeared followed by an arrow in the location previously occupied by the neutral face on 95% of the trials. In the control condition,

there were threatening and non-threatening faces and no contingency between cues and probes.

Participants completed 560 trials in one block. Each of the 70 identity-faces was presented four times, either presented alone expressing a neutral face, or presented alone expressing a disgust face, or both simultaneously (according to the condition). This allowed all combinations of the locations and probe types to be represented, and this procedure was repeated 2 times (i.e., $560 = 70 \text{ stimuli} \times 2 \text{ positions} \times 2 \text{ arrow directions} \times 2 \text{ repetitions}$). Instructions were presented on the computer and were identical for all conditions. Faces were positioned 4 cm from the top/bottom of the screen, 8 cm from the ipsi-lateral edge, 22.5 cm from the contro-lateral edge, and centred vertically. Each face was 7.5 cm tall by 7.5 cm wide.

6.2.5. General Procedure

The procedure was based on a previous study examining the effect of a single-session of attention training on reactions to performing a speech in social anxiety (Amir et al., 2008). Participants were randomly assigned to one of the four conditions. The participants and the experimenters were blind to condition. Participants first completed a demographic questionnaire, the STAI (Trait version) and the BDI-I, and the anxiety and depression visual analogue scales. Next, they were asked to complete the modified Posner spatial cueing task, which provided a baseline index of attention bias. Participants then completed the training task. The training task lasted around 30 minutes. After completing the training, participants filled in the second anxiety and depression visual analogue scales to assess the immediate effect of the training task on participants' mood

and anxiety. Next, participants completed the second modified Posner spatial cueing task to examine the influence of attention training on an independent measure of attention bias. Finally, participants were completed the speech task, including the third anxiety and depression visual analogue scales and the video-recorded performance. Participants were fully debriefed at the end of the experiment.

6.3. Results

6.3.1. Group Equivalence

Preliminary analyses indicated no differences among the groups at baseline on STAI-trait, $F(3, 78) = 1.38, p > .26, \eta_p^2 = .05$, BDI-II, $F(3, 78) = 1.34, p > .27, \eta_p^2 = .05$, and LSAS, $F(3, 78) = 1.72, p > .17, \eta_p^2 = .06$. All groups were similar in terms of age $F(3, 78) = .27, p > .76$, gender, $\chi^2(3, N = 79) = 5.17, p > .16$, and years of education, $F(3, 78) = 1.59, p > .19, \eta_p^2 = .06$.

6.3.2. Compliance monitoring of the training task

Performance in the training task was investigated to check compliance with instructions (errors and outliers). Participants made very few errors on the training task ($M = 1.70\%$, $SD = .09$) and there were few outliers ($M = 2.24\%$, $SD = .90$). The different training conditions did not differ with regards to the number of erroneous responses nor outliers (all $ps > .10$).

6.3.3. Independent measure of attentional bias

Data reduction. Latencies from trials with errors were excluded (2.5 % of the data). Data beyond 2 standard deviations below or above each participant's mean were discarded as outliers (4.5 % of the data). At baseline, the four groups did not differ significantly in error rates, $F(3, 78) = 2.13, p > .10, \eta_p^2 = .08$.

Change in attentional bias. We subjected response latencies to a 4 (Groups) x 2 (Time: Baseline, post-training) x 2 (Validity: valid, invalid) x 2 (Word Type: Social threat, neutral) analysis of variance (ANOVA) with repeated measurement on the last three factors. Due to a leptokurtic distribution, a logarithmic transformation was used. The ANOVA revealed a significant Group x Time x Word Type x Validity interaction, $F(3, 75) = 6.338, p < .002, \eta_p^2 = .20$.

To follow-up this third level interaction, we computed separate Group x Time x Validity ANOVAs for social threat and neutral words. The three-way interaction was significant for social threat words, $F(3, 75) = 3.52, p < .02, \eta_p^2 = .12$, as well as for neutral words, $F(3, 75) = 6.50, p < .01, \eta_p^2 = .21$. To follow-up these three-way interactions, we conducted separate Group x Time ANOVAs for valid and invalid trials, for social threat and neutral words separately. For invalid social threat words, this analysis revealed a significant Time x Group interaction, $F(3, 75) = 3.81, p < .02, \eta_p^2 = .13$. For valid neutral words, this analysis revealed a significant Time x Group interaction, $F(3, 75) = 6.28, p < .001, \eta_p^2 = .20$. For invalid neutral words and for valid social threat words, the interactions were not significant ($p > .38$).

For invalid social threat words, follow-up paired t-tests revealed that participants from the Disengage condition and those from the Disengage/Re-engage condition became

faster on invalid social threat words from pre- to post-training, $t(1,21) = 4.25$, $p < .001$, and, $t(1,19) = 5.63$, $p < .001$, respectively. There were no significant changes from pre- to post-training for participants who were in the control condition and for those in the Re-engage condition, $t(1,18) = .57$, $p > .57$ and $t(1,17) = .74$, $p > .47$, respectively. One-way ANOVAs revealed that although groups did not differ in their responses latency to invalid social threat words before training, $F(3, 78) = .72$, $p > .975$, $\eta_p^2 < .001$, there was a significant group difference at post-training, $F(3, 78) = 4.51$, $p < .01$, $\eta_p^2 = .15$. Post-hoc comparisons, using the LSD procedure, revealed that the Disengage/Re-engage group as well as the Disengage group were significantly faster in their response latency to invalid social threat words than the Re-engage and Control groups. These results suggest that participants from the Disengage/Re-engage training and those from the Disengage training increased their capacity to disengage attention from socially threatening stimuli. This pattern of results is displayed in Table 2.

Table 2. Means of Response Latencies in milliseconds by Group on the Spatial Cueing Task (Standard Deviations in Parentheses)

		Condition							
Trials	Cue	Disengage/Re-engage		Disengage		Re-engage		Control	
		Pretraining	Posttraining	Pretraining	Posttraining	Pretraining	Posttraining	Pretraining	Posttraining
Validity	Word Type								
Valid	Threat	354.95	307.66	360.55	302.62	349.24	361.95	349.77	309.31
		(77.12)	(65.20)	(66.39)	(38.61)	(22.25)	(50.85)	(82.76)	(70.32)
	Neutral	358.39	328.62	359.00	311.52	362.12	272.21	350.39	312.54
		(73.73)	(64.28)	(65.64)	(51.37)	(50.11)	(56.29)**	(93.10)	(71.37)
Invalid	Threat	396.56	340.77	403.63	350.28	397.44	389.90	400.49	386.18
		(67.21)	(37.53)*	(66.27)	(39.50)*	(31.74)	(75.28)	(93.24)	(52.95)
	Neutral	399.02	365.02	403.23	357.97	408.71	370.74	394.63	373.26
		(69.03)	(63.17)	(84.01)	(71.00)	(26.62)	(63.98)	(98.22)	(69.52)

Note. “*” indicates a significant difference between pre- and post- training in that group according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons. **p* < .05; ***p* < .01

For valid neutral words, follow-up paired *t*-tests revealed that participants from all groups became faster on valid neutral words from pre- to post-training ($ps < .03$). One-way ANOVAs revealed that although groups did not differ in their response latencies to valid neutral words before training, $F(3, 78) = .28, p > .84, \eta_p^2 = .01$, there was a significant group difference at post-training, $F(3, 78) = 3.23, p < .03, \eta_p^2 = .11$. Post-hoc comparisons, using the LSD procedure, revealed that the Re-engage group responded significantly faster to valid neutral words than the others groups. This pattern of results suggests that the participants from the Re-engage group became more able to engage their attention to non-threatening stimuli.

6.3.4. *Speech task*

Visual Analogue Scales. We computed separate 4 (Groups) x 3 (Time: Baseline, Post-training, speech) ANOVAs with repeated measurement on the second factor for mood and anxiety analogue scales. Due to a leptokurtic distribution, a logarithmic transformation was used. For the mood scale, the ANOVA only revealed a main effect of Time, $F(2, 150) = 15.42, p < .001, \eta_p^2 = .17$. For the anxiety scale, although there were no significant Group x Time interaction, $F(6, 150) = 1.01, p > .41, \eta_p^2 = .04$, the ANOVA revealed a main effect of Time, $F(2, 150) = 57.56, p < .001, \eta_p^2 = .43$, qualified by a significant effect of Group, $F(3, 75) = 4.34, p < .01, \eta_p^2 = .14$. Follow-up paired *t*-tests revealed that, although there were no significant changes from baseline to post-training for all groups, all groups showed a significant increase in their level of self-reported anxiety from post-training to the stress phase ($ps < .001$). One-way ANOVAs revealed that although groups did not differ in their level of self-reported anxiety before training, F

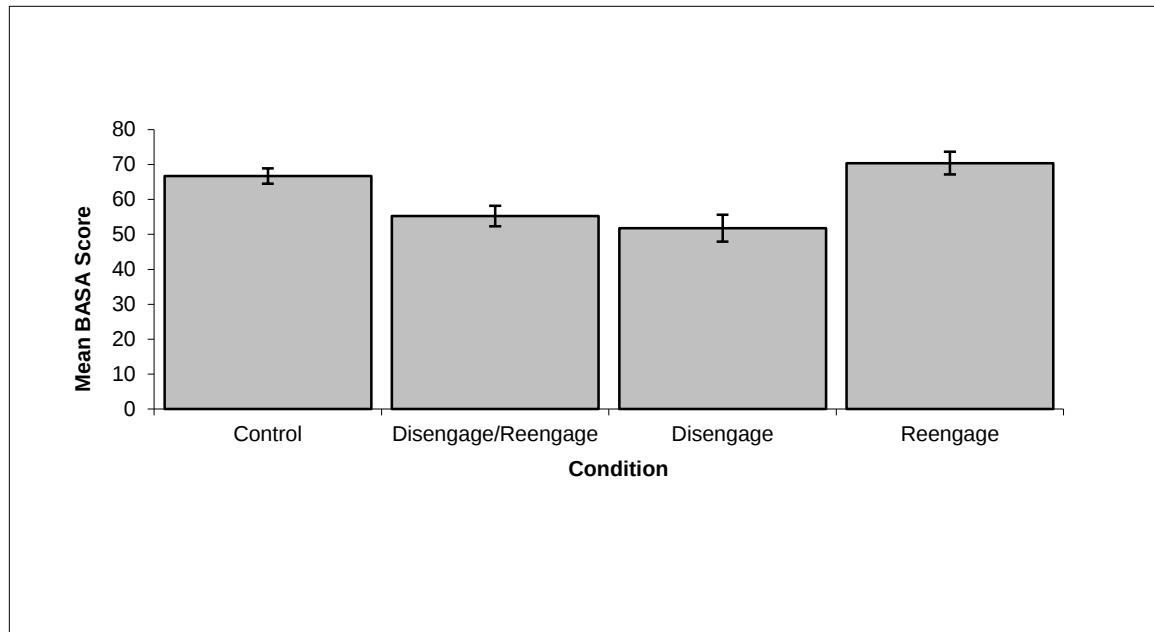
(3, 78) = .88 $p > .45$, $\eta_p^2 = .03$, and after training, $F(3, 78) = 1.06$, $p > .37$, $\eta_p^2 = .14$, there were a significant group difference at speech performance, $F(3, 78) = 7.90$, $p < .001$, $\eta_p^2 = .24$. Post-hoc comparisons, using the LSD procedure, revealed that the Disengage/Re-engage group ($M = 328.10$, $SD = 101.40$) as well as the Disengage group ($M = 300.27$, $SD = 75.95$) reported less anxiety than the Re-engage ($M = 403.11$, $SD = 79.96$) and Control ($M = 396.42$, $SD = 59.50$) groups.

Behavioral change. We computed a one-way ANOVA on the total BASA scores. The ANOVA revealed a significant difference among Groups, $F(3, 78) = 7.843$, $p < .001$, $\eta_p^2 = .24$. Post-hoc comparisons, using the LSD procedure, revealed that participants in the Disengage/Re-engage group and the Disengage group were significantly rated as less anxious during their speech performance than participants who were in the Re-engage and Control groups. This pattern of results is displayed in Figure 1.

6.3.5. Mediation Analyses

To examine whether the effects of attentional training task on behavioural measures were mediated by changes in the ability to disengage attention from social threat, we performed mediation analyses according to the procedure of MacKinnon, Fairchild, and Fritz's (2007).

Figure 1. *Mean Score of the Behavioural Speech Anxiety Assessment as a Function of Condition. Errors bars represent standard error of the mean.*



This procedure tests the product of the coefficients for the effects of (a) the independent variable (contrast coded: Disengage group = +3, Disengage/Re-engage group = + 1, Re-engage group = -3, control group = -1) to the mediator (change in reaction times for invalid threat trials from pre-treatment to post-treatment) (alpha), and (b) the mediator to the dependent variable when the independent variable is taken into account (beta). This procedure is a variation on the Sobel (1982) test that accounts for the non-normal distribution of the alpha–beta path through the construction of asymmetric confidence intervals (MacKinnon et al., 2007).

We examined whether the impact of treatment condition on the dependent variable (BASA score) was mediated by change in the ability to disengage from threat. Consistent with a statistically significant mediation, the 95% confidence interval of the indirect path (alpha–beta) did not contain zero (lower limit = .953, upper limit = 16.478). The same conclusion was supported by the results of the Sobel test, $Z = 2.183$, $p < .030$ (two-tailed).

We also examined whether the impact of treatment condition variable (contrast coded: Disengage group = -3, Disengage/Re-engage group = + 1, Re-engage group = +3, control group = -1) on the dependent variable (BASA score) was mediated by change in the ability to attend to non-threat cues. Inconsistent with a statistically significant mediation, the 95% confidence interval of the indirect path (alpha–beta) contain zero (lower limit = -1.89, upper limit = 5.95). The same conclusion was supported by the results of the Sobel test, $Z = .999$, $p = .32$ (two-tailed).

These findings are consistent with the hypothesis that the affect of attention training on behavioral anxiety during a social stressor is mediated by a decrease in the difficulty of disengaging attention for threatening social stimuli.

6.4. Discussion

The primary purpose of this study was to investigate the critical processes in attention training for social phobia. At this end, participants were randomized to either attention training to disengage from threat, engage toward non-threat, both disengage from threat and engage toward non-threat, or a control training. Consistent with the

disengagement hypothesis, training benefits were observed only for participants trained to *disengage attention from threat cues* and those trained to *disengage from threat cues and re-engage to non-threat cues*. Specifically, during the speech task, participants from these two conditions reported less anxiety and exhibited fewer behavioral indices of anxiety relative to participants in the control condition and those only trained to attend to non-threat cues.

Nevertheless, as such, these observations cannot support the conclusion that this change in symptoms can confidently be attributed to selective attentional processing elicited by the training. As argued by MacLeod, Koster, and Fox (2009a), the successful induction of the target cognitive change must be confirmed by demonstrating predicted performance changes on a cognitive task reliably measuring the cognitive process of interest. Secondly, they also suggest that, in order to strengthen the conclusion that symptom change results from cognitive change elicited by the training, it is desirable to demonstrate that the magnitude of assessed symptom change is related to the magnitude of observed cognitive change across individuals.

To address the first requirement, in the present case, as compared to participants in the two other conditions, those trained to *disengage from threat and re-engage to neutral stimuli* as well as those trained to *only disengage from threat* exhibited, after training, a greater reduction in latency for identifying probes during invalid threat trials. Congruently, as compared to participants in the three other conditions, those trained to engage their attention to non-threat showed, after training, shorter latencies to identify probes during valid non-threat trials. As mentioned above, previous work (e.g., Amir et al., 2003) showed that reaction times for invalid social threat is related to the capacity to

disengage attention from socially threatening stimuli while reaction times for valid non-threat cues is related to the capacity to engage attention towards non-socially threatening stimuli. We may therefore conclude that all three manipulations worked regarding change in attentional bias. The processing bias was thus modified by the experimental manipulation as intended.

Furthermore, the present study included an independent measure of attention bias which is a spatial cueing task with words rather than a dot-probe task with faces and demonstrated that changes in attention generalized to a different measure of attention bias and to a different type of stimulus. This observation suggests that the experimental procedure exerts a general impact on the selective processing of the categories of information from which the present training stimuli were drawn.

We conducted mediational analyses to address the second recommendation of MacLeod et al. (2009a) to evaluate the mediation of attentional change on the impact of attention training on symptom change. They revealed that attention training has an indirect effect on behavioural performance during speech through decreased difficulty to disengage attention from social threatening stimuli. These observations support the conclusion that the behavioural change observed in this study can confidently be attributed to the selective attentional processing elicited by the training

At a fundamental level, this finding converges with previous studies suggesting that attention training procedures can affect vulnerability to anxiety (e.g., Amir et al., 2008; MacLeod et al., 2002). It replicates observations of an effect of attention training on behavioural performance during a speech task (Amir et al., 2008). Furthermore, the

current work expands the literature by suggesting that the critical process of attention training in social phobia is the training of attentional disengagement from threat.

In relation to the cognitive models of social phobia, the present data support the notion that selective attention to threatening social stimuli plays a causal role in the maintenance of this disorder (Clark, 1999; Clark & Wells, 1995; Rapee & Heimberg, 1997). The present findings clearly bolster the argument that the difficulty in disengaging attention from threat is causally involved in the maintenance of the disorder (e.g., Amir et al., 2003). Furthermore, Fox et al. (2001) propose that the ability to disengage from threat cues may serve as a protective factor from anxiety reactivity, whereas an inability to effectively disengage from threat may serve to maintain or increase anxiety. They postulate that the tendency to dwell on threat cues may contribute to maladaptive rumination. According to Buckner, Maner and Schmidt (2010), in the case of social anxiety, it may be that the difficulty in disengaging attention from social threat increases the tendency of socially anxious individuals to engage in maladaptive rumination, which may in turn activate memories of prior experiences of negative evaluation. Furthermore, it may also be that the difficulty in disengaging attention from threat results in constant anxiety by creating a vicious cycle in which anxiety is increased as the individual dwells on the social threat. Consistent with these notions, the present data revealed that training socially anxious individuals to improve their ability to disengage from social threat cues clearly led to a significant reduction in anxiety. As a consequence, one cannot exclude that this change occurs through a reduction in maladaptive rumination and in memories of prior experiences of negative evaluation. It may also be that attention training is efficient because it disrupts the vicious cycle in which anxiety is increased as the

individual dwells on threat cues. Future experiments are clearly needed to evaluate the possibility that attention training is efficient because it disrupts the vicious cycle mentioned above.

At a clinical level, the present data are consistent with recent developments in cognitive bias modification (e.g., Browning, Holmes, & Harmer, 2010; Hakamata et al., 2010) demonstrating that the attention bias for threatening stimuli can be changed and that this change is related to cognitive and behavioural benefits. More precisely, the current double-blind randomized experiment adds to a small but growing empirical literature revealing the efficacy of computerized attention training procedure in reducing clinical symptoms in individuals who suffers from social phobia (Amir et al., 2009, Schmidt et al., 2009). Specifically, the present experiment represents an attempt to better understand the mechanisms underlying this procedure. Indeed, results showed that, in a single-session design, disengagement from threat is more important than allocation to non-threat. However, it is possible that for larger dose treatments involving attention training, training socially anxious individuals to attend to non-threat would become important after these participants can disengage from threat. Future studies should further investigate this question.

Regarding implications for treatments, present findings suggest that clients may benefit from clinical intervention specifically targeting the ability to disengage attention from threat-related stimuli. At this end, computerized training may be delivered, such as the disengagement training used in the present paper. Likewise, as suggested by Wadlinger and Isaacowitz (2011), meditative interventions, such as mindfulness training, may be also used. Indeed, a consensus emerges to suggest that mindfulness training

might promote effective emotion regulation through the improvement of the ability to disengage attention from threat-related cues and thoughts (e.g., Chiesa & Serretti, 2010; Heeren & Philippot, 2011; Heeren, Van Broeck, & Philippot, 2009).

The present study has limitations. First, we used a single-session design and did not collect follow-up data. As such, one cannot determine whether group differences were long-lasting or simply a transient effect. Second, there was no significant Group x Time interaction for the self-reported measure of anxiety. Although no significant difference among groups before and just after the manipulation were observed, post-hoc tests, however, revealed that the Disengage/Re-engage as well as the Disengage group reported significantly less anxiety than the Re-engage and Control groups at speech performance. Such lack of interaction does not fit with previous findings showing strong effects of attention training on self-reported measures. One cannot exclude the small sample size as an explanation. An alternative explanation might be that the present visual analogue scales were not sufficiently discriminative. Future studies should use reliable measures of self-reported anxiety (e.g., STAI-state). Third, we used a spatial cueing task as a measure of attention bias. Mogg, Holmes, Garner, and Bradley (2008) have argued that the spatial cueing task may not provide unambiguous evidence for delayed disengagement, as there may be a confound between delayed disengagement and a generic slow-down effect caused by the presence of threat. Although this limits the conclusions that can be drawn from this task, Cisler and Olatunji (2010) recently found that the difficulty in disengaging in the spatial cueing task remained in anxious individuals when statistically controlling for the generic response slowing, suggesting that this task confound does not explain difficulties in disengagement. Fourth,

participants from the Disengage group and the Re-engage group do not have to attend to the threat value of the stimulus in order to perform the task. Indeed, these two conditions are more similar to a Posner spatial cueing task than a dot-probe task. Therefore, one cannot exclude that participants from these two conditions just learned to attend to either the opposite or same location as the cue. As a consequence, it might be that these two conditions require different processes of change than those involved in the usual dot-probe training. The present data should thus be interpreted with caution. Future studies should further investigate this question. For instance, researchers may include eye-tracker techniques during the training to better understand what participants effectively do during these two conditions. Fifth, although both speech raters have at least three years of CBT training, they were not trained to use the BASA. Although one may assume that someone trained in CBT is qualified to rate anxiety, it would be preferable to ensure that raters were trained to use the BASA. However, the impact of this weakness is limited by the high-standardisation of the BASA (i.e., including self-report items for each of the 18 categories, good psychometric properties, and high inter-rater reliability). This same suggestion applies to how the clinicians were trained to use the MINI. Finally, given recent evidence that anxious individuals, regardless of their type of anxiety, appear to demonstrate attentional biases towards threat (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007), future experiments should examine whether the effects observed in the current study generalize to individuals with other anxiety disorders.

In conclusion, present findings show that training individuals with social phobia to disengage from threat reduces social anxiety during a speech performance.

Furthermore, it appears that this effect is particularly related to an improvement in the ability to disengage attention from threat.

6.5. Rationale for the transition from Study 4 to Study 5

The primary purpose of Study 4 was to investigate the critical processes in attention training for social phobia. To this end, participants were randomized to either attention training to disengage from threat, engage toward non-threat, both disengage from threat and engage toward non-threat, or a control training. Consistent with the disengagement hypothesis, training benefits were observed only for participants trained to *disengage attention from threat cues* and those trained to *disengage from threat cues and re-engage to non-threat cues*. Specifically, during the speech task, participants from these two conditions reported less anxiety and exhibited fewer behavioral indices of anxiety relative to participants in the control condition and those only trained to attend to non-threat cues.

At a fundamental level, however, uncertainty still abounds regarding the nature of the processes that mediate this effect. According to Klumpp and Amir (2010), attention training may be efficient by increasing executive attentional control, which in turn may improve the ability to disengage attention from threatening stimuli. To date, no previous study has assessed attentional control for non-emotional stimuli before and after attention training. The executive attention control system consists of three independent attention networks: alerting, orienting, and executive attention (e.g., Posner & Rothbart, 2007). Executive attention network is defined as the function that enables an individual to resolved conflicts among responses and involves the top-down control of attention. As argued by Raz and Buhle (2006), it is used to monitor and control information processing between computations in different neural areas. In contrast, orienting network is defined

as the ability to select information from sensory input. Attention engagement, shift, and disengagement are included in the orienting network. Finally, alerting network is defined as the ability to achieve and maintain a state of high sensitivity or readiness in preparation for incoming stimuli.

In Study 5, we assessed the effects of attention training on the three independent attention networks as well as on self-report and behavioral measures of anxiety during a speech performance.

Chapter 7

Does Executive Attention Control Impact on the Malleability of Attentional Bias for

Threat in Social Anxiety?

A Preliminary Exploration using the Attention Network Task

(Study 5)

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Abstract

Social phobics exhibit an attentional bias for threat in probe detection and probe discrimination paradigms. Attention training programs, in which probes always replace nonthreatening cues, reduce attentional bias for threat and self-reported social anxiety. According to Klumpp and Amir (2010), attention training may be efficient by increasing executive attentional control, which may inhibit threat processing. Previous attention training studies did not include systematic testing of the general executive attentional processes hypothesis. In the present double-blind experiment, we randomly assigned individuals with social anxiety disorder to one of two conditions: 1) attend to non-threat stimuli or 2) attend to threat stimuli. We assessed the effects of these procedures on change on executive control as well as self-report and behavioral measures of anxiety during a speech performance. Our results are congruent with Klumpp and Amir's conclusion that training in either direction (toward or away from threat) bolsters top-down executive attentional control in ways that may foster the ability to control's one anxiety.

Keywords: Attention training, attention control, top-down control, Social Phobia, speech performance, cognitive bias modification, attentional bias

7.1. Introduction

During the last four years, using a modified probe discrimination task in which there was a contingency between cues and probes, researchers have trained social phobics to attend to nonthreat cues. Li, Tan, Qian, and Liu (2008) have observed that, in comparison to a control condition in which there was no contingency between cues and probes, 7-days of attention training toward positive faces diminished attentional bias for negative faces and reduced self-reported fear of social interaction. Similarly, Amir, Weber, Beard, Bomyea, and Taylor (2008) trained, in a single-session, socially phobic individuals either to attend to neutral faces or to a control task in which there were no contingency between probe and cues. As compared to the latter condition, the former reduced anxiety in response to an impromptu speech. Blind raters judged the speeches of those in the no-threat attention training group more positively than those of the control group. Further, using a modified Posner (1980) spatial cueing paradigm before and after attention training, these authors observed that changes in attention biases for threat mediated the effects of the training on anxiety reactivity, and that this decrease in anxiety, in turn, improved speech performance. Likewise, Schmidt, Richey, Buckner, and Timpano (2009) have observed that training individuals with social phobia to attend to neutral faces led to a significant reduction in social anxiety and trait anxiety, in comparison to a control group exposed to no contingency between cues and probe. At a 4-month follow-up, the treatment group had improved further on measures of anxiety. Recently, using the same experimental design, Amir, Beard, Taylor, Klump, Elias, Burns, and Chen (2009) have replicated these results.

In a recent study, Klumpp and Amir (2010) randomly allocated moderately socially anxious individuals to one of three different attention training conditions: (1) training to attend away from threat, (2) attend to threat, or (3) a control condition in which there was no contingency between cues and probe. After a single-session of training, individuals who were trained to attend to threat and those trained to attend away from threat reported less anxiety in response to an impromptu speech compared to individuals in the control condition. Klumpp and Amir concluded that training in either direction (toward or away from threat) bolsters top-down executive attentional control in ways that may foster the ability to control one's anxiety. Unfortunately, this work has not yet been replicated. Klumpp and Amir also only included self-report assessment of anxiety in response to speech (i.e., STAI-State) and did not include behavioral (e.g., ratings of speech performance). However, in a recent study, Heeren, Reese, McNally, and Philippot (2012) did not replicate this effect among a sample of individuals presenting a diagnosis of generalized social phobia. They observed that training social phobics to attend to non-threatening stimuli reduces self-report, behavioral, and physiological measures of social anxiety. But, those trained to attend to threatening stimuli showed no such benefits.

As a corollary, these data suggest that processes mediating the impact of attention training on anxiety may be more complicated than commonly assumed. According to Klumpp and Amir (2010), attention training may be efficient by increasing executive attentional control, which may inhibit threat processing. As defined by Cisler and Koster (2010), executive attention control is an individual difference variable that refers to individuals' ability to regulate their attentional allocation. In accordance to this

hypothesis, Koster, Baert, Bockstaele, and, De Raedt (2010) found that attention training influences late (1500 ms) rather than early (30 or 100 ms) stages of threat processing. Congruently, in an electroencephalographic experiment, Eldar and Bar-Haim (2010) found that training attention away from pictures of angry faces in trait-anxious individuals reduced P2 and P3 amplitudes and increased N2 amplitude in response to the onset of these stimuli compared to placebo training. They interpreted these data as implying that attention training involves top-down executive attention control rather than early orienting of attention. Consistent with these findings, Browning, Holmes, Murphy, Goodwin, and Harmer (2010) also showed that prefrontal cortical regions mediate attention training.

However, it remains unclear whether the Amir and Klumpp's effect effectively result from increased executive attention control. Indeed, the study did not include any such measurement. Further, in contrast to Klumpp and Amir's hypothesis, recent evidence have formulated that attentional bias for threatening stimuli may also result of the original impairment of the orienting process for non-emotional stimuli (e.g., Jongen, Smulders, Ranson, Arts, Krabbendam, 2007; Moriya & Tanno, 2009). More precisely, previous research specifically focused on the attentional disengagement in the orienting network (that includes disengagement, shift, and engagement; Posner & Petersen, 1990), and have indicated that impaired attentional disengagement was related to negative affect (Compton, 2002). Further, regarding neuroanatomy, the orienting system (as measured by the Attention Network Task, see below) is associated with parietal sites, particularly the superior parietal lobe and the temporoparietal junctions (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005). Regarding threat processing, one of the important roles of

the parietal cortex is the detection of salient new stimuli. For instance, Luo et al. (2007) have reported that emotional salencies are associated with increased activity in the parietal cortex. As developed by Moriya and Tanno (2009), abnormal activity in parietal cortex might prevent anxious people from inhibiting attention to salient emotional stimuli. Therefore, one cannot exclude that attention training may lead to a change in orienting process for non-emotional stimuli, which, in turn, may lead to improvement in the ability to inhibit attention toward salient emotional stimuli.

To date, no previous study has assessed the attentional system for non-emotional stimuli before and after attention training. The attentional system consists of three independent attention networks: alerting, orienting, and executive attention (e.g., Fan, McCandliss, Sommer, Raz, & Posner, 2002; Posner & Rothbart, 2007). Executive attention network is defined as the function that enables an individual to resolve conflicts among responses and involves the top-down control of attention. As argued by Raz and Buhle (2006), it is used to monitor and control information processing between computations in different neural areas. In contrast, orienting network is defined as the ability to select information from sensory input. Attention engagement, shift, and disengagement are included in the orienting network. To this end, Posner's spatial cueing task is the most commonly used task. Finally, alerting network is defined as the ability to achieve and maintain a state of high sensitivity or readiness in preparation for incoming stimuli. Typical task used to assess alerting are vigilance tasks in which a cue is presented to inform the participant that a target is about to appear, but no information is given regarding where the target will appear (Posner, 1978).

To measure the three attentional networks simultaneously and efficiently, Fan et al. (2002) developed an attention network test (ANT). The ANT is a combination of Posner's cueing task (Posner, 1980) and the flanker tasks (Ericksen & Ericksen, 1974). It produces reliable estimates of the three attentional networks, and their efficiencies are uncorrelated. Further, imaging data have revealed that each network is controlled by different neuroanatomic structure (Fan et al., 2005; Posner, & Rothbart, 2007; Raz & Bulhe, 2006). Executive attention is associated with the anterior cingulate cortex (ACC) and the prefrontal cortex (PFC). Orienting is associated with parietal sites and frontal eye fields. Finally, alerting is associated with the thalamic, frontal, and parietal regions of the cortex.

In the present double-blind experiment, we randomly assigned individuals with social anxiety disorder to one of two conditions: 1) attend to non-threat stimuli or 2) attend to threat stimuli. We assessed the effects of these procedures on change on attentional networks as well as self-report and behavioral measures of anxiety during a speech performance. If, as Klumpp and Amir have argued, attention training is effective because of increased attentional control regardless of the direction of attention, then subjects in either the attend to threat or attend to non-threat conditions should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in the executive attention network. In contrast, if as Eldar and Bar-Haim (2010) and Browning et al. (2010) have argued, attention training is effective because of increased top-down executive control rather than early orienting of attention, then only subjects in the attend to non-threat conditions should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in

executive attention network. Finally, if attention training is effective because of increased ability to orient attention regardless of the emotional nature of the stimuli, then participants trained to attend toward non-threat should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in the orienting attention network.

7.2. Method

7.2.1. Participants

We recruited 32 individuals with a primary DSM-IV (American Psychiatric Associations, 1994) diagnosis of Specific Social Anxiety Disorder from the Université catholique de Louvain community. A total of 198 volunteers responded to our invitation to take part in an investigation of the mechanisms underlying social interaction among shy people. Forty-three individuals met the initial eligibility criteria assessed via a screening questionnaire (i.e., Liebowitz Social Anxiety scale, Liebowitz, 1987) and subsequently completed a structured interview to assess diagnostic eligibility. The Mini International Neuropsychiatric Interview (MINI; Lecrubier, Weiller, Bonora, Amorin, & Lépine, 1994), a structured interview assessing specific DSM-IV axis I disorders, was used for diagnostic eligibility. One clinical psychologist administered the MINI. A second independent clinical psychologist rated a randomly selected portion of the interview (15%). Inter-rater agreement for the diagnosis was good ($\kappa = .89$). Nine of the 43 pre-selected volunteers met criteria for other diagnoses than social anxiety disorder and two declined to participate. The remaining 32 participants only met the DSM-IV diagnosis of Specific Social Anxiety Disorder and were included in the study; their

characteristics are displayed in Table 1. We obtained written informed consent from each participant.

In addition to the DSM-IV diagnosis of Social Anxiety Disorder, all participants had to fulfill several inclusion criteria: (a) no current substance abuse or dependency, (b) no current heart, respiratory, neurological problems or use of psychotropic medications, (c) no current psychological or psychiatric treatment and (d) normal or corrected-to-normal vision. Each participant was tested individually in a quiet room and all sessions were completed in the same laboratory. Participants received compensation (5 euros) for their participation. The study conformed to the ethical standards of the American Psychological Association.

Table 1. *Participants' Characteristics as a Function of Group Allocation (Standard Deviations in Parentheses)*

	Attention to threat	Attention to non- threat
<i>n</i>	15	17
Age	24.06 (6.46)	29.87 (11.99)
% Female	80.00%	70.60%
Years of education	16.82 (2.33)	17.67 (2.58)
BDI-II	12.88 (7.16)	11.73 (8.46)
STAI-T	48.71 (7.41)	50.67 (9.02)
LSAS	71.65 (9.45)	69.60 (9.94)

Note. BDI-II is Beck Depression Inventory-II, STAI-T is Spielberger State-Trait Anxiety Inventory-Trait; LSAS is Liebowitz Social Anxiety Scale.

7.2.2. Materials

Attention training stimuli. We randomly selected 70 face pairs without hairlines (35 men, 35 women) from the Karolinska Emotional Directed Faces database (Lundqvist, Flykt, & Öhman, 1998), which is a standardized set of emotional expressions. The faces displayed either threatening (i.e., disgust) or neutral facial expressions. We chose disgust faces as threat cues for several reasons. First, previous studies have found that socially anxious individuals exhibit an attentional bias toward disgust faces (Pishyar et al., 2004). Second, disgust conveys a message of aversion or rejection (e.g., Rozin, Lowery, & Ebert, 1994), a central concern of individuals with social phobia (American Psychiatric Association, 2000). Finally, previous studies indicating the effectiveness of attention training programs in reducing attentional bias toward threat cues in social anxiety have used faces expressing disgust as threatening stimuli. We thus used disgust faces to remain consistent with previous work.

Attention bias assessment stimuli. The stimuli used for the attention bias assessment task (modified Posner task) were eight social threat words (e.g., stupid, humiliation, embarrassed) and eight neutral words (e.g., book, radiator, procession). These proportions were based on previous studies on attentional bias in social anxiety (e.g., Amir et al., 2010). Words types were matched on frequency and usage in French (Lambert & Chesnet, 2001; New, Pallier, Ferrand, & Matos, 2001). There was no significant difference in word length between social threat and neutral words, $t(14) = .44$, $p > .66$, $d = .23$. We used words, rather faces, in the assessment trials in order to show

that the effects of training with one type of stimuli can be generalized to another type of stimuli.

7.2.3. Measures

Questionnaires. Participants were selected according to their responses on the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987). Participants were also asked to complete the Trait Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Beck Depression Inventory (BDI-II; Beck Steer, & Brown, 1996) at the beginning of the first training session.

The LSAS is a 24-item scale that measures the anxiety induced by, and the avoidance of, social interaction and performance situations. Yao et al. (1999) have reported good psychometric properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .76.

The STAI-Trait is a 20-item self-report questionnaire assessing anxiety trait vulnerability. Bruchon-Schweitzer and Paulhan (1993) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .86.

The BDI is a 21-item self-report measure of symptoms of depression. Beck, Steer, and Brown (1998) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .87.

Measure of attention bias. For assessing effects of training on attention to threat cues, participants were asked to complete an independent measure of attention bias at baseline and post-training. We used a modified version of the Posner spatial cueing task

identical to that reported in Amir et al. (2008) and in Amir et al. (2010). Words were presented in lowercase (5-8 mm in height) white letters against a black background in the center of the screen. Social threat or neutral cue words appeared in one of two locations on the computer screen (i.e., rectangles located to the right or left of a central fixation cross), thereby directing attention to one of two screen locations (i.e., right or left). After 600 ms, the cue word disappeared, and participants were instructed to detect a probe (“*”) that immediately appeared in one of the two locations. The probe remained onscreen until the participant responded, and response latencies were recorded from the onset of the probe to the button press. The inter-trial interval from the target offset to the next fixation cross was 1650 ms. On some trials, the cue word was valid (i.e., the probe appeared in the same location as the cue word). On other trials, the cue word was invalid (i.e., the probe appeared in the location opposite to the cue word).

Participants were exposed to 192 experimental trials, two thirds of which were validly cued ($128 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions} \times 4 \text{ repetitions}$), one sixth were invalidly cued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$), and one sixth were uncued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$). The decision to use these proportions was based on previous research (Posner, 1988; Stormark, Nordby, & Hugdahl, 1995). Trials were presented in a different random order for each participant.

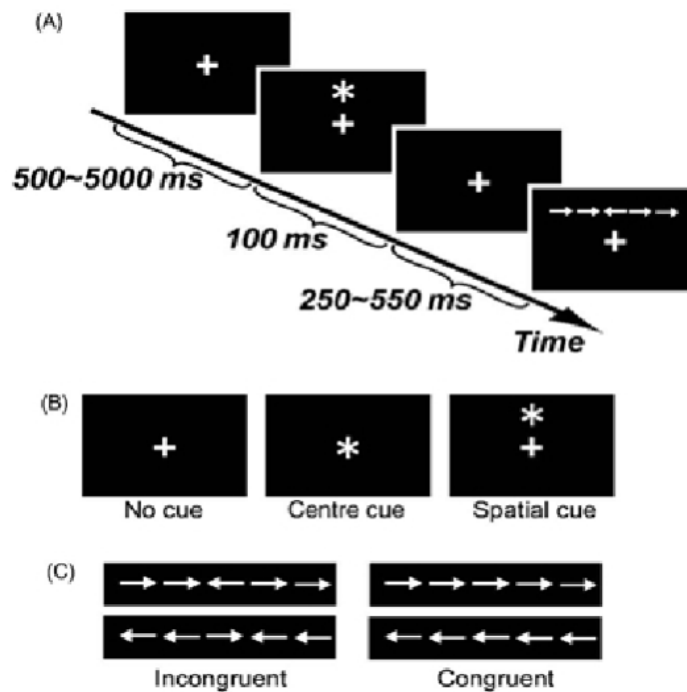
Participants completed four practice trials (including four neutral words) prior to the experimental trials. During the practice trials, participants received feedback regarding the accuracy of their response. Feedback was not provided during the experimental trials. Participants sat approximately 30 cm from the computer screen. In previous research using this task (e.g., Amir et al., 2003), socially anxious participants

showed significantly longer response latencies on invalid cued social threat trials compared to non-anxious controls, suggesting that an attentional bias may be due to difficulty in disengaging from threatening stimuli.

Attentional network task (ANT). The ANT determines the efficiency of three independent attention functions: alerting, orienting and executive conflict (for a more detailed presentation of the ANT, see Fan et al., 2002). Response times are dependent on alerting cues, orienting cues and flankers. Responses were collected via two input keys on the keyboard. Stimuli consisted of a row of five arrows pointing left or right, against a grey background. Participants were instructed to determine the direction of the central arrow (the target) by pressing the “Q” key for the left direction and the “M” key for the right direction. As shown in Figure 1, the target was flanked on either side by two arrows in the same direction (congruent condition), in the opposite direction (incongruent condition), or by lines (neutral condition). Each trial began with a central fixation period for random variable duration (400–1600 ms). Then, a warning cue was presented for 100 ms. Alerting was due to the four types of cue: a neutral cue, a central cue, a double cue and a spatial cue. There was a fixation period for 400 ms after the warning cue and then the target and its flankers appeared above or below the fixation point, until the participant responded (no longer than 1700 ms). The central arrow and its flankers disappeared immediately after the participant's response and a last fixation period began (variable duration based on the duration of the first fixation and RT) (3500 ms minus duration of the first fixation period minus RT) before a new trial. The three effects were measured as following: (1) Alerting = $(RT_{\text{No cue}} - RT_{\text{Double cue}})$, (2) Orienting = $(RT_{\text{Central cue}} - RT_{\text{Spatial cue}})$, and Executive conflict = $(RT_{\text{Incongruent}} - RT_{\text{Congruent}})$. For both Alerting

and Orienting, higher scores indicated greater efficiency. Higher scores of Executive attention indicated impaired efficiency in a different way from alerting and orienting as conflicts in the incongruent conditions increased the reaction times (Fan et al., 2005, 2007).

Figure 1. *Sequence of the ANT. (A) Trial sequence of events in spatial-cue and incongruent condition. (B) The cue condition. (C) The target and flanker conditions.*



Speech task. We administered a speech task to assess self-report and behavioral responses to a social stressor at baseline and post-training. Each participant began the task, sitting in a chair 30 cm from a computer screen. A set of instructions then appeared on screen and informed participants that they would have to make a 2-minute speech that were widely discussed in the national media at the time of data collection and that their performance would be video recorded. Two different topics (abortion and legalization of cannabis) were randomly counterbalanced between times of assessment. They were given 2 minutes to prepare and a sheet of paper to write down their notes; however, they were told that they would not be allowed to use these notes during the speech. After participants had prepared their speech, they were directed to stand in front of a video camera. Just before the speech, the experimenter asked participants to rate their level of situational anxiety from 0 (not anxious) to 100 (extremely anxious) (Subjective Units of Discomfort Scale [SUDS]; Wolpe, 1958). The participant then performed the speech while being videorecorded.

Behavioral assessment. Speech performance was rated by two judges with at least two years of CBT training. Speech ratings were scored by the same raters at baseline and post-training. They were blind to training condition. The rating scheme was the Behavioural Assessment of Speech Anxiety (BASA; Mulac & Sherman, 1974), which includes 18 molecular categories (e.g., having a clear voice, searching for the words). The total score of these categories has shown excellent concurrent validity with experts' ratings of speech anxiety (Mulac & Sherman, 1974). Inter-rater reliability of the total score was high ($r = .82$, $p < .01$ at baseline; $r = .79$, $p < .01$ at post-training), suggesting

that a mean score of the two raters may be computed. Internal consistency of the data in our study was good ($\alpha = .90$ at baseline; $\alpha = .83$ at post-training).

7.2.4. Attention training

Attention training consisted of a standard probe discrimination task, which was modified to train participants either to attend primarily to non-threat cues, or to threat cues. For both conditions, a fixation cross appeared for 500-ms followed either by two facial expressions, a disgust face and a neutral face, presented for 500 ms. Then a probe appeared (i.e., a white arrow), pointing either up or down. The probe remained onscreen until the participant indicated the direction of the arrow by pressing the corresponding key. The inter-trial interval was 1500 ms.

In the attend-to-non-threat condition, a neutral and a threatening face appeared followed by an arrow in the location previously occupied by the non-threatening face on 95% of the trials. In the attend-to-threat condition, a neutral and a threatening face appeared followed by an arrow in the location previously occupied by the threatening face on 95% of the trials.

Participants completed 560 trials in one block. Each of the 70 threatening faces was presented four times, paired with a non-threatening face of the same individual, in positions that represented all combinations of the locations and probe types. This procedure was repeated 2 times (i.e., $560 = 70 \text{ stimuli} \times 2 \text{ positions} \times 2 \text{ arrow directions} \times 2 \text{ repetitions}$). The instructions were presented on the computer and were identical for both conditions. Faces were positioned 4 cm from the top/bottom of the screen, 8 cm

from the ipsi-lateral edge, 22.5 cm from the contro-lateral edge, and centred vertically. Each face was 7.5 cm tall by 7.5 cm wide.

7.2.5. General Procedure

The procedure consisted of two sessions of attention bias modification, including one day between the two sessions. Participants were randomly assigned to one of the two training conditions. Using a computerized randomization system, neither the participant nor the experimenter was aware of the assigned training condition. Participants first completed a demographic questionnaire, the STAI (Trait version) and the BDI-I, the modified Posner spatial cueing task, which provided a baseline index of attention bias, the ANT, and a stressful video-recorded speech performance during which we recorded behavioral and subjective responses. Next, they were asked to complete the two training tasks. The training task lasted around 30 minutes. After completing the second training, participants completed the second ANT as well as the second modified Posner spatial cueing task to examine the influence of attention training on independent measures of attention. Finally, participants were completed the video-recorded speech performance, including the recording of behavioral and subjective responses. For each time of assessment, to avoid a carry-over effect, the order of the dependent variables' administration was counter-balanced across participants. Participants were fully debriefed at the end of the experiment.

7.3. Results

7.3.1. Group Equivalence

Preliminary analyses indicated no differences among the groups at baseline on STAI-Trait, $t(30) = .67, p > .54, d = .25$, BDI-II, $t(30) = .41, p > .68, d = .15$, LSAS, $t(30) = .61, p > .54, d = .22$. Both groups were similar in terms of age, $t(30) = 1.734, p > .09, d = .63$, level of education, $t(30) = .97, p > .33, d = .35$, and gender, $\chi^2(1, N = 31) = .38, p > .53$. Data appear in Table 1.

7.3.2. Compliance monitoring of the training task

The output of the attention modification task was investigated to check compliance with the task instructions (errors and outliers). Participants made very few errors on the training task ($M = .03\%$, $SD = 1.57$) and there were few outliers ($M = .04\%$, $SD = .11$). Both conditions did not differ with regard to the number of erroneous responses or outliers (all $ps > .60$). Further, these results also suggest that participants were compliant to the attention modification task.

7.3.3. Independent measure of attentional bias

Data reduction. Before the main analyses, response latency data from attention bias assessment were prepared in keeping with recommendations from Radcliff (1993). First, trials with incorrect responses were excluded (.005 % of the data). Second, latencies less than 100 ms or greater than 2000 ms were eliminated from analysis of the pre- and post-training assessment tasks (.001% of trials with correct responses). Third, response latencies more than 2.5 standard deviations below or above each participant's mean were discarded as outliers (.001 % of the remaining trials). At baseline, both groups did not differ significantly in error rates, $t(30) = .113, p > .91, d = .04$.

Change in attentional bias. We subjected response latencies to a 2 (Groups: Attend-to-threat, Attend-to-non-threat) x 2 (Time: Pre-training, Post-training) x 2 (Cue Validity: valid, invalid) x 2 (Word Type: threat, neutral) analysis of variance (ANOVA) with repeated measurement on the last three factors. The ANOVA revealed a significant Group x Time x Cue Validity interaction, $F(1, 30) = 6.42, p < .02, \eta_p^2 = .18$. To follow-up this interaction, we conducted separate Group x Time ANOVAs for valid and invalid trials. For valid trials, the interaction was not significant, $F(1, 30) = 0.40, p > .53, \eta_p^2 < .02$. For invalid trials, analyses revealed a significant Time x Condition interaction, $F(1, 30) = 6.27, p < .02, \eta_p^2 = .17$. Although both groups did not differ in their performance at baseline, $t(30) = .35, p > .72, d = .13$, a comparison Student *t*-test computed on reaction times to invalid trials at post-training showed a significant difference between groups, $t(30) = 2.66, p < .02, d = .97$. In addition, separate sample-*t*-test revealed marginally significant difference from baseline to post-training for both conditions: Participants from the attend-to-threat condition showed a marginally significant increase in reaction times for invalid trials from baseline to post-training, $t(14) = 1.82, p = .09$. In contrast, participants from the attend-to-non-threat condition exhibited a marginally significant decrease in reaction times for invalid trials from baseline to post-training, $t(16) = 1.78, p = .09$. Data appear in Table 2.

7.3.4. Speech task

For the SUDS, we subjected responses to a 2 (Groups: Attend-to-threat, Attend-to-non-threat) x 2 (Time: Pre-training, Post-training) ANOVA with repeated measurement on the last factors. Analyses only revealed a main effect of Time, $F(1, 30)$

= 18.57, $p < .0001$, $\eta_p^2 = .38$. The Time x Condition interaction was not significant, $F(1, 30) = .722$, $p = .40$, $\eta_p^2 = .02$. Participants from both conditions reported a significant decrease from baseline to post-training [attend-to-threat: $t(16) = 4.06$, $p < .001$; attend-to-non-threat: $t(16) = 2.30$, $p < .05$]. Further, it should be noted that groups did not differ in their performance at baseline, $t(30) = .41$, $p > .41$, $d = .15$, as well as in post-training, $t(30) = .67$, $p > .51$, $d = .25$. Data appear in Figure 2.

For the BASA, we subjected responses to a 2 (Groups: Attend-to-threat, Attend-to-non-threat) x 2 (Time: Pre-training, Post-training) ANOVA with repeated measurement on the last factors. Analyses only revealed a main effect of Time, $F(1, 30) = 14.28$, $p < .001$, $\eta_p^2 = .36$. The Time x Condition interaction was not significant, $F(1, 30) = .42$, $p = .53$, $\eta_p^2 = .02$. Participants from both conditions reported a significant decrease from baseline to post-training [attend-to-threat: $t(15) = 1.96$, $p < .05$; attend-to-non-threat: $t(17) = 3.77$, $p < .01$]. Further, it should be noted that groups did not differ in their performance at baseline, $t(30) = 1.60$, $p = .12$, $d = .57$, as well as in post-training, $t(30) = .185$, $p = .09$, $d = .66$. Data appear in Figure 3.

Table 2. Means of Response Latencies in milliseconds by Group on the Spatial Cueing Task (Standard Deviations in Parentheses)

Trials		Condition			
		Attend-to-threat		Attend-to-non-threat	
Validity	Material	Baseline	Post-training	Baseline	Post-training
Valid	Neutral	414.11 (49.75)	391.71 (62.13)	396.49 (72.96)	364.43 (63.29)
	Threat	420.68 (54.47)	390.17 (58.93)	410.37 (84.62)	366.96 (59.29)
Invalid	Neutral	425.25 (64.54)	457.52 (77.60)*	410.99 (55.36)	404.65 (54.37)*
	Threat	427.57 (64.19)	466.98 (72.59)*	425.61 (89.60)	398.29 (79.75)*

Note. “*” indicates a marginally significant difference between pre- and post- training in that group according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons. **p* < .09

Figure 2. Mean score of the Subjective Units of Discomfort Scale (SUDS) as a function of condition and time. Errors bars represent standard error of the mean.

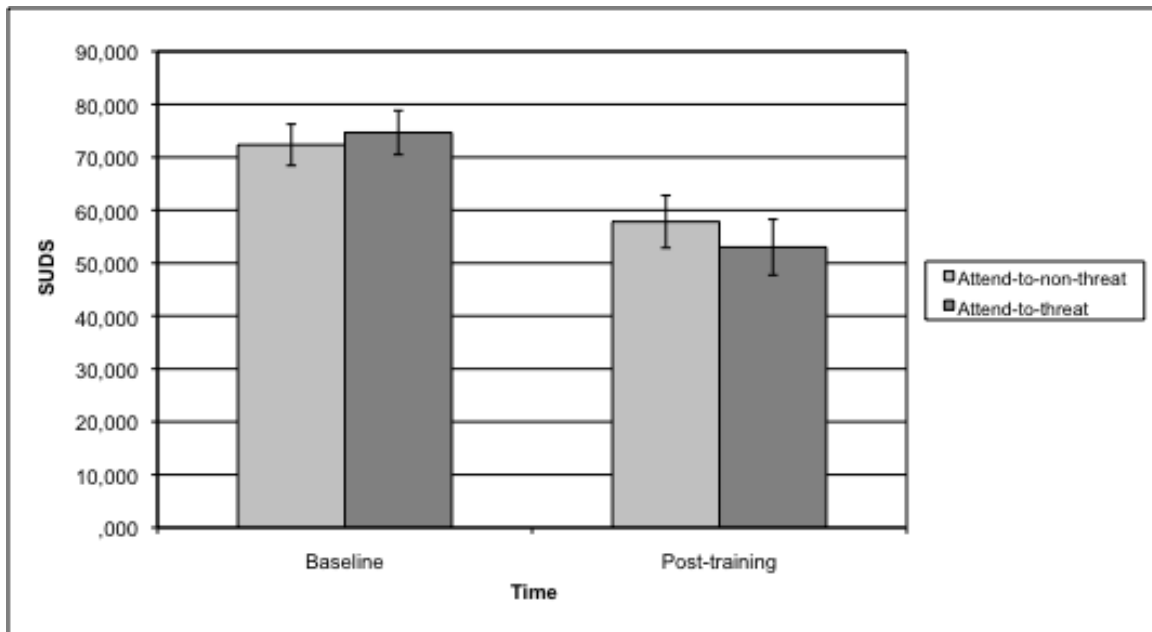


Figure 3. Mean score of the Behavioural Assessment of Speech Anxiety (BASA) as a function of condition and time. Errors bars represent standard error of the mean.

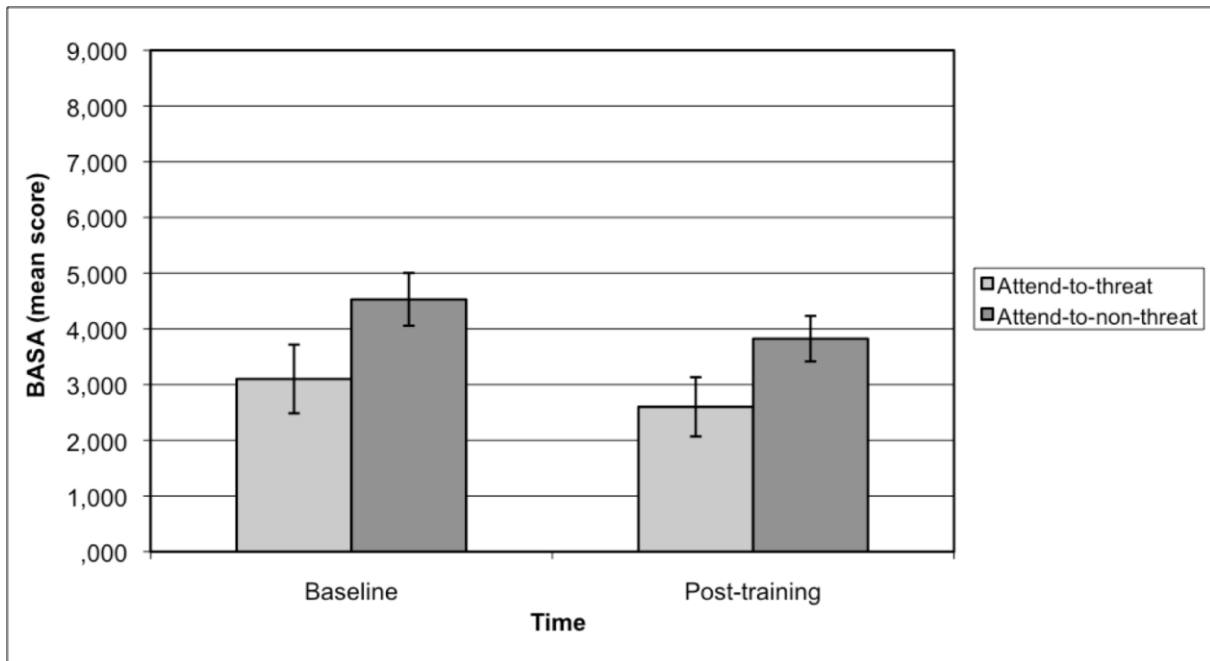


Table 3. *Changes in performance for the Attention Network Task as a Function of Condition and Time (Standard Deviations in Parentheses)*

Network	Attend to Threat		Attend to Positive	
	Baseline	Post-training	Baseline	Post-training
Orienting	55.55 (30.25)	48.49 (33.41)	51.42 (16.01)	47.88 (14.32)
Alerting	43.77 (25.51)	54.27 (19.71)	53.14 (24.40)	57.07 (24.88)
Executive conflict	99.83 (35.41)	116.60 (35.23)*	88.37 (32.84)	99.51 (32.17)*

Note. “*” indicates a significant difference between pre- and post- training in that group according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons. **p* < .01

7.3.5. *Change in the ANT task*

Data reduction. Before the main analyses, response latency data from attention bias assessment were prepared in keeping with recommendations from Radcliff (1993). First, trials with incorrect responses were excluded (.017 % of the data). Second, latencies less than 100 ms or greater than 2000 ms were eliminated from analysis of the pre- and post-training assessment tasks (.003% of trials with correct responses). Third, response latencies more than 2.5 standard deviations below or above each participant's mean were discarded as outliers (.007 % of the remaining trials). Both groups did not differ significantly in error rates at baseline, $t(30) = .72, p > .48, d = .26$, as well as at post-training, $t(30) = .16, p > .87, d = .06$.

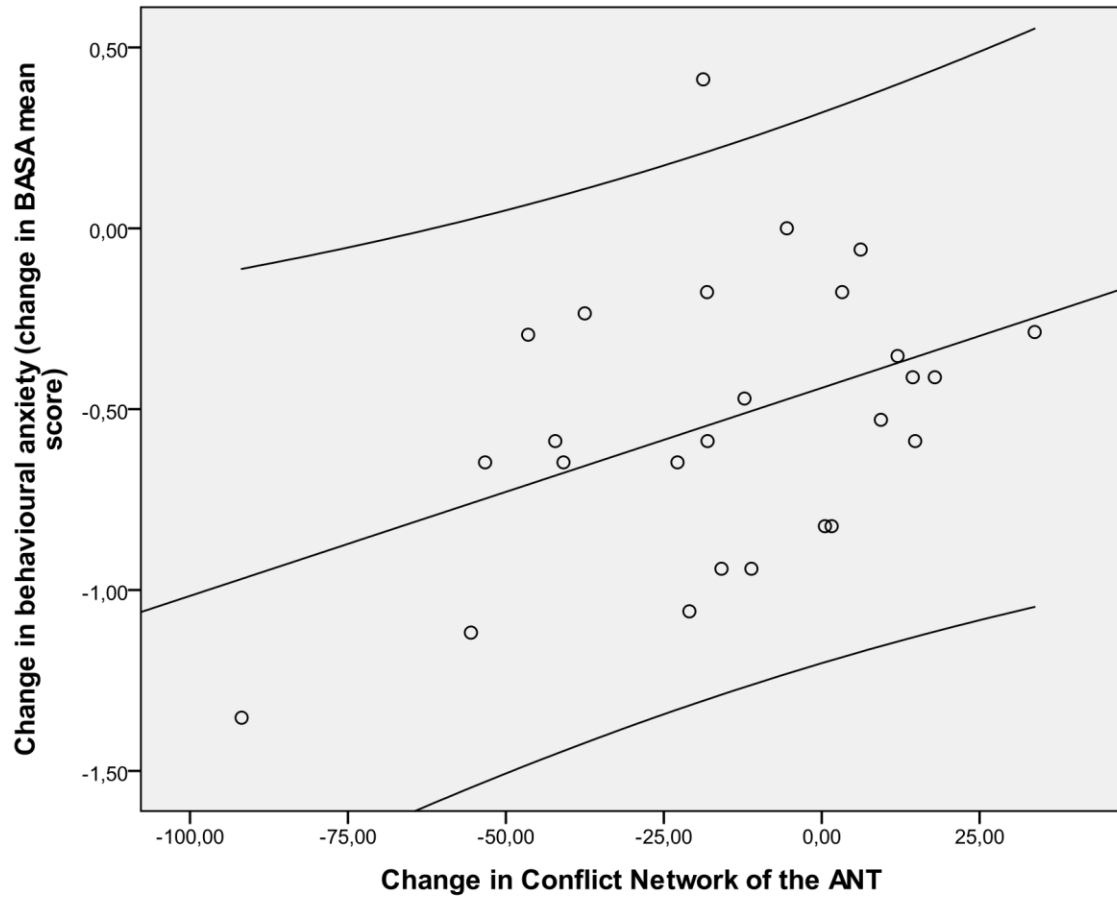
Change in attention network. We subjected the responses to a 2 (Groups: Attend-to-threat, Attend to non-threat) x 2 (Time: Pre-training, Post-training) multivariate analysis of variance (MANOVA) for Alerting, Orienting, and Executive Conflict networks as the dependent variables. The MANOVA only revealed a significant multivariate main effect of Time, Wilks' $\lambda = .18, F(8, 310) = 52.07, p < .01, \eta_p^2 = .57$. Univariate output only showed a main effect of Time for Executive conflict network, $F(1, 30) = 9.02, p < .01, \eta_p^2 = .25$. As showed in Figure 3, there was a significant improvement from baseline to post-training in executive conflict for both conditions. No such changes were observed for alerting, $F(1, 30) = 1.95, p = .17, \eta_p^2 = .06$, or orienting, $F(1, 30) = 2.16, p = .15, \eta_p^2 = .07$. Data appear in Table 3.

7.3.6. *Relationship between executive attention control and speech performance*

Before conducting the main analyses, we screened for multivariate outliers by examining leverage and Cook's distance values. This procedure did not identify any influential outliers. We computed Pearson's correlations to examine the relationship between change in executive attention control (i.e., executive conflict network) and change in behavioral anxiety during the speech performance. As shown on Figure 4, results indicated that, for both groups, reductions in impaired executive attention control was positively correlated with change in behavioral anxiety, $r(32) = .42, p < .05$. However, the correlation between change in SUDS and change in executive attention control was not significant, $r(32) = .10, p = .62$. Thus, the reduction of impaired executive attention control after training is related to attenuated behavioral anxiety during speech after training but not to attenuated self-reported speech's anxiety.

7.4. Discussion

The primary purpose of this study was to investigate the critical processes in attention training for social phobia. As we mentioned below, we examined three different hypotheses. First, if as Eldar and Bar-Haim (2010) and Browning et al. (2010) have argued, attention training is effective because of increased top-down executive control rather than early orienting of attention, then only subjects who were in the attend to non-threat conditions should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in executive attention network.



Second, if the result of attention training is effective because of increased ability to orient attention regardless of the emotional nature of the stimuli, then participant trained to attend toward non-threat should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in orienting attention network. Finally, if as Klumpp and Amir (2010) have argued, attention training is effective because of increased attentional control regardless of the direction of attention, then subjects in either the attend to threat or attend to non-threat conditions should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in executive attention network.

In accordance to Klumpp and Amir (2010), data revealed that subjects in either the attend to threat or attend to non-threat conditions demonstrated reductions in self-reported and behavioural anxiety. Further, regardless of the direction of attention during the training, increased executive attention control were also observed. Regarding orienting and alerting networks, no such changes were observed. These findings converge with the results of Klumpp and Amir (2010) suggesting that attention training may be efficient by increasing attentional control, which may inhibit threat processing. Participants in either attention condition exhibited improved executive attention network after training.

Moreover, evidence against the executive attentional control hypothesis would be the difference between groups on the Posner spatial cueing task at post-training. As compared to baseline performance, participants trained to attend-to-non-threat exhibited, after training, a significant reduction in latency for identifying probes during invalid

trials, regardless of the emotional valence of the trials. In contrast, participants trained to attend-to-threat exhibited, after training, a significant increase in latency for identifying probes during invalid trials, regardless of the emotional valence of the trials. As mentioned above, previous work (e.g., Posner, 1980) showed that reaction times for invalid trials is related to the capacity to disengage attention from these stimuli while reaction times for valid cues is related to the capacity to engage attention towards these stimuli. Although previous studies have reported that there was no evidence of increased reaction times for valid threat trials in the attend-to-threat training, this result is not as easily interpreted. For instance, it is inconsistent with Heeren et al. (2012) showing that those trained to attend to threat cues showed no significant change in attentional bias after training while those trained to attend-to-nonthreat exhibited a significant decrease in vigilance for threat during a probe discrimination task. Further, this is also inconsistent with Klumpp and Amir (2010) reporting that participants in either attention training condition exhibited faster reaction times after training during a probe discrimination task. However, one cannot exclude the possibility that our effects are related to the absence of attentional bias for threat at baseline. Indeed, recent studies have suggested that the efficacy of attention training for social phobia required that participants exhibit that bias before training (e.g., Amir, Taylor, Donohue, 2011). To test for an attentional bias for threat before training, we computed, for each group, separate 2 (Cue Validity: valid, invalid) x 2 (Word Type: threat, neutral) analysis of variance (ANOVA) with repeated measurement on the last two factors. Data revealed that there was no significant Cue Validity x Word Type interaction [Attend-to-threat group: $F(1, 14) = .201, p = .66, \eta_p^2 = .01$; Attend-to-non-threat group: $F(1, 16) = .007, p = .93, \eta_p^2 = .01$], indicating the

absence of attentional bias for threat at baseline. This is in striking contrast with Heeren et al. (2012) who reported that their participants strongly exhibited an attentional bias for threat at baseline. Unfortunately, Klumpp and Amir (2010) did not report this information.

Regarding change on invalid trials from baseline to post-training on the Posner task, different explanations could be formulated. First, in contrast to Heeren et al., (2012) and Klumpp & Amir, (2010) who respectively used a discrimination and detection task to assess change in attentional bias, ours was a Posner spatial cueing task. As demonstrated by Mogg, Holmes, Garner, and Bradley (2008), the spatial cueing task may not provide unambiguous evidence for delayed disengagement, as there may be a confound between delayed disengagement and a generic slow-down effect caused by the presence of threat. In that way, it might be possible that participants trained-to-attend-to-threat exhibited impoverished reaction times due to the repetitive focus on threat (i.e., during the training and within the context of the spatial cueing task). Further, previous findings have reported that excessive attention to external threat cues render the environment more threatening than it actually is (Heeren, Peschard, Philippot, in press). Therefore, it could be also argued that neutral words were evaluated as more threatening than they actually were, providing the observed increased reaction times for both threat and neutral invalid trials. In contrast, for participants who were in the attend-to-non-threat condition, one cannot exclude that they were particularly trained to massively disengage their attention during the experiment. Indeed, this ability to disengage attention was initially trained during the attend-to-non-threat training. In reality, as demonstrated by Heeren, Lievens, and Philippot (2011), attend to non-threat training is efficient through it improves the ability

to disengage attention from threat, while this not actually the case in the attend-to-threat training. Second, in respect to the design of the study which included an important assessment of attention process, their ability to disengage attention from both threat and non-threat cues was then trained during spatial cueing task and during the ANT. Consistently, some recent studies have reported that massively mobilizing executive attentional resources is associated with a decrease in psychological distress (e.g., Bomyea & Amir, 2011; Heeren, Van Broeck, & Philippot, 2009). However, these explanations remain not tested. Further investigations are clearly needed to better understand these effects.

As a consequence, it remains difficult to ensure that the replication of the Amir and Klumpp's effect (2010) result from the processes they postulated to be involved. Particularly, uncertainty remains regarding the nature of the sample. As we mentioned above, Heeren et al. (2012) did not replicate their findings. Klumpp and Amir's participants, however, were only moderately socially anxious, whereas those of Heeren et al. (2011a) had generalized social phobia. The present sample, however, included specific social phobics. As a consequence, one cannot reject the possibility that these different findings are the result of this sample difference. As argued by Koster, Baert, Bockstaele, and De Raedt (2010), this divergence can be explained if one assumes that high-anxious individuals (i.e., generalized anxiety disorder and social anxiety disorder) exhibit attentional biases to a wide range of mildly threatening cues (Mogg & Bradley, 1998). Therefore, as demonstrated by Amir et al. (2009) and Schmidt et al. (2009), training to attend away from threat may be more helpful in anxiety disorders marked by these attentional biases towards mildly threatening cues. However, in accordance with theories

of fear reduction predicting that attentive processing of threat is required to facilitate emotional processing (Foa & Kozak, 1986), training to attend to threat may also be helpful for anxiety disorders driven by a narrow band of threat cues (e.g., specific social phobia).

At the very least, while the present results should be interpreted with cautions until they have been replicated, it suggests that, as already argued by Klumpp and Amir (2010), attention training impacts on executive attention control. This finding is clearly in line with Browning et al. (2010) who showed that prefrontal cortical regions mediate attention training. This is clearly congruent with recent development suggesting that higher-order cortical structures, such as the prefrontal cortex and its functionally related structures (e.g., anterior cingulate cortex, typically involved during Executive Attention Network, Fan et al., 2005) may serve as a regulatory purpose and can down-regulate emotion-relevant limbic structures, thus providing a top-down processing influence (Miller and Cohen, 2001). For instance, previous works have reported that the prefrontal cortex and related structures are critically involved in down-regulating amygdala processing during extinction learning (e.g., Myers & Davis, 2007; Quirk et al., 2006, 2003). In that way, as suggested by the correlation between improvement in executive attention control and decrease in behavioral anxiety, one cannot exclude that massively mobilize attention control, such as done in the present experiment, have a generic effect of top-down regulatory control over sub-cortical fear circuits, then facilitating extinction learning.

The present study has several limitations. First, the sample size is small, which provides limited power to conduct statistical analysis. Second, we did not collect follow-

up data. As such, one cannot determine whether group differences were long-lasting or simply a transient effect. Third, one cannot exclude the possibility that the changes in the executive attention network are the result of a low test-retest reliability commonly observed among measures assessing such processes. Indeed, recent works revealed that performance on task assessing executive functions improved with repeated administrations (e.g., Basso, Bornstein, & Lang, 1999; Ishigami & Klein, 2010). For instance, Ishigami and Klein (2010) repeatedly administered the ANT among a sample of young adults. They reported that participants became better at ignoring irrelevant information and at disengaging from attended locations over time. Fourth, we used a single-item measure (SUDS) as an index of self-report anxiety. Future studies should use reliable measures of self-reported anxiety (e.g., STAI-state). Fifth, although the internal consistency of the LSAS ($\alpha = .76$) was good, it was less than ideal. Therefore, it could be argued that results may be due to participants' selection. However, the impact of this weakness is strongly limited by the use of the MINI as a second selection's measure. Sixth, we used a spatial cueing task as a measure of attention bias. As we already mentioned above, Mogg et al. (2008) have argued that the spatial cueing task may not provide unambiguous evidence for delayed disengagement, as there may be a confound between delayed disengagement and a generic slow-down effect caused by the presence of threat. Although this limits the conclusions that can be drawn from this task, Cisler and Olatunji (2010) recently found that the difficulty in disengaging in the spatial cueing task remained in anxious individuals when statistically controlling for the generic response slowing, suggesting that this task confound does not explain difficulties in disengagement.

In conclusion, the present findings show that training social phobics to attend to either threat or non-threat stimuli reduces self-report and behavioral measures of social anxiety. Further, the study indicates that both training lead to change in the executive attention network.

7.5. Rationale for the transition from Study 5 to Study 6

The primary purpose of Study 5 was to investigate the critical processes in attention training for social phobia. We examined three different hypotheses. First, if as Eldar and Bar-Haim (2010) and Browning et al. (2010) have argued, attention training is effective because of increased top-down executive control rather than early orienting of attention, then only participants who were in the attend to non-threat conditions should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in executive attention network. Second, if the result of attention training is effective because of increased ability to orient attention regardless of the emotional nature of the stimuli, then participant trained to attend toward non-threat should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in orienting attention network. Finally, if as Klumpp and Amir (2010) have argued, attention training is effective because of increased attentional control regardless of the direction of attention, then participants in either the attend to threat or attend to non-threat conditions should demonstrate reductions in anxiety on self-report and behavioral measures as well as an improved performance in executive attention network.

In accordance to Klumpp and Amir (2010), data revealed that participants in either the attend to threat or attend to non-threat conditions demonstrated reductions in self-reported and behavioural anxiety. Further, regardless of the direction of attention during the training, increased executive attention control were also observed. Regarding orienting and alerting networks, no such changes were observed. These findings converge

with the results of Klumpp and Amir (2010) suggesting that attention training may be efficient by increasing attentional control, which may inhibit threat processing. Participants in either attention condition exhibited improved executive attention network after training.

However, there was no Group x Time interaction for other measure of symptoms as well as no change in attentional bias for threat. Different explanations for these divergent results may be proposed. First, one cannot exclude the nature of the sample as an explanation. Indeed, participants in previous studies (e.g., Amir et al., 2009; Schmidt et al., 2008; Studies 2, 3, & 4) fulfilled the criteria for generalized social phobia, whereas those from Studies 5 participants with less severe social anxiety. However, results of Study 1 militate against this hypothesis, as they showed the efficacy of attention training among highly socially anxious who were not necessarily satisfying to the DSM-IV criteria for generalized social phobics. Second, the absence of effects in these two studies might be related to the absence of attentional bias for threat at baseline. Indeed, recent studies have suggested that the efficacy of attention training for social phobia requires that participants exhibit that bias before training (e.g., Amir, Taylor, Donohue, 2011). Finally, the inclusion of particularly resource-consuming measures as additional dependent variable (i.e., ANT) may also explain these discrepancies, as these resources constitute a cognitive training in themselves. Indeed, recent works on the examination of test-retest reliability of tasks assessing executive processes revealed that task's performance improved with repeated administration (e.g., Basso et al., 1999; Ishigami & Klein, 2010).

Regarding cognitive model of attentional bias, however, it has been suggested that the difficulties to inhibit prepotent response and not only poorer executive attention control may lead to difficulty in disengaging attention from threat (Derakshan, Ansari, Hansard, Shoker, and Eysenck, 2009). The inhibition function is used to resist interference from task-irrelevant stimuli and responses. There is considerable evidence that anxiety impairs the functioning of the inhibition function (see Derakshan & Eysenck, 2009, for a review). For instance, Wieser, Pauli, and Mühlberger (2009) reported that socially anxious individuals exhibited difficulties in inhibiting the reflexive orienting to neutral as well as to emotional stimuli. Further, it is important to note that this result was not due to higher state or trait anxiety of the socially anxious individuals participants, as the additional analyses using these anxiety scores as covariates revealed.

Thus, Study 6 focuses on the involvement of the ability to inhibit a prepotent response in the efficacy of attention training in social phobia. We predicted that attention training should lead to improvement in the ability to inhibit prepotent response, which in turn should lead to improvement in the ability to disengage attention from threat.

Chapter 8

Does Inhibition Process Impact on the Malleability of Attentional Bias for Threat in

Social Anxiety?

A Preliminary Investigation using the Hayling Task

(Study 6)

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Abstract

Attention training programs, in which probes always replace nonthreatening cues, reduce attentional bias for threat and self-reported social anxiety. Recently, it has been formulated that attention training may be effective by improving executive control, rather than targeting the stimulus driven components of attentional bias for threat. However, there is accumulating evidence suggesting that various executive functions are associated with top-down executive control. For instance, using latent-variable analysis to identify the main underlying executive functions, Miyake et al. (2000) have identified partially independent inhibition, shifting, and functions. There is considerable evidence that anxiety impairs the functioning of the inhibition function (see Derakshan & Eysenck, 2009, for a review). Regarding cognitive model of attentional bias for threat, it has been also suggested that the difficulties to inhibit prepotent response may lead to difficulty in disengaging attention from threat (Derakshan, Ansari, Hansard, Shoker, and Eysenck, 2009). Thus, the present paper focuses on the involvement of the ability to inhibit a prepotent response in the efficacy of attention training in social phobia. We predicted that attention training should lead to improvement in the ability to inhibit prepotent response, which in turn should lead to improvement in the ability to disengage attention from threat. Unfortunately, our data did not fit with our prediction.

Keywords: cognitive bias modification, social phobia, inhibition process, probe detection task, attentional bias, attention training, social anxiety.

8.1. Introduction

Recently, many studies have suggested the efficacy of attention training to alleviate anxious disorders (for a review, see Hakamata et al., 2010). In these studies, attention training consisted of a modified probe discrimination task in which there is a contingency between cues and probes. Studies have revealed that attention training appears particularly effective on social phobia. Li, Tan, Qian, and Liu (2008) have observed that, in comparison to a control condition, 7-days of attention training toward positive faces diminished attentional bias for negative faces and reduced self-reported fear of social interaction. Similarly, Amir, Weber, Beard, Bomyea, and Taylor (2008) trained, in a single-session, socially phobic individuals either to attend to neutral faces or to a control task in which there were no contingencies between probe and cues. Relative to those who completed the control task, the individuals who underwent attention training reported reduced anxiety in response to an impromptu speech. Moreover, blind raters judged the speeches of those in the attention training group more positively than the speeches of those in the control group. Further, the authors found that changes in attentional biases for threat mediated the effects of the training on anxiety reactivity, and the decrease in anxiety, in turn, improved speech performance. In a recent study, Heeren, Reese, McNally, and Philippot (2012) replicated these findings and extended them to physiological responses to stressors. Likewise, Schmidt, Richey, Buckner, and Timpano (2009) observed that individuals with social phobia who completed eight sessions of attention training toward neutral faces over a 4-week period exhibited a significantly greater reduction in social anxiety and trait anxiety, when compared to individuals who

completed a control condition. At a 4-month follow-up, the training group had improved further on measures of anxiety. Using a similar design, Amir, Beard, Taylor, Klump, Elias, Burns, and Chen (2009) have recently replicated these results.

Taken together, these studies suggest that reducing attentional bias for threat can reduce social anxiety. However, mechanisms underlying these effects are still relatively unknown. As mentioned, it has been repetitively observed that changes in the ability to disengage attention from threat cues on the Posner spatial cueing task mediate the impact of attention training on change in emotional vulnerability to subsequent stressor (e.g., Amir et al., 2008). Further, crossing the presence/absence of disengagement from threat and allocation to non-threat in four different attention training conditions, it has been recently demonstrated that the critical process of attention training in social phobia is the training of attentional disengagement from threat cues (Heeren, Lievens, & Philippot, 2011).

Regarding basic processes underlying attentional biases, recent studies highlighted the important role of top-down executive control in the expression of attention bias toward threat. Centrally, it has been observed that individual differences in the ability to control attention moderate the relationship between attentional bias and anxiety, such that anxious individuals with good attentional control do not exhibit attentional bias for threat (Derryberry & Reed, 2002). As a consequence, attention training may be effective by improving attentional control overall, rather than targeting the stimulus driven components of attentional bias for threat. Supporting this hypothesis, Koster, Baert, Bockstaele, and De Raedt (2010) found that attention training influences late (1500 ms) rather than early (30 or 100 ms) stages of threat processing. Congruently,

in an electroencephalographic experiment, Eldar and Bar-Haim (2010) found that training attention away from pictures of angry faces in trait-anxious individuals reduced P2 and P3 amplitudes and increased N2 amplitude in response to the onset of these stimuli compared to placebo training. They interpreted these data as implying that attention training involves top-down executive attention control rather than early orienting of attention. Consistent with these findings, Browning, Holmes, Murphy, Goodwin, and Harmer (2010) have also showed that attention training altered lateral prefrontal activation to emotional stimuli, reflecting the involvement of top-down processing rather than bottom-up.

However, there is accumulating evidence suggesting that various executive functions are associated with top-down executive control. For instance, using latent-variable analysis to identify the main underlying executive functions, Miyake et al. (2000) have identified partially independent inhibition, shifting, and functions.

The inhibition function is used to resist interference from task-irrelevant stimuli and responses. There is considerable evidence that anxiety impairs the functioning of the inhibition function (see Derakshan & Eysenck, 2009, for a review). For instance, Wieser, Pauli, and Mühlberger (2009) reported that socially anxious individuals exhibited difficulties in inhibiting the reflexive orienting to neutral as well as to emotional stimuli. Further, it is important to note that this result was not due to higher state or trait anxiety of the socially anxious individuals participants, as the additional analyses using these anxiety scores as covariates revealed.

Regarding cognitive model of attentional bias, it has been suggested that the difficulties to inhibit prepotent response may lead to difficulty in disengaging attention

from threat (Derakshan, Ansari, Hansard, Shoker, and Eysenck, 2009). Thus, the present paper focuses on the involvement of the ability to inhibit a prepotent response in the efficacy of attention training in social phobia. We predicted that attention training should lead to improvement in the ability to inhibit prepotent response, which in turn should lead to improvement in the ability to disengage attention from threat.

8.2. Method

8.2.1. Participants

We recruited 36 Caucasian individuals with a primary DSM-IV (American Psychiatric Associations, 1994) diagnosis of Social Phobia from the Université Catholique de Louvain community. A total of 177 volunteers responded to our invitation to take part in an investigation of the mechanisms underlying social interaction among shy people. Seventy-three individuals met the initial eligibility criteria as assessed via a screening questionnaire and subsequently completed a structured interview to assess diagnostic eligibility. To confirm the diagnosis of Social Anxiety Disorder, we administered the social phobia section of the Mini International Neuropsychiatric Interview (MINI; Lecrubier, Weiller, Bonora, Amarin, & Lépine, 1994). One assessor administered the MINI to all participants. She had over two years of CBT training and one year of intensive training on using the MINI to make reliable diagnoses. A second independent assessor with at least three years of CBT training rated a randomly selected portion of the interviews (25%). He had over three years of CBT training and one year of intensive training on using the MINI to make reliable diagnoses. Inter-rater agreement for

the diagnosis was good ($\kappa = .83$). Twenty-five of the 73 pre-selected volunteers did not meet criteria for social phobia and 12 refused to participate. The remaining 36 participants were included in the study; their characteristics appear in Table 1. In addition to a primary diagnosis of Social Anxiety Disorder, all participants: (a) had no current substance abuse, (b) no current or past heart, respiratory, neurological problems, (c) no current or past use of psychotropic medications, (d) were not currently engaged in any form of psychological or psychiatric treatment, and (e) had normal or corrected-to-normal vision. Each participant was tested individually in a quiet laboratory room. Participants received compensation (5 euros) for their participation. We conducted the study in accordance with the ethical standards of the American Psychological Association. We obtained written informed consent from each participant.

8.2.2. Materials

Attention bias modification stimuli. We randomly selected 70 faces (35 men, 35 women) from the Karolinska Emotional Directed Faces database (Lundqvist, Flykt, & Öhman, 1998), which is a standardized set of emotional expressions. All picture were adjusted to exclude interference if background stimuli (hair, clothing) so that only the face was presented. The faces displayed either threatening (i.e., disgust) or neutral facial expressions. We chose disgust faces as threat cues for several reasons. First, disgust conveys a message of aversion or rejection (e.g., Rozin, Lowery, & Ebert, 1994), a central concern of individuals with social phobia (American Psychiatric Association, 1994).

Table 1. *Participants' Characteristics as a Function of Group Allocation (Standard Deviations in Parentheses)*

	Attention training	Control training
<i>n</i>	17	19
Age	21 (3.69)	20.47 (2.58)
% Female	94.11	94.73
BDI-II	15.29 (9.06)	13.32 (8.05)
STAI-T	54.06 (6.24)	49.68 (6.07)
FNE	26.24 (4.42)	25.79 (3.84)
LSAS	84.29 (13.95)	78.16 (15.33)

Note. BDI-II is Beck Depression Inventory-II, STAI-T is Spielberger State-Trait Anxiety Inventory-Trait, FNE is Fear of Negative Evaluation scale; LSAS is Liebowitz Social Anxiety Scale.

Second, previous studies have found that socially anxious individuals exhibit an attentional bias toward disgust faces (Pishyar et al., 2004). Finally, previous studies supporting the effectiveness of attention training programs in reducing attentional bias towards threat cues in social anxiety have used faces expressing disgust as threatening stimuli. We thus used disgust faces to remain consistent with previous work.

Attention bias assessment stimuli. The stimuli used for the attention bias assessment task (modified Posner task) were eight social threat words (e.g., stupid, humiliation, embarrassed) and eight neutral words (e.g., book, radiator, procession). These proportions were based on previous studies on attentional bias in social anxiety (e.g., Amir et al., 2003). Words types were matched on frequency and usage in French (Lambert & Chesnet, 2001; New, Pallier, Ferrand, & Matos, 2001). There was no significant difference in word length between social threat and neutral words, $t(14) = .44, p > .66, d = .23$. We used words, rather than faces, in the assessment trials in order to show that the effects of training with one type of stimulus can be generalized to another type of stimulus.

8.2.3. Measures

Questionnaires. Participants were asked to complete the Trait-Anxiety Inventory (STAI-Trait; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) and the Beck Depression Inventory (BDI-II; Beck et al., 1996) at the beginning of the first training session. Participants were selected according to their responses on the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987).

The STAI-Trait is a 20-item self-report questionnaire assessing anxiety trait vulnerability. Bruchon-Schweitzer and Paulhan (1993) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alphas in the current sample were .78 at baseline.

The BDI is a 21-item self-report measure of the symptoms of depression. Beck, Steer, and Brown (1996) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alphas in the current sample were .87 at baseline.

The LSAS is a 24-item scale that measures the anxiety induced by, and the avoidance of, social interaction and performance situations. Yao, Note, Fanget, Albuissou, Bouvard, Jalenques, and Cottraux (1999) as well as Heeren, Maurage, Rossignol, Van Haelen, Peschard, Eeckhout, and Philippot (in press) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alphas in the current sample were .79 at baseline and .82 at post-training.

The FNE is a 30-item self-report questionnaire that measures a person's apprehension about negative evaluation. Studies have reported good psychometric properties as well as structural validity of the French adaptation of the scale (Douilliez, Baeyens, & Philippot, 2008; Musa, Kostogianni, & Lépine, 2004). Cronbach's alphas in the current sample were .83 at baseline and .84 at post-training.

Measure of inhibition of a prepotent response. The Hayling Task (Burgess & Shallice, 1996; French adapted version, Meulemans, Steyaert, & Vincent, 2001) was used to assess the capacity to inhibit cognitive prepotent responses. There were two conditions (automatic and inhibition), for which two different sets of 15 sentences were assigned. In

the automatic condition, the experimenter read aloud each sentence to the participant. The participant had to listen to the sentence and to complete it with the appropriate word as quickly as possible. In the inhibition condition, participants were instructed to complete the sentence with an unrelated, nonsensical word that as quickly as possible. Two examples for each sentence were given to participants prior to the task. For all trials, if a participant gave an erroneous response, the examiner repeated the instructions. No time limit was given for responding. Two dependent variables were measured: response latency and error rate. Response latencies were recorded using a recorder and latencies were computer-estimated from this recording, beginning when the last word was pronounced by the examiner and ending when the participant began to respond. Burgess and Shallice's (1996) scoring system was used to measure response accuracy in the inhibition condition. Three points were given to participants when they completed the sentence with an appropriate word (e.g., "the captain wanted to stay with the sinking boat"), one point when participants gave an antonym, a semantically related word, or a word that made a vague reference to the target word, and zero points when an unrelated response was provided. A sample of 14 % of the responses was rated by a second independent rater. Inter-rater agreement was good ($\kappa = .79$)

Measure of attention bias. For assessing the effects of training on attention to threat cues, participants were asked to complete an independent measure of attention bias at baseline and after bias induction. We used a modified version of the Posner spatial cueing task identical to that reported in Amir et al. (2003, 2008). Words were presented in lowercase (5-8 mm in height) white letters against a black background in the centre of the screen. Socially threatening or neutral cue words appeared in one of two locations on the

computer screen (i.e., rectangles located to the right or left of a central fixation cross), thereby directing attention to one of two screen locations (i.e., right or left). After 600 ms, the cue word disappeared, and participants were instructed to detect a probe (“*”) that immediately appeared in one of the two locations. The probe remained onscreen until the participant responded, and response latencies were recorded from the onset of the probe to the button press. The inter-trial interval from the target offset to the next fixation cross was 1650 ms. On some trials, the cue word was valid (i.e., the probe appeared in the same location as the cue word). On other trials, the cue word was invalid (i.e., the probe appeared in the location opposite to the cue word).

Participants performed 192 experimental trials, two thirds of which were validly cued ($128 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions} \times 4 \text{ repetitions}$), one sixth were invalidly cued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$), and one sixth were uncued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$). The decision to use these proportions was based on previous research that used the same proportions (Stormark, Nordby, & Hugdahl, 1995). Trial order was randomised for each participant.

Participants completed four practice trials (including four neutral words) prior to the experimental trials. During the practice trials, participants received feedback regarding the accuracy of their response. Feedback was not provided during the experimental trials. Participants sat approximately 30 cm from the computer screen. In previous research using this task (e.g., Amir et al., 2003), socially anxious participants showed significantly longer response latencies on invalid cued social threat trials compared to non-anxious controls, suggesting that an attentional bias may be due to difficulty in disengaging from threatening stimuli.

8.2.4. Attention bias modification

Attentional bias was modified using a standard probe discrimination task, which was modified to train participants either to attend primarily to non-threat cues, or to attend equally to threat and neutral cues. For both conditions, a fixation cross appeared for 500-ms followed either by two facial expressions, a disgust face and a neutral face, presented for 500 ms. Then a probe appeared (i.e., a white arrow), pointing either up or down. The probe remained onscreen until the participant indicated the direction of the arrow by pressing the corresponding button. The inter-trial interval was 1500 ms.

In the attend-to-non-threat condition, a neutral and a threatening face appeared followed by an arrow in the location previously occupied by the non-threatening face on 95% of the trials. In the control condition, there was no contingency between the face cues and probes.

Participants completed 560 trials in one block. Each of the 70 threatening faces was presented four times, paired with a non-threatening face of the same individual, in positions that represented all combinations of the locations and probe types. This procedure was repeated 2 times (i.e., $560 = 70 \text{ stimuli} \times 2 \text{ positions} \times 2 \text{ arrow directions} \times 2 \text{ repetitions}$). The instructions were presented on the computer and were identical for both conditions. Faces were positioned 4 cm from the top/bottom of the screen, 8 cm from the ipsi-lateral edge, 22.5 cm from the contro-lateral edge, and centred vertically. Each face was 7.5 cm tall by 7.5 cm wide.

8.2.5. General Procedure

The procedure consisted of two sessions of attention bias modification, including one day between the two sessions. Participants were randomly assigned to one of the two training conditions. Using a computerized randomization system, the participants and the experimenters were blind to condition. Participants first completed a demographic questionnaire and self-report assessment. Next, they completed the modified Posner spatial cueing task, and the Hayling task, which respectively provided baseline indices of attention bias and of inhibition of prepotent responses. After completing the training, participants again completed the modified Posner spatial cueing task and the Hayling task to respectively examine the influence of attention training on an independent measure of attention bias and of inhibition process overall. Next, participants again filled in the self-report assessment. At the end of the procedure, participants were fully debriefed.

8.3. Results

8.3.1. Group Equivalence

Preliminary analyses indicated no differences among the groups at baseline on STAI-Trait, $t(34) = .76$, $p > .21$, $d = .24$, FNE, $t(34) = .32$, $p > .74$, $d = .11$, BDI-II, $t(34) = .69$, $p > .49$, $d = .24$, LSAS, $t(34) = 1.25$, $p > .22$, $d = .43$. Both groups were similar in terms of age, $t(34) = .50$, $p > .62$, $d = .17$, gender, $\chi^2(1, N = 36) = .01$, $p > .93$, and level of education, $\chi^2(1, N = 36) = 1.72$, $p > .42$. Data appear in Table 1. Although the difference between groups at baseline on LSAS was not significant, the the effect size of the Cohen's d ($d = .43$) was medium. Therefore, we decided to re-run all the analyses

with the LSAS score at baseline as a covariate. However, the same pattern of results was observed.

8.3.2. Compliance monitoring of the training task

The output of the attention modification task was investigated to check compliance with the task instructions (errors and outliers). Participants made very few errors on the training task ($M = 1.04\%$, $SD = .21$) and there were few outliers ($M = 1.46\%$, $SD = .11$). Both conditions did not differ with regard to the number of erroneous responses or outliers (all $ps > .40$). Further, these results also suggest that participants were compliant to the attention modification task.

8.3.3. Independent measure of attentional bias

Data reduction. Before the main analyses, response latency data from attention bias assessment were prepared in keeping with recommendations from Radcliff (1993). First, trials with incorrect responses were excluded (.52 % of the data). Second, latencies less than 100 ms or greater than 2000 ms were eliminated from analysis of the pre- and post-training assessment tasks (.45% of trials with correct responses). Third, response latencies more than 2.5 standard deviations below or above each participant's mean were discarded as outliers (1.2 % of the remaining trials). At baseline, both groups did not differ significantly in error rates, $t(34) = .03$, $p > .97$, $d = .01$.

Change in attentional bias. We subjected response latencies to a 2 (Groups: Attention training, Control training) x 2 (Time: Pre-training, Post-training) x 2 (Cue Validity: valid, invalid) x 2 (Word Type: threat, neutral) analysis of variance (ANOVA)

with repeated measurement on the last three factors. The ANOVA revealed a significant Group x Time x Validity interaction, $F(1, 34) = 6.11, p = .02, \eta_p^2 = .15$.

To follow-up this three-way interaction, we computed separate Group x Time ANOVAs for valid and invalid trials. For valid trials, the interaction was not significant, $F(1, 34) = .028, p = .87, \eta_p^2 < .01$. For invalid trials, analyses revealed a significant Time x Condition interaction, $F(1, 34) = 4.07, p < .05, \eta_p^2 = .11$.

However, although both groups did not differ in their performance at baseline, $t(34) = .54, p > .83, d = .28$, a comparison Student *t*-test computed on reaction times to invalid trials at post-training showed no significant difference between groups, $t(34) = 1.49, p = .14, d = .51$. Nevertheless, while participants from the Control Condition showed no significant differences from baseline to post-training, $t(18) = .17, p = .87$, those from the Attention training condition showed a significant decrease in reaction times for invalid trials, $t(16) = 2.80, p < .01$. Data appear in Table 2.

Table 2. Means of Response Latencies in milliseconds by Group on the Spatial Cueing Task (Standard Deviations in Parentheses)

Trials		Condition			
		Control training		Attention training	
Validity	Material	Baseline	Post-training	Baseline	Post-training
Valid	Neutral	394.16 (59.51)	359.67 (67.71)	360.84 (34.85)	368.97 (33.21)
	Threat	392.41 (60.55)	350.73 (64.67)	421.89 (45.32)	410.54 (46.73)
Invalid	Neutral	423.19 (70.99)	432.73 (80.20)	326.72 (40.38)	335.53 (43.28)*
	Threat	424.02 (67.49)	422.45 (78.28)	392.18 (54.87)	386.41 (47.47)*

Note. “*” indicates a significant difference between pre- and post- training in that group according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons. **p* < .01

Table 3. Means of Scores and Response Latencies in milliseconds by Group on the Hayling Task (Standard Deviations in Parentheses)

		Condition			
		Control training		Attention training	
		Baseline	Post-training	Baseline	Post-training
Performance	Part A	601.84 (62.29)	547.11 (60.65)	597.56 (71.65)	551.47 (47.59)
	Part B	3347.48 (1260.61)	2933.16 (1992.40)	2951.64 (968.22)	2359.20 (841.26)
Accuracy	Part B	6.11 (2.71)	5.79 (4.76)	7.64 (3.889)	5.59 (4.73)

Note. There was no significant difference between pre- and post- training for both groups according to paired *t*-test comparisons. For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons.

8.3.4. Self-report assessment of social anxiety

For the LSAS, we subjected responses to a 2 (Groups: Attention training, Control training) x 2 (Time: Pre-training, Post-training) ANOVA with repeated measurement on the last factors. Analyses only revealed a main effect of Time, $F(1, 34) = 9.18, p < .01, \eta_p^2 = .21$. The Group x Time interaction was not significant, $F(1, 34) = 1.49, p = .23, \eta_p^2 = .04$. Data appear in Figure 1.

For the FNE, we subjected responses to a 2 (Groups: Attention training, Control training) x 2 (Time: Pre-training, Post-training) ANOVA with repeated measurement on the last factors. Analyses revealed a main effect of Time, $F(1, 34) = 7.18, p < .02, \eta_p^2 = .17$, as well as a significant Group x Time interaction, $F(1, 34) = 6.19, p < .02, \eta_p^2 = .15$. Participants from control training showed no differences from baseline to post-training, $t(18) = .12, p > .90$. In contrast, participants who were in attention training condition reported significant decreases in social anxiety from baseline to post-training, $t(16) = 4.74, p < .001$. However, while the groups did not differ in their scores at baseline, $t(34) = .34, p > .74, d = .01$, comparison student t-tests computed on the score at post-training, $t(34) = .62, p = .54, d = .21$, did not revealed significant difference between groups. Data appear in Figure 2.

Figure 1. Mean score of the Liebowitz Social Anxiety Scale as a Function of Group Allocation. Error bars represent standard error of the mean.

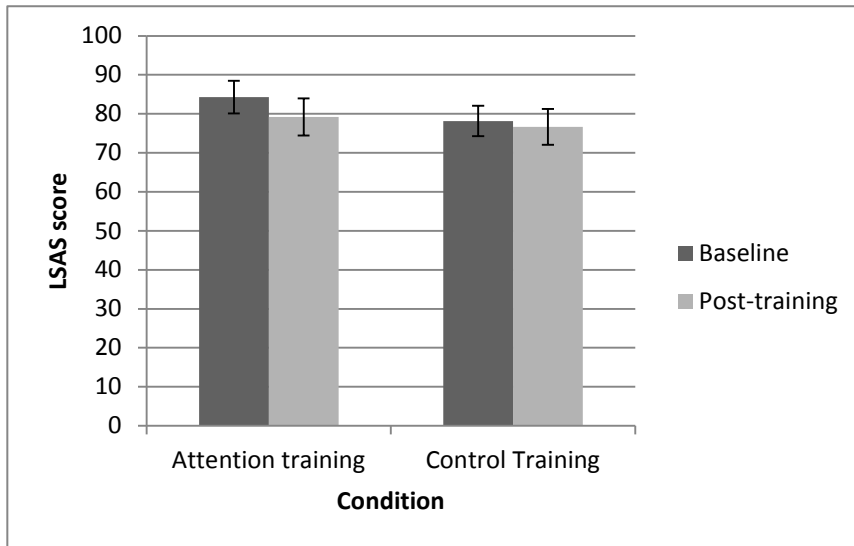
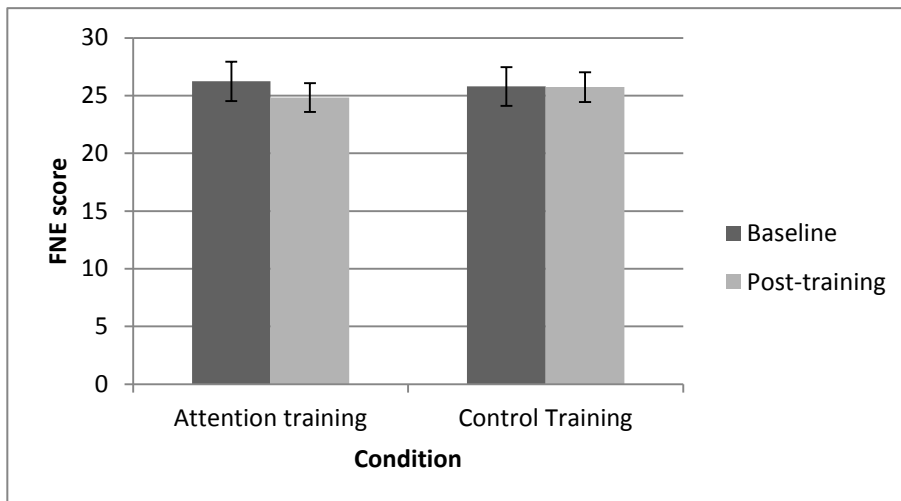


Figure 2. Means score of the Fear of Negative Evaluation as a Function of Group Allocation. Error bars represent standard error of the mean.



8.3.5. *Change in inhibition process*

Data reduction. Before the main analyses, response latencies more than 2.5 standard deviations below or above each participant's mean were discarded as outliers (0.7 % of the remaining trials). At baseline, groups did not differ significantly in outliers, $t(34) = .02, p > .92, d = .01$. In order to best estimate the time required for inhibit the prepotent response and select an alternative one, we computed a difference score involving the subtraction of the responses latencies of the Automatic Part from the Inhibition part of the Hayling.

Change in response latencies. We subjected the difference to a 2 (Groups: Attention training, Control training) x 2 (Time: Pre-training, Post-training) ANOVA with repeated measurement on the last factor. The ANOVA revealed a significant main effect of Time, $F(1, 34) = 10.51, p < .01, \eta_p^2 = .24$. The Group x Time interaction was not significant, $F(1, 34) = .45, p = .51, \eta_p^2 = .01$. Data appear in Table 3

Change in error score. We subjected the error score to a 2 (Groups: Attention training, Control training) x 2 (Time: Pre-training, Post-training) ANOVA with repeated measurement on the last factor. The ANOVA did not reveal significant main effect of Time, $F(1, 34) = 1.84, p = .18, \eta_p^2 = .05$, Group x Time interaction, $F(1, 34) = .99, p = .33, \eta_p^2 = .03$. Data appear in Table 3.

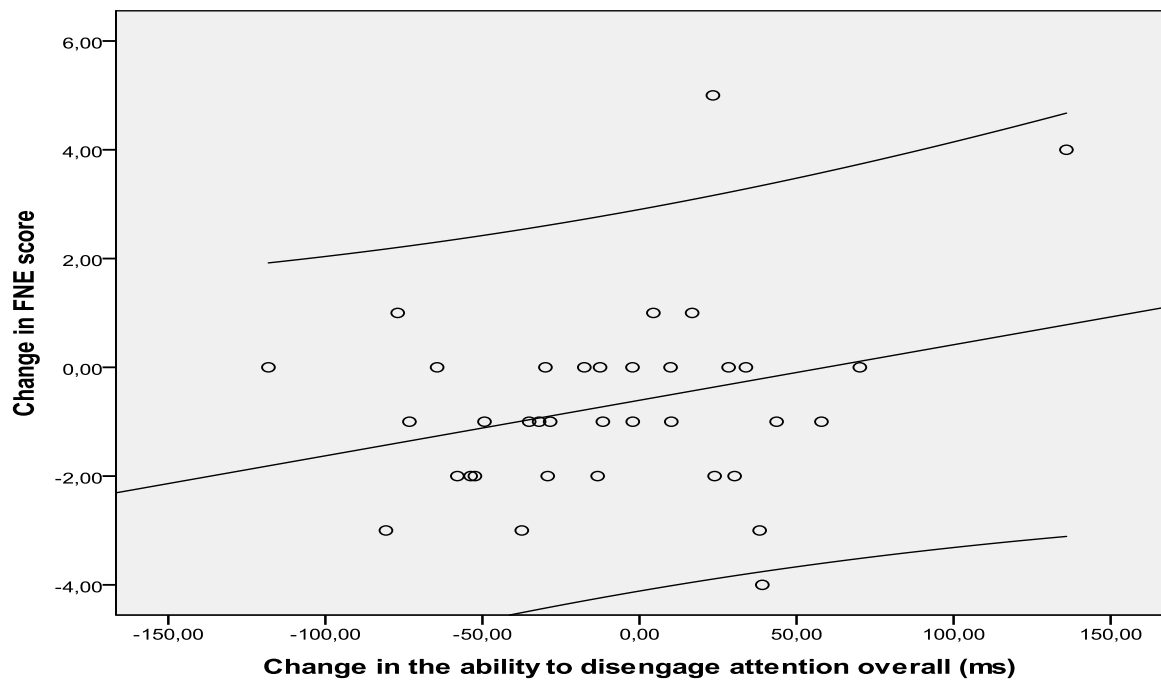
8.3.6. *Relationship between changes on inhibition, attention, and social anxiety*

First, we examined whether change on reaction times for invalid trials significantly correlated with change on social anxiety. As shown on Figure 3 change from baseline to post-training on invalid trials overall significantly correlated with change on fear of negative evaluation, $r(36) = .34, p < .05$.

Then, to examine whether changes in the ability to disengage attention overall mediated changes FNE, we performed mediational analyses according to MacKinnon, Fairchild, and Fritz's (2007) procedure. This procedure tests the product of the coefficients for the effects of (a) the independent variable (contrast coded: Attention training: +1; Control = -1) to the mediator (change in reaction for invalid trials from baseline to post-training) (alpha), and (b) the mediator to dependent variable when the independent variable is taken into account (beta). This procedure is a variation of the Sobel (1982) test that accounts for the nonnormal distribution of the alpha–beta path through the construction of asymmetric confidence intervals (MacKinnon et al., 2007). We examined whether change in attentional bias mediated the impact of training condition on the dependent variables. However, the results were not consistent with a statistically significant mediation. The 95% confidence interval of the indirect path (alpha–beta) did not contain zero (lower limit = -.337, upper limit = .057). Results from the Sobel test supported this conclusion, $Z = 1.44, p = .15$ (two-tailed).

We also examined whether change on the Hayling task significantly correlated with change on FNE and change in reaction times for invalid trials. However, there were no significant correlations with the FNE, $r(36) = .01, p = .95$, nor with the change on invalid trials, $r(36) = .27, p = .11$.

Figure 3. Relationship between change in the ability to disengage attention overall and change in fear of negative evaluation. Lines below/above the regression line represent 95% confidence interval of the estimated point.



8.4. Discussion

The primary purpose of this study was to answer two major questions. First, does attention training improve the ability to inhibit prepotent response overall? Second, we sought to further examine whether the impact of attention training on the ability to inhibit prepotent response would result in reduced difficulty to disengage attention from threat, which in turn would result in reduced anxiety.

First, consistent with previous studies (e.g., Heeren et al., 2011; Li et al., 2008), participants trained to attend to non-threat stimuli reported reductions in self-reported assessment of the fear of being negatively evaluated. They also reported decreased reaction times for invalid trials. In contrast, participants from the control condition showed no such reductions. Moreover, although there was no mediation of this latter change on the former one, change on invalid trials overall significantly correlated with change on fear of negative evaluation.

However, the present study failed to replicate previous findings showing that attention training reduced attentional bias for threat (e.g., Amir et al., 2008; Heeren et al., 2011). In addition, the present study also failed to replicate previous studies demonstrating that attention training reduces LSAS-score (e.g., Heeren et al., 2012).

Different explanations may be formulated. First, one cannot exclude the possibility that our effects are related to the absence of attentional bias for threat at baseline. Indeed, recent studies have suggested that the efficacy of attention training for social phobia required that participants exhibit that bias before training (e.g., Amir, Taylor, Donohue, 2011). To test for an attentional bias for threat at baseline, we

computed a 2 (Cue Validity: valid, invalid) x 2 (Word Type: threat, neutral) analysis of variance (ANOVA) with repeated measurement on the last two factors. Data revealed that there was no significant Cue Validity x Word Type interaction $F(1, 36) = 1.59, p = .22, \eta_p^2 = .04$, indicating the absence of attentional bias for threat at baseline. This is in striking contrast with Heeren et al. (2012) who reported that their participants strongly exhibited an attentional bias for threat at baseline.

Second, in comparison to previous study demonstrating that attention training reduces LSAS (e.g., Heeren et al., 2012), our sample of participants are not specifically only generalized social phobia but also specific social phobics, whereas they all had a generalized social phobia. One cannot exclude the possibility that training to attend away from threat may benefit only highly anxious individuals. As argued by Koster, Baert, Bockstaele, and De Raedt (2010), this divergence can be explained if one assumes that high-anxious individuals (i.e., generalized anxiety disorder and social anxiety disorder) exhibit attentional biases to a wide range of mildly threatening cues (Mogg & Bradley, 1998). Therefore, as demonstrated by Amir et al. (2009), Schmidt et al. (2009) and Heeren et al. (2011), training to attend away from threat may be helpful in anxiety disorders marked by these attentional biases towards mildly threatening cues. However, in accordance with theories of fear reduction predicting that attentive processing of threat is required to facilitate emotional processing (Foa & Kozak, 1986), training to attend to threat may be helpful in anxiety disorders driven by a narrow band of threat cues (e.g., more specific social phobia). Finally, regarding the impact of attention training on the ability to disengage attention overall, one cannot exclude that, because of the absence of

attention bias for threat at baseline, the training just improved participant's ability to orient attention overall.

The present study has limitations. First, we used only self-reported assessment of social anxiety. Second, we used the Hayling task as a measure of inhibition process. However, as argued by Eysenck and Derakshan (2011), it is important for research in this context to use conceptually simple tasks that are as process pure as possible. The Hayling task, including semantic knowledge, certainly cannot fulfill this latter condition. The antis-sacade task was identified by Miyake et al. (2000) as such a task. In this task, a visual cue is presented to the left or the right of the fixation point, and the instruction are to make an eye movement to the opposite side as quickly as possible. The latency of the first saccade to the correct side is measured. There is also a control task (the pro-saccade task), in which the instructions are to fixate the cue when it appears. Third, we used words for both assessment of attentional bias and inhibition. An alternative explanation for the findings would be that the Hayling task and the Posner spatial cueing task using words use similar semantic and verbal cognitive components, leading to cascading interference. Future studies may use pictures for the spatial cueing task.

In conclusion, consistent with previous studies, the present findings replicate the effect of attention training on self-reported assessment of social anxiety (e.g., Li et al., 2008). However, our prediction of an involvement of inhibition process on the impact of attention training was not observed. However, as we developed, the present study suffers from several limitations that may account for the absence of the predicted effect.

8.5. Rationale for the transition from Study 6 to Study 7

In Study 6, because some cognitive models posit that inhibition plays an important role in the phenomenon of delayed disengagement from threat (e.g., Eysenck et al., 2007), we assessed the ability to inhibit a prepotent response before and after a standard attention training and a no-contingency condition. We predicted that attention training would lead to improvement in the ability to inhibit prepotent response, which in turn would lead to improvement in the ability to disengage attention from threat. Although participants trained to attend to non-threat stimuli reported reductions in self-reported assessment of the fear of being negatively evaluated, we failed to find any effect of attention training on the inhibition of a prepotent response. However, we did not find any effect of attention training on the ability to disengage from threat. Again, one cannot exclude the possibility that our effects are related to the absence of attentional bias for threat at baseline. Further, regarding the assessment of the ability to inhibit a prepotent response, we used the Hayling task. We now realize that the Hayling task exhibits a better reliability in the assessment of the ability to inhibit a prepotent response in people with brain damages (such as tumors, strokes, acquired brain injury, dementia) than in healthy people (e.g., Burgess & Shallice, 1996). Moreover, as argued by Eysenck and Derakshan (2011), it is important for research in the context of information-processing bias to use conceptually simple tasks that index a process as purely as possible. The Hayling task, including semantic knowledge, certainly cannot fulfill this latter condition. Perhaps the first step in this direction should be to examine whether an attention training

protocol that utilizes non-affective stimuli, such as geometric shapes improves delayed disengagement from threat, which in turn, reduces anxiety.

As we pointed out in the General Introduction, within the cognitive models accounting for attentional bias for threat, only one explicitly states that anxiety disorders may stem from attentional bias (i.e., Bar-Haim et al. (2007)). At an empirical level, we reviewed the few studies that have examined the hypothesis that individual differences in attentional bias for threat can causally impact on vulnerability to anxiety through modified response to subsequent stressor. Although MacLeod et al. (2002) and Eldar et al. (2008) reported evidence in favor of this hypothesis, it remains unclear how this effect occurs. For instance, both studies included a probe discrimination task as a measure of attentional bias for threat, which is less than ideal for distinguishing among subcomponents of attentional biases (i.e., difficulties to disengage from threatening stimuli vs. facilitated attention orientation for threatening stimuli). To address this issue, researchers could administer, for instance, a modified version of the Posner paradigm as an independent measure of attention bias before and after training. Moreover, it remains unclear whether participants who are trained to attend to specific threatening stimuli (e.g., reject faces) show more anxiety during social exclusion specifically, or whether they would also exhibit other changes in mood.

Study 7 explicitly investigates this issue. We used an experimental design similar to MacLeod et al. (2002), which involved two consecutive experimental phases: an attentional bias induction phase and a stress phase. During the attentional bias induction, participants completed modified versions of a dot-probe task; for half of the participants the task was designed to induce a biased attentional response for faces expressing disgust,

for the other half, the task induced no bias. Then, all participants were exposed to a task inducing social rejection. We predicted that training to attend to threatening stimuli should lead to increase in delayed disengagement from threat, which in turn should lead to increase reactivity to the social stressor.

Chapter 9

The Causal Role of Attentional Bias for Threat Cues in Social Anxiety:

A Test on a Cyber-Ostracism Task

(Study 7)

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Heeren, A., Peschard, V., & Philippot, P. (in press). The causal role of attentional bias for threat cues in social anxiety: A test on a cyber-ostracism task. *Cognitive Therapy and Research*

Abstract

Cognitive models of social phobia postulate that attentional biases for threat play an important role in the maintenance of this disorder (e.g., Clark, 2001). Consistent with this idea, studies have demonstrated that training social phobics to attend to non-threatening stimuli results in clinical benefits (Amir et al., 2008). However, no study has directly examined the causal status of selective attentional bias in social phobia. The present study explicitly investigated this issue. We used an experimental design similar to MacLeod et al. (2002), which involved two consecutive experimental phases: an attentional bias induction phase and a stress phase. During the attentional bias induction, participants completed modified versions of a dot-probe task; for half of the participants the task was designed to induce a biased attentional response for faces expressing disgust, for the other half, the task induced no bias. Then, all participants were exposed to a task inducing social rejection. Results indicate that the induction of an attentional bias for threatening information resulted in increased anxiety during social rejection. Implications for cognitive models of social phobia are discussed.

Keywords: Attention bias modification, social phobia, attentional bias, emotional vulnerability, cyber-ostracism, social exclusion

9.1. Introduction

Most cognitive models of anxiety pose that selective attention to threat cues contributes to the development and maintenance of emotional disorders (e.g., Mathews & MacLeod, 1994; Williams, Watts, MacLeod, & Mathews, 1997). Selective attention in social anxiety may take the form of attentional bias for internal or external threat cues. Attentional bias for internal threat cues (e.g., negative self-evaluation, physiological symptoms) may contribute to social anxiety by interfering with the ability to process external cues that disconfirm social fears (Clark & Wells, 1995). Conversely, excessive attention to external threat cues (e.g., disgust faces) may encourage one to interpret that the environment is more threatening than it actually is, thus promoting anxiety (e.g., Bradley, Mogg, Falla, & Hamilton, 1998; Mogg & Bradley, 1998).

Attention to external threat cues has often been investigated using probe detection and probe discrimination tasks. In these tasks, individuals with social anxiety respond faster to probes replacing threat cues than to probes replacing neutral cues, which demonstrates an attentional bias for threat that is absent in non-anxious individuals (e.g., Mogg, Philippot, & Bradley, 2004; Pishyar, Harris, & Menzies, 2004). Recent studies have attempted to dismantle this bias to identify which attention component underlies it. Most of these studies used the modified Posner (1980) spatial cueing task in which a threat (or non-threat) cue appears on either the left or right side of a computer screen, followed by a probe that either replaces the cue or appears on the other side of the screen (e.g., Amir, Elias, Klumpp, & Przeworski, 2003; Fox, Russo, Bowles, & Dutton, 2001). These studies showed that anxious participants are no faster to respond to probes

replacing threat than non-threat cues, but they are slower to respond to probes that appear opposite to threat cues relative to non-threat ones. This pattern of results suggests that, rather than being faster to engage attention to threat, anxious participants experience difficulties in disengaging attention from threat (e.g., Amir, et al., 2003). Recent evidence using eye-tracking measures confirms that individuals with social anxiety exhibit difficulties in disengaging their attention from social threat cues (Buckner, Maner, & Schmidt, 2010).

Beyond these cross-correlational studies, recent evidence supports the notion that attentional bias for external threat cues is causally involved in the maintenance of social anxiety. Li, Tan, Quian, and Liu (2008) have observed that 7-days of training attention towards positive faces diminished attentional bias for negative faces. Moreover, this training reduced self-reported fear of social interaction. Similarly, Amir, Weber, Beard, Bomyea, and Taylor (2008) trained, in a single-session, socially phobic individuals either to attend to neutral faces or to perform a control task in which there was no contingency between probes and cues. As compared to the latter condition, the former reduced self-reported anxiety in response to an impromptu speech. Further, using a modified Posner paradigm after attention training, these authors observed that the improvement in the ability to disengage attention from threat mediated the effects of training on anxiety reactivity, and that this decrease in anxiety, in turn, improved speech performance. Recently, Heeren, Reese, McNally, and Philippot (submitted) have replicated these observations and extended their findings to changes in sympathetic activation to stressors. They observed that change in attentional bias occurring after attention training mediated a reduction in skin conductance reactivity to an impromptu

speech. Likewise, Schmidt, Richey, Buckner, and Timpano (2009) have observed that training individuals with social phobia to attend to neutral faces led to a significant reduction in social anxiety and trait anxiety, in comparison to a control group exposed to no contingency between the cues and probe. In this study, the protocol included eight 20-min sessions delivered over a 4-week period (i.e., twice weekly sessions). At a 4-month follow-up, the treatment group had improved further on measures of anxiety. Using a similar design, Amir, Beard, Taylor, Klump, Elias, Burns, and Chen (2009) have replicated these results.

These results are consistent with the hypothesis that attention bias is causally involved in the maintenance of social anxiety. However, cognitive models also postulate that attentional bias for threat plays a causal role, not only in the maintenance, but also in the installation of social anxiety (e.g., Clark, 2001). Only one study has directly assessed the impact of an induced attentional bias on anxiety proneness (MacLeod, Rutherford, Campbell, Ebbsworthy, & Holker, 2002). Using a dot-probe detection task, MacLeod and colleagues trained non-anxious participants to attend either to neutral or to threatening stimuli. The task comprised 672 trials in which pairs of words (one threatening and one neutral) appeared on a computer screen. In the attend-to-threat condition, probes replaced threat words (e.g., bomb, dead, nausea, sad), whereas in the attend-to-neutral condition, probes replaced neutral words (e.g., curve, league, journal, aisle). Participants had to press a button as soon as they detected the probe. Relative to those trained to attend to neutral material, participants trained to attend to threat material reported more anxiety and negative mood after performing a stressful anagram task. This result suggests that

selective attention for negative information increases anxiety reactivity to an experimental stressor.

However, it is not yet known whether a similar causal relationship between attention to threat and anxiety reactivity also applies to the development of social anxiety. Two aspects of this question require further consideration. First, it remains unclear whether participants who are trained to attend to socially threatening stimuli (e.g., disgust faces) would show more anxiety during social exclusion specifically, or whether they would also exhibit other changes in mood. Second, the anagram task used by MacLeod et al. (2002) was a very explicit stressor. It might be that a change in processing bias might impact on reactions to the explicit stressors without actually modifying emotional vulnerability to more subtle (or weaker) stressors. Indeed, it has been reported that socially anxious individuals tend to evaluate less explicit (or more ambiguous) information as more threatening than non-anxious controls (e.g., Amir, Beard, & Bower, 2005; Stoppa & Clark, 2000; Yoon & Zinbarg, 2007). Therefore, uncertainty abounds regarding the impact of attentional bias induction on more ambiguous (or less explicit) stressors.

Using an experimental design similar to that used by MacLeod et al. (2002), the present experiment addressed these issues. During the attentional bias inducing phase, participants completed modified versions of a dot-probe task; for half of the participants the task was designed to induce a biased attentional response for faces expressing disgust, for the other half the task induced no bias. Then, all participants performed a task that exposed them to an explicit as well as an implicit social rejection, based on a cyberball task (see below). Attentional biases were also assessed both before and after the

attentional bias induction phase. This allowed us to control whether attentional responses to emotional information were indeed systematically altered by the experimental procedure. We predicted that inducing an attentional bias for social threat in healthy people would result in an increase of anxiety during the explicit as well as the implicit social rejection task.

9.2. Method

9.2.1. *Participants*

We recruited 42 Caucasian individuals from a large university community; their characteristics are displayed in Table 1. They were all French speaking. They were invited to take part in the experiment presented as an investigation of the effects of cognitive abilities on mental visualization during a videogame. They were selected using the French version of the Liebowitz Social Anxiety Scale (LSAS; Liebowitz, 1987). In order to select non-socially anxious individuals, they all have a LSAS-score below 24 (i.e., the lower quartile of the large university community sample we administered the LSAS). Further, to ensure that their level of social anxiety was extremely low, we computed a one-sample-t-test testing whether their LSAS score were significantly lower than 81 (i.e., the French-LSAS-mean score among a sample of patients diagnosed as social phobics; Yao et al., 1999). Data confirmed that the mean score of our sample ($M = 13.18$, $SD = 6.23$) was significantly lower than social phobics, $t(41) = -70.59$, $p < .00001$ (one-tailed). In addition, all participants: (a) had no current or past substance abuse, (b) no current or past heart, respiratory, neurological problems, (c) no current or past use of psychotropic medications, (d) were not currently engaged in any form of psychological or

psychiatric treatment, and (e) had normal or corrected-to-normal vision. They received compensation (5 euros and a lottery ticket) for their participation. The study conformed to the ethical standards of the American Psychological Association.

Table 1. *Participants' Characteristics as a Function of Group Allocation (Standard Deviations in Parentheses)*

	Attend-to-threat condition	Control condition
<i>n</i>	21	21
Age	22.17 (3.93)	22.11 (3.41)
% Female	55.6	50.0
Years of Education	15.94 (1.39)	15.78 (1.06)
BDI-II	5.29 (0.94)	4.33 (1.59)
STAI-T	35.14 (1.66)	36.86 (1.51)
NBS	38.69 (6.02)	37.89 (6.87)
LSAS	12.02 (6.61)	14.33 (6.22)

Note. BDI-II is Beck Depression Inventory-II, STAI-T is Spielberger State-Trait Anxiety Inventory-Trait, NBS is Need to Belong Scale; LSAS is Liebowitz Social Anxiety Scale.

9.2.2. Measures

Questionnaires. The French version of the Trait Anxiety Inventory (STAI-Trait; Spielberger et al., 1983) is a 20-item self-report questionnaire assessing anxiety trait vulnerability. Bruchon-Schweitzer and Paulhan (1993) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .87.

The French version of the Beck Depression Inventory (BDI-II; Beck, Steer & Brown, 1996) is a 21-item self-report measure of the symptoms of depression. Beck, Steer, and Brown (1998) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .80.

The French version of the Need to Belong scale (Leary et al., 2007; French version: Kuppens & Yzerbyt, 2011) is a 10-item self-report measure assessing the need to belong (Leary, Kelly, Cottrell, & Scheindorfer, 2007). Kuppens and Yzerbyt (2010) have reported good psychometric properties of the French version. Cronbach's alpha in the current sample was .84.

The LSAS is a 24-item scale that assesses a range of social interaction and performance situations that individuals with social phobia may fear and/or avoid. Yao et al. (1999) and Heeren et al. (in press) have reported good psychometric and structural properties of the French adaptation of the scale. Cronbach's alpha in the current sample was .88.

Visual Analogue Scale. To assess the level of negative mood and anxiety states at baseline, at post-inducing and during the stress phase, participants completed two visual

analogue scales on a computer. Each scale consisted of a 740-pixel horizontal line. One was an anxiety scale anchored from *relaxed* to *anxious* and the other was a mood scale anchored from *happy* to *depressed*. Previous studies on attention bias modification have used similar scales (e.g., MacLeod et al., 2002). To complete these scales, participants used the mouse to move a cursor along the line corresponding to their current state. This yielded a score between 0 and 740 pixels, depending on which point on the line was selected. For each response, the presentation order of the scales and localization of the anchor label (i.e., from happy to relaxed vs. from relaxed to happy) were randomised.

Measure of attention bias. For assessing the effects of training on attention to threat cues, participants were asked to complete an independent measure of attention bias at baseline and after bias induction. We used a modified version of the Posner spatial cueing task identical to that reported in Amir et al. (2008, 2010). Regarding the stimuli, eight social threat words (e.g., stupid, humiliation, embarrassed) and eight neutral words (e.g., book, radiator, procession) were used. These proportions were based on previous studies on attentional bias in social anxiety (e.g., Amir et al., 2003). Words types were matched on frequency and usage in French (Lambert & Chesnet, 2001; New, Pallier, Ferrand, & Matos, 2001). There was no significant difference in word length between social threat and neutral words, $t(14) = .44$, $p > .66$, $d = .23$. We used words, rather than faces, in the assessment trials in order to show that the effects of training with one type of stimulus can be generalized to another type of stimulus.

During the task, words were presented in lowercase (5-8 mm in height) white letters against a black background in the centre of the screen. Socially threatening or neutral cue words appeared in one of two locations on the computer screen (i.e.,

rectangles located to the right or left of a central fixation cross), thereby directing attention to one of two screen locations (i.e., right or left). After 600 ms, the cue word disappeared, and participants were instructed to detect a probe (“*”) that immediately appeared in one of the two locations. The probe remained onscreen until the participant responded, and response latencies were recorded from the onset of the probe to the button press. The inter-trial interval from the target offset to the next fixation cross was 1650 ms. On some trials, the cue word was valid (i.e., the probe appeared in the same location as the cue word). On other trials, the cue word was invalid (i.e., the probe appeared in the location opposite to the cue word).

Participants performed 192 experimental trials, two thirds of which were validly cued ($128 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions} \times 4 \text{ repetitions}$), one sixth were invalidly cued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$), and one sixth were uncued ($32 = 8 \text{ words} \times 2 \text{ word types} \times 2 \text{ word positions}$). The decision to use these proportions was based on previous research that used the same proportions (Stormark, Nordby, & Hugdahl, 1995). Trial order was randomised for each participant.

Participants completed four practice trials (including four neutral words) prior to the experimental trials. During the practice trials, participants received feedback regarding the accuracy of their response. Feedback was not provided during the experimental trials. Participants sat approximately 30 cm from the computer screen. In previous research using this task (e.g., Amir et al., 2003), socially anxious participants showed significantly longer response latencies on invalid cued social threat trials compared to non-anxious controls, suggesting that an attentional bias may be due to difficulty in disengaging from threatening stimuli.

Social rejection task. Cyberball (e.g., Williams, 2007) is a virtual ball-tossing task in which participants are told they are playing with two others participants connected over the Intranet, although the other “players” are, in fact, computer generated. Participants are informed that it does not matter who throws or catches, but rather, that they should use the animated ball-toss game to assist them in visualizing the other player. The cover story is meant to assure participants that not getting the ball has no detrimental effects on their performance in the experiment. The time taken by each of the computer-generated players to make their decision and throw the ball was varied each turn to increase the believability that they were “real” participants.

Each participant was submitted to three different conditions during the Cyberball task: the inclusion condition, the explicit ostracism condition, and the implicit ostracism condition. During the inclusion condition, the probability that participants would be thrown the ball was 67%. During the explicit ostracism condition, the probability that participants would be thrown the ball was 0%. During this condition, participants saw that the two others players were still playing together. During the implicit ostracism condition, the probability that participants would be thrown the ball was again 0%. However, during this condition, participants did not see that the two others players were still playing, instead, a screen appeared indicating that there was a technical problem involving a network transitory disconnection. This last condition was added to assess the differential effects of emotional responding to an explicit versus implicit social exclusion condition. Indeed, Eisenberger et al. (2003) previously reported that regardless of whether ostracism was intentional or not, it was associated with increased activation of the dorsal anterior-cingulate cortex among healthy participants, a region of the brain that

shows activation during, among others, exposure to loss of social connections (e.g., Lieberman, 2007).

Each condition lasted for 50 throws, except the implicit ostracism condition, which presented the technical problem for 60 seconds. To avoid a carry-over effect, the order of the two ostracism conditions were counter-balanced across participants. Computerized visual analogue scales (see emotional assessment) were used to record the degree to which each procedure served to elevate levels of anxiety. Emotional reactivity was assessed before and after the attentional bias induction phase, just prior to the cyberball task, and after each condition of the cyberball task.

9.2.3. Attention bias modification

Material. We randomly selected 70 Caucasian face pairs without hairlines (35 men, 35 women) from the Karolinska Emotional Directed Faces database (Lundqvist, Flykt, & Öhman, 1998), which is a standardized set of emotional expressions. The faces displayed either threatening (i.e., disgust) or neutral facial expressions. We chose disgust faces as threat cues for several reasons. First, disgust conveys a message of aversion or rejection (e.g., Rozin, Lowery, & Ebert, 1994), a central concern of individuals with social phobia (American Psychiatric Association, 1994). Second, previous studies have found that socially anxious individuals exhibit an attentional bias toward disgust faces (Pishyar et al., 2004). Finally, previous studies supporting the effectiveness of attention training programs in reducing attentional bias towards threat cues in social anxiety have used faces expressing disgust as threatening stimuli. We thus used disgust faces to remain consistent with previous work.

Bias modification task. Attentional bias was induced using a standard probe discrimination task, which was modified to train participants either to attend primarily to threat cues, or to attend equally to threat and neutral cues. For both conditions, a fixation cross appeared for 500-ms followed either by two facial expressions, a disgust face and a neutral face, presented for 500 ms. Then a probe appeared (i.e., a white arrow), pointing either up or down. The probe remained onscreen until the participant indicated the direction of the arrow by pressing the corresponding button. The inter-trial interval was 1500 ms.

In the attend-to-threat condition, a neutral and a threatening face appeared followed by an arrow in the location previously occupied by the threatening face on 95% of the trials. In the control condition, there was no contingency between the face cues and probes.

Participants completed 560 trials in one block. Each of the 70 threatening faces was presented four times, paired with a non-threatening face of the same individual, in positions that represented all combinations of the locations and probe types. This procedure was repeated 2 times (i.e., $560 = 70 \text{ stimuli} \times 2 \text{ positions} \times 2 \text{ arrow directions} \times 2 \text{ repetitions}$). The instructions were presented on the computer and were identical for both conditions. Faces were positioned 4 cm from the top/bottom of the screen, 8 cm from the ipsi-lateral edge, 22.5 cm from the contro-lateral edge, and centred vertically. Each face was 7.5 cm tall by 7.5 cm wide.

9.2.4. General Procedure

The procedure was based on a previous study examining the effect of a single-session of attention bias modification on reactivity to a social stressor (Amir et al. 2008). Participants were randomly assigned to one of the two attention training conditions ($n_{\text{attention-to-threat}} = 21$, $n_{\text{control}} = 21$). Using a computerized randomization system, the participants and the experimenters were blind to condition. Participants first completed a demographic questionnaire, the STAI (Trait version), NBS, and BDI-II as well as visual analogue scales assessing mood and anxiety. Next, they completed the modified Posner spatial cueing task, which provided a baseline index of attention bias. Participants then completed the bias induction task. After completing the training, participants again filled in the visual analogue scales to assess the immediate effect of the training task on participants' mood and anxiety. Next, participants again completed the modified Posner spatial cueing task to examine the influence of attention training on an independent measure of attention bias. Finally, participants performed the cyberball task. They also completed the visual analogue scale immediately after each condition of the cyberball task. At the end of the procedure, participants were fully debriefed. The possibility to remove the induced bias, using the reverse procedure, was proposed to participants who were in the attend-to-threat condition.

9.3. Results

9.3.1. Group characteristics

Preliminary analyses indicated no significant differences among the groups at baseline on STAI-Trait, $t(40) = .76$, $p > .45$, $d = .24$, NBS, $t(40) = .401$, $p > .69$, $d = .13$,

BDI-II, $t(40) = .52, p > .60, d = .16$, LSAS, $t(40) = 1.21, p > .23, d = .38$. Both groups were similar in terms of age, $t(40) = .63, p > .53, d = .20$, gender, $\chi^2(1, N = 42) = 1.62, p > .20$, and years of education, $t(40) = 1.39, p > .17, d = .44$. Means and standard deviations for each variable of each group appear in Table 1.

9.3.2. Compliance monitoring of the training task

The output of the attention modification task was investigated to check compliance with the task instructions (errors and outliers). Participants made very few errors on the training task ($M = 1.09\%$, $SD = .23$) and there were few outliers ($M = 1.12\%$, $SD = .08$). The different conditions did not differ with regard to the number of erroneous responses or outliers (all $ps > .30$). Further, these results also suggest that participants were compliant to the attention modification task.

9.3.3. Independent measure of attentional bias

Data reduction. Trials with errors were excluded (.52 % of the data). Data more than 2.5 standard deviations below or above the participant's mean were discarded as outliers (1.2 % of the data). At baseline, both groups did not differ significantly in error rates, $t(40) = .70, p > .48, d = .22$.

Change in attentional bias. We subjected response latencies to a 2 (Groups: Attend-to-threat, Control) x 2 (Time: Baseline, after bias induction) x 2 (Validity: valid, invalid) x 2 (Word Type: threat, neutral) analysis of variance (ANOVA) with repeated measurement on the last three factors. Due to a leptokurtic distribution, a logarithmic transformation was used. The ANOVA revealed a significant Group x Time x Word Type

x Validity interaction, $F(1, 40) = 4.14, p < .05, \eta_p^2 = .10$. To follow-up this four-way interaction, we computed separate Group x Time x Validity ANOVAs for social threat and neutral words. For the neutral words, the Group x Time x Validity interaction was not significant, $F(1, 40) = .08, p > .77, \eta_p^2 < .01$. For threat words, the three-way interaction was significant, $F(1, 40) = 7.52, p < .01, \eta_p^2 = .16$. To follow-up this interaction, we conducted separate Group x Time ANOVAs for valid and invalid threat trials. Analyses only revealed a significant Time x Condition interaction for invalid trials, $F(1, 40) = 14.20, p < .01, \eta_p^2 = .26$.

Table 2. Means of Response Latencies in milliseconds by Group on the Spatial Cueing Task (Standard Deviations in Parentheses)

Trials		Condition			
		Attend-to-threat		Control	
Validity	Material	Baseline	Post-training	Baseline	Post-training
Valid	Neutral	369.33 (62.04)	366.33 (67.85)	373.64 (38.59)	345.59 (37.58)
	Threat	388.93 (50.19)	368.26 (72.67)	377.00 (46.74)	337.29 (34.11)
Invalid	Neutral	397.14 (58.38)	402.07 (70.35)	414.72 (54.06)	395.87 (49.73)
	Threat	405.79 (67.17)	437.02 (70.62)*	414.51 (58.56)	390.86 (57.90)

Note. “*” indicates a significant difference between pre- and post- training in that group according to paired *t*-test comparisons.

For all types of measures, there were no significant differences in baseline between groups according *t*-test comparisons

* $p < .01$.

Although both groups did not differ in their performance at baseline, $t(40) = .50$, $p > .62$, $d = .16$, a comparison Student t -test computed on reaction times to threat invalid trials at post-training showed a significant difference between groups, $t(40) = 2.50$, $p < .02$, $d = .79$. Participants from the Control Condition showed no significant differences from baseline to after bias induction, $t(20) = 2.08$, $p > .05$. For participants from the attend-to-threat condition, there was a significant increase in reaction times for threat invalid trials from baseline to post-training, $t(20) = 3.51$, $p < .01$. Data appear in Table 2.

9.3.4. Emotional responses to the social exclusion task

We subjected responses from the visual analogue scale to a 2 (Groups: Attend-to-threat, Control) $\times$ 5 (Time: Baseline, post-training, social inclusion, explicit ostracism, implicit ostracism) multivariate analysis of variance (MANOVA) for mood and anxiety responses as the dependent variables. Values more than 2.5 standard deviations below or above the mean were discarded as outliers (0.71 % of the data). Groups did not differ significantly in outliers rates, $t(40) = .59$, $p > .56$, $d = .18$.

The MANOVA revealed a significant multivariate main effect of Time, Wilks' $\lambda = .18$, $F(8, 310) = 52.07$, $p < .01$, $\eta_p^2 = .57$, and a significant Group $\times$ Time interaction, Wilks' $\lambda = .89$, $F(8, 310) = 2.39$, $p < .02$, $\eta_p^2 = .06$. Univariate output showed, for mood scale, there was only a main effect of Time, $F(4, 156) = 169.32$, $p < .001$, $\eta_p^2 = .81$. As showed in Figure 1, there were significant decreases in mood during the explicit ostracism condition as well as the implicit ostracism condition of the cyberball task for both between-subject conditions.

Figure 1. Visual Analogue Mood Scale ratings as a Function of Group Allocation. Error bars represent standard error of the mean.

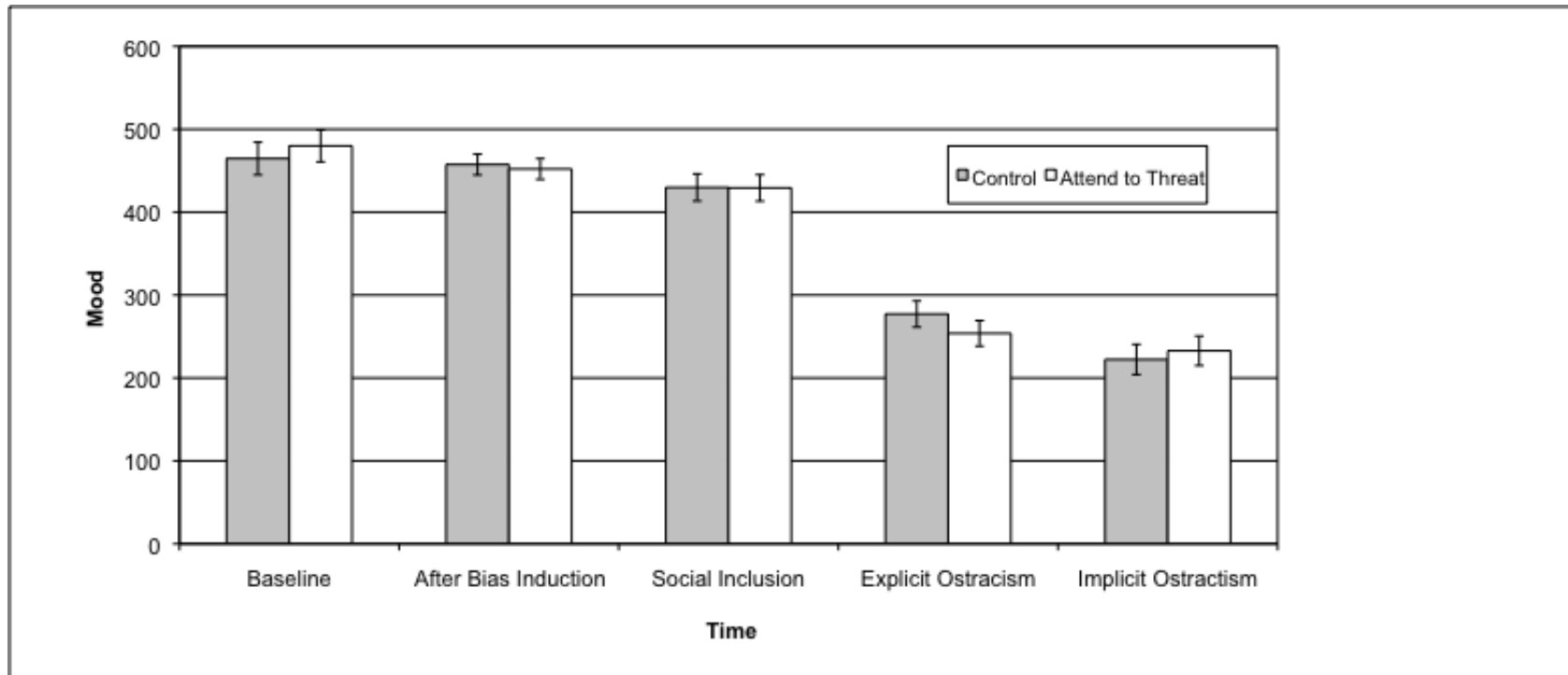
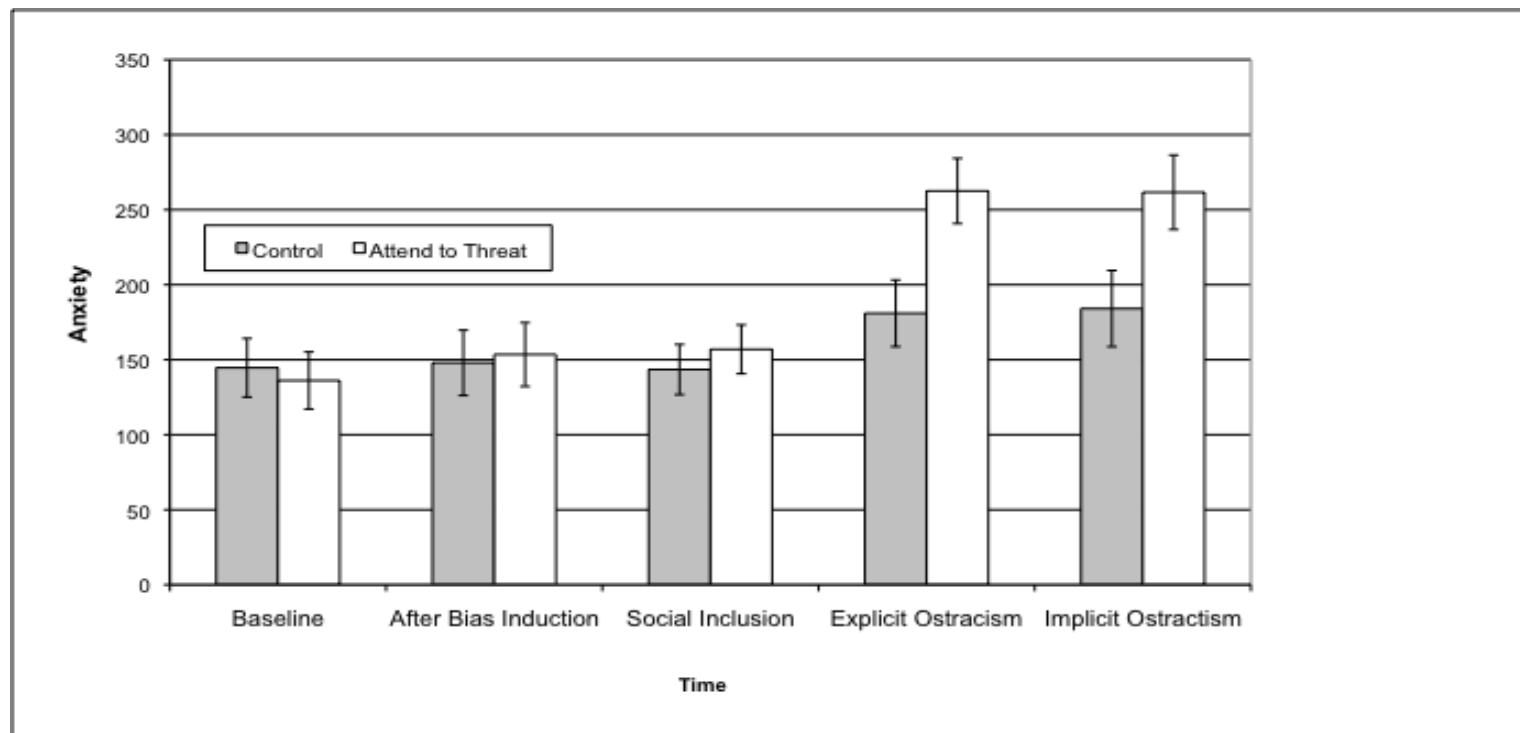


Figure 2. Visual Analogue Anxiety Scale ratings as a Function of Group Allocation. Error bars represent standard error of the mean.



For anxiety scale, there was a significant main effect of Time, $F(4, 156) = 16.33$, $p < .01$, $\eta_p^2 = .30$, qualified by a significant Group $\times$ Time interaction, $F(4, 156) = 4.29$, $p < .01$, $\eta_p^2 = .10$. As showed in Figure 2, participants from both conditions reported a significant increase in anxiety from both baseline to explicit and implicit ostracism conditions. However, although the groups did not differ in their scores at baseline, $t(40) = .59$, $p > .77$, $d = .19$, after bias induction, $t(40) = .23$, $p > .82$, $d = .07$, as well as during the social inclusion condition of the Cyberball, $t(40) = .58$, $p > .56$, $d = .18$, there were significant differences between groups in the explicit ostracism condition, $t(40) = 2.56$, $p < .02$, $d = .81$, and in the implicit ostracism condition, $t(40) = 2.18$, $p < .05$, $d = .69$. As shown in Figure 2, participants who were trained to attend-to-threat reported significantly more anxiety during both explicit and implicit ostracism than those from the Control Condition.

9.4. Discussion

The main aim of this study was to explore whether an attentional bias for external threat cues plays a causal role in social anxiety. As predicted, the anxiety induced by social exclusion was significantly more intense for participants trained to attend to threat cues relative to those in the control condition. Specifically, during the cyberball game, participants from the former condition reported more anxiety during the explicit as well as during implicit social exclusion conditions. These findings converge with previous studies suggesting that attention bias modification procedures can affect anxiety vulnerability (e.g., Amir et al., 2008; MacLeod et al., 2002). Moreover, this study goes

further in being the first to directly assess the causal role of attentional bias to external threat cues in the development of anxiety to social stressors. The present results clearly suggest that attentional biases affect anxiety proneness even when social exclusion is implicit and unintentional, hence supporting the notion that selective attention to threatening social stimuli plays a causal role in anxiety vulnerability to implicit and explicit social stressors (Clark, 1999; Clark & Wells, 1995; Rapee & Heimberg, 1997). At a more general level, these observations are consistent with the clinical cognitive model tenet that attentional bias to threat plays a causal role in the development of emotional vulnerability (e.g., Beck, 1995; Foa et al., 1993).

Nevertheless, as such, these observations alone cannot fully support the conclusion that the change in vulnerability to social exclusion can confidently be attributed to the selective attentional processing resulting from the bias induction. As argued by MacLeod, Koster, and Fox (2009a, p.94), the successful induction of the target cognitive change must be confirmed by demonstrating predicted performance changes on a cognitive task reliably measuring the cognitive process of interest. In the present case, this condition is satisfied. Indeed, as compared to control participants, those trained to attend to threat exhibited a greater reduction in latency for identifying probes during invalid threat trials. As mentioned above, previous work (e.g., Amir et al., 2003) showed that reaction times for invalid social threat is related to the capacity to disengage attention from socially threatening stimuli. We may therefore conclude that the experimental manipulation induced a difficulty in disengaging from threat and resulted in increased vulnerability to social rejection.

Regarding the Cyberball, the main effect of Time for both mood and anxiety during the explicit as well as implicit social exclusion is congruent with previous accounts. Former studies have provided ample evidence that cyberball-based ostracism increases self-reported distress among healthy participants (e.g., Leary et al. 1995; Sommer et al., 2001, Williams et al., 2000; Zadro et al., 2004). We may therefore conclude that our experimental induction of social exclusion produced the desired effects.

At a fundamental level, the present findings highlight two major points. First, regarding the nature of the attentional biases sustaining emotional vulnerability, the observed changes in the spatial cueing task bolster the argument that the difficulty in disengaging attention from threat is causally involved in the development of social anxiety (e.g., Amir et al., 2003; Heeren, Lievens, & Philippot, 2011). Fox et al. (2001) propose that the ability to disengage from threat cues may serve as a protective factor from anxiety reactivity, whereas an inability to effectively disengage from threat may serve to maintain or increase anxiety. They postulate that the tendency to dwell on threat cues may contribute to maladaptive rumination. According to Buckner, Maner and Schmidt (2010), in the case of social anxiety, it may be that the difficulty in disengaging attention from social threat increases the tendency of socially anxious individuals to engage in maladaptive rumination, which may in turn activate memories of prior experiences of negative evaluation. Furthermore, it may also be that the difficulty in disengaging attention from threat results in constant anxiety by creating a vicious cycle in which anxiety is increased as the individual dwells on the social threat. Consistent with these notions, the present data reveal that training individuals to attend to threat reduces their ability to disengage their attention from it and clearly leads to a significant increase

in anxiety during a social rejection task. Future research is needed to evaluate the possibility that this type of bias induction increases anxiety because it generates the vicious cycle (e.g., negatively skewed judgements of social events) mentioned above.

Second, regarding the nature of the emotional stressor, our findings suggest that attentional bias for threat contributes to the increase of anxiety during both explicit and implicit social rejection. This suggests that emotional change during social rejection, even if unintentional (i.e., the implicit social ostracism condition), comes from a modified perception of threat early in the appraisal process. According to Gross' model (2002), if attention acts as an initial filter on the processing of environmental cues, then modulating selective attention to threat would be expected to allow for modified processing of other types of social information and modified the perception of threat early in the appraisal process. Further, as supported by White et al. (2011), preferentially allocating attention towards threat cues may cause a negative interpretative bias because subsequent processing resources may favour threat-related interpretation. As demonstrated by these authors, when individuals are faced with ambiguous stimuli, an anxiety-related interpretation may be readily accessed when attention has been consistently directed to threat cues. Consistent with this rationale, participants who were trained to attend to threat cues reported more anxiety not only during the explicit but also during the implicit ostracism condition. Future studies should further examine these potential mediating mechanisms.

At a clinical level, the present data are consistent with recent developments in cognitive bias modification (e.g., Hakamata et al., 2010) demonstrating that the attention bias for threatening stimuli can be manipulated and that these modifications are related to

emotional changes. Further, the present data suggest that attentional biases play a causal role not only in the maintenance of the disorder but also in the development of anxiety during social exclusion. Therefore, the current results clearly suggest that using attention training as a prophylactic intervention before the development of social phobia might be useful. Future studies should further investigate this question.

The present study has limitations. First, we used a single-item measure to assess self-reported change in anxiety. Future studies should use reliable measures of self-reported state anxiety (e.g., STAI-state). Second, we used only self-reported measure of mood and anxiety. Future research should incorporate other measures, such as skin conductance reactivity, heart rate and cortisol release. Third, we used a spatial cueing task as a measure of attention bias. Mogg, Holmes, Garner, and Bradley (2008) have argued that the spatial cueing task may not provide unambiguous evidence for delayed disengagement, as there may be a confound between delayed disengagement and a generic slow-down effect caused by the presence of threat. Although this limits the conclusions that can be drawn from this task, Cisler and Olatunji (2010) recently found that disengagement difficulty in the spatial cueing task remained in anxious individuals when statistically controlling for generic response slowing, suggesting that this task confound does not explain difficulties in disengagement. Fourth, it should be noted that, to our knowledge, there was no study examining whether Cyberball increase anxiety among socially anxious individuals. Therefore, although the perception of social rejection precisely targets the core construct of social anxiety, to ensure that the present finding generalize to individuals with elevated social anxiety, future experiment should ensure that these latter exhibit increased anxiety during both explicit and implicit ostracism

conditions. Finally, given recent evidence that anxious individuals, regardless of their type of anxiety, appear to demonstrate attentional biases towards threat (e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007), future experiments should examine whether the result underlying the current study generalizes to vulnerability for other anxiety disorders.

In conclusion, the current findings provide support for the proposal that attentional bias to external threat cues plays a role in the development of social anxiety. The adverse consequences of inducing an attentional bias to threat cues in terms of increased anxiety during social rejection, even if implicit, were evident in individuals who are within the normal range for social anxiety.

9.5. Rationale for the transition from Study 7 to the General Discussion

According to Bar-Haim et al. (2007), anxiety disorders may stem from attentional bias for threatening stimuli. No previous study has directly examined the causal status of selective attentional bias for threat in the installation of symptoms of social phobia. Study 7 explicitly investigated this issue. We used an experimental design similar to MacLeod et al. (2002), which involved two consecutive experimental phases: an attentional bias induction phase and a stress phase. During the attentional bias induction, participants completed modified versions of a dot-probe task; for half of the participants the task was designed to induce a biased attentional response for faces expressing disgust, for the other half, the task induced no bias. Then, all participants were exposed to a task inducing social rejection.

In accordance to Bar-Haim et al.'s hypothesis (2007), our findings suggest that attentional bias for threat contributes to the increase of anxiety during a stressor. They are consistent with a diathesis-stress conceptualization of information-processing bias that frames the latter as a latent vulnerability factor having little or no effect on anxiety until the individual encounters a stressor (e.g., Beck, 1987; MacLeod, Campbell, Rutherford, & Wilson, 2004). According to Gross' model (2002), if attention acts as an initial filter on the processing of environmental cues, then modulating selective attention to threat would be expected to allow a modified subsequent emotional information processing. Further, regarding the nature of the attentional bias feature sustaining these effects, our results indicate that there was only an increase in reaction times for invalid threat trials, thereby bolstering the argument that the difficulty in disengaging attention from threat

may be causally involved in the development of emotional vulnerability.

In the next section, we will summarize and discuss the main results of the whole set of our empirical studies with respect to the five issues raised in the General Introduction: replication, generalisability, attentional bias features modulated during the training, attention control implication, and the question of causality of attentional bias for threat in the installation of vulnerability to emotional stressor. Then, we will formulate theoretical and applied consequences of our findings.

Chapter 10

General Discussion

Back to basics

In the General Introduction, we have extensively discussed the causal nature of attentional bias for threatening stimuli in the etiology and the maintenance of anxiety disorders. At a theoretical level, some prominent cognitive models of anxiety state that attentional bias for threatening stimuli is causally involved in the etiology (i.e., Bar-Haim et al., 2007) and the maintenance (e.g., Rapee and Heimberg, 1997; Williams et al., 1997) of the disorder. As we reviewed, studies provided empirical support for these claims. First, an association between attentional bias for threat and anxiety has been established through different experimental behavioral paradigms and across different anxiety disorders (e.g., Bar-Haim et al., 2007). Secondly, beyond this strictly correlational demonstration, we reviewed some prospective studies. However, on one hand, it has been reported that attentional bias for threatening stimuli is a vulnerability factor for developing anxiety in response to stress, suggesting that attentional bias for threat may be causally involved in the etiology of anxiety disorder (e.g., Pury, 2002; van den Hout, Tenney, Huygens, Merckelbach, & Kindt, 1995). On other hand, there is also evidence in favor of the alternative explanation of a temporal precedence of anxiety on the onset of attentional bias for threat, suggesting that attentional bias might be a mere by-product of anxiety (e.g., Van Damme, Crombez, Eccleston, & Goubert, 2004).

As we argued, overcoming the uncertainty about the causal nature of this relation can only be accomplished by studies designed to systematically manipulate attentional bias for threat. Such studies consistently provided empirical support for this hypothesis (e.g., MacLeod et al., 2002). At a theoretical level, these findings are consistent with the statement of Bar-Haim et al. (2007) that *anxiety disorder may stem from attentional bias*.

Similar empirical support was also provided by studies designed to systematically manipulate attention for threat among anxious patients (for a review, see the meta-analysis of Hakamata et al., 2010). These findings support the hypothesis that individual differences in *attentional bias for threat can causally impact on the maintenance of anxiety* (with the exception of more circumscribed fear, such as in specific phobia).

However, beyond these first encouraging results, we raised several issues needed for a better understanding of this phenomenon. First, we noted that it remains unclear whether the impact of such procedure comes from change in the ability to disengage from threat, or from the ability to re-allocate attention to non-threat, or both simultaneously. Second, we noted that, although Eysenck et al. (2007) as well as Cisler and Koster (2010) postulated that top-down attention control underlies attentional bias for threat, uncertainty remains regarding the requirement of such process in reducing attentional bias. Third, we also noted that researchers on attention training have mainly relied on self-report measures and diagnostic interviews to assess the impact of attention training, thereby constituting a severe limitation for understanding how change in attentional bias for threat impacts on anxiety. Finally, we formulated some recommendations for future research examining how attentional bias for threat may be involved, not only as a maintenance factor, but also as a vulnerability factor in the etiology of the disorder. In the empirical section of the present dissertation, our goal was to investigate these questions.

10.1. Question-wise summary

We will summarize and discuss the main results of the empirical studies with

respect to the five issues raised in the General Introduction: replication, generalisability, attentional bias features modulated during the training, attention control implication, and the question of causality of attentional bias for threat in the installation of vulnerability to emotional stressor.

10.1.1. Replication and extension

Although previous studies have suggested that reducing attentional bias for threat diminishes anxiety, some recent data suggest that the efficacy and the reliability of the attention training procedure may be more complex than commonly depicted. For instance, Boettcher, Berger, and Renneberg (in press) recently failed to replicate that attention training leads to more clinical improvement than a no-contingency placebo training. Moreover, participants who were trained to attend to non-threat did not show any change in their attentional bias for threat.

As we developed in the General Introduction, Hakamata et al. (2010) conducted a meta-analysis on 12 studies on attention training among social anxiety and generalized anxiety. It revealed a significant benefit of attention training on anxiety, with a medium effect size and estimated to 54 the number of unpublished studies with effect sizes of zero needed to reduce the aggregated effect below significance. However, it should be noted that, after the removal of three possible outliers with particularly large effect size (experiment 1 and 2 of Mathews & Macleod, 2002; Schmidt et al., 2009), the overall effect size was reduced and the fail-safe n dropped to 7, suggesting that replications are

clearly needed to establish the reliability of this effect. Therefore, one of the primary questions of the present dissertation was to ensure the reliability of these effects. Our main prediction was that *training anxious individuals to attend to non-threatening stimuli should lead to greater decrease in anxiety than a no-contingency training* (**Hypothesis 1**). Overall, our prediction was supported.

In Study 1, *high socially anxious individuals* trained to attend to non-threat cues reported reductions in social anxiety as well as trait-anxiety from baseline to post-training. In Study 2, through an ABA single-case study, the efficacy of this procedure was observed *among a treatment-seeking client with social phobia*. At 2-month and 6-month follow-up, significant improvement was evidenced in the ecological situation of delivering a speech (i.e., behavioral and subjective responses). The client also reported changes regarding her social anxiety, as disclosed in the self-reported measure of social anxiety. Regarding criteria of Social Phobia, the diagnostic interview revealed the absence of DSM-IV diagnosis of Social Phobia at 2-month and 6-month follow-up. However, these benefits disappeared at one-year follow-up. One cannot exclude that environmental factors (e.g., events, stress, work) have engendered that return of fear. Moreover, it should be noted that Study 2 is the first study including a follow-up assessment more than 4 month after treatment (e.g., Schmidt et al., 2009). In that way, it remains difficult to interpret the relapse at one-year follow-up. In order to solve this issue, future randomized controlled trials should include a one-year follow-up assessment. Future studies might also examine the benefit of including boosting sessions between the 6-month and the one-year follow-up.

In Studies 3 and 4, while our methodology differs from the usual attention procedure because of additional conditions, the same pattern of results was observed among individuals presenting *generalized social phobia*. In Study 3, we observed that four sessions of the usual attention training condition led to a significant decrease in self-reported social anxiety as well as a significant beneficial effects across verbal, behavioral, and physiological responses to a speech task. Further, decrease in social anxiety was maintained at a 2-week-follow-up assessment. In Study 4, a single-session of attention training led to a significant decrease in behavioral anxiety in response to a speech task.

Overly enthusiastic conclusions about the robustness of attention training effects need to be tempered as we failed to observe effect on our measures of anxiety in Studies 5 and 6. Indeed, except in the latter in which we reported a significant decrease only in self-reported fear of being observed among participants who were in the attention training condition, there was no Group x Time interaction for other measure of symptoms as well as no change in attentional bias for threat. Different explanations for these divergent results may be proposed. First, one cannot exclude the nature of the sample as an explanation. Indeed, participants in previous studies (e.g., Amir et al., 2009; Schmidt et al., 2008; Studies 2, 3, & 4) fulfilled the criteria for generalized social phobia, whereas those from Studies 5 and 6 included participants with less severe social anxiety. However, results of Study 1 militate against this hypothesis, as they showed the efficacy of attention training among highly socially anxious who were not necessarily satisfying to the criteria for generalized social phobics. Second, the absence of effects in these two studies might be related to the absence of attentional bias for threat at baseline. Indeed, recent studies have suggested that the efficacy of attention training for social phobia

required that participants exhibit that bias before training (e.g., Amir, Taylor, Donohue, 2011). This point will be further discussed below. Finally, the inclusion of particularly resource-consuming measures as additional dependent variable (i.e., ANT and Hayling task) may also explain these discrepancies, as these resources constitute a cognitive training in themselves. This latter point will be also further developed below.

Considered together, our studies generally replicated previous findings noting the effect of attention training among sample of socially anxious individuals (e.g., Amir et al., 2008; Li et al., 2008) and among patients diagnosed with generalized social phobia (e.g., Amir et al., 2009; Schmidt et al., 2009). Hence, findings on attention training in social anxiety seem replicable and attentional bias for threat might be more than merely a by-product of anxiety. At a fundamental level, these data are clearly consistent with the hypothesis held by cognitive models of anxiety that attentional bias for threat may be causally involved in the maintenance of the disorder (i.e., Eysenck et al., 2007; Mogg & Bradley, 1998; Williams et al., 1997). Similarly, both Rapee and Heimberg (1997) and Clark and Wells (1995) models predict that attentional bias for threat are involved in the maintenance of social anxiety. Our data clearly fit with this hypothesis and provide stronger evidence in favor of the causal involvement of attentional bias for threat in the maintenance of social anxiety.

10.1.2. Generalisability to emotional reactivity and information processing

i. Generalisability to emotional reactivity

We have drawn attention to the limitation that researchers have seldom included behavioral measures of anxiety reduction and few have taken physiological measures of anxiety reduction. To our knowledge, only two studies have examined the effects of attention training on physiological responses to stressors. Measuring hormonal response rather than a traditional measure of psychophysiology, Dandeneau et al. (2007), found that attention training lowered cortisol release in response to stress. However, this study was conducted among non-anxious participants. Further, the experimental manipulation of this study involved a procedure based on a visual search task rather than a dot-probe task. In contrast, Van Bockstaele et al. (2011b) did not find any effect of attention training on skin conductance and heart rate in response to pictures of spiders among spider phobics. It should be noted, however, that this study did not evidence effects of training on any other measures of anxiety.

As argued by MacLeod et al. (2009a), exclusive reliance on self-reported measures is vulnerable to two criticisms. First, the completion of self-report measures involves judgment and inferences, giving rise to the possibility that a cognitive manipulation might affect questionnaire scores even when emotional experience itself is unaffected. Second, it could be argued that demand may contribute to the observed effect. Moreover, as Lang (1968; 1993) as well as Bradley and Lang (2000) have argued, emotional response is not only expressed through language. Emotions are expressed in three different responses systems: 1) overt behaviors (e.g., avoidance), 2) language (i.e., self-report measures), and 3) physiological responses (e.g., skin conductance). *Our prediction was that training anxious individuals to attend to non-threatening stimuli should reduce self-report, behavioral, and physiological measures of anxiety*

(Hypothesis 2).

In the present dissertation, results from Studies 2, 3, and 4 are consistent with previous studies showing that attention training impacts on behavioral measures of fear and anxiety (e.g., Amir et al., 2008; Reese, McNally, Najmi, & Amir, 2010). Further, Study 3 results evidenced decreases in self-reported anxiety, behavioral manifestations of anxiety, and physiological arousal in response to a speech task, in participants trained to attend to non-threatening stimuli. These results are consistent with previous studies showing that training socially anxious to attend to non-threat faces reduces emotional vulnerability to subsequent stressors (e.g., Amir et al., 2008), extending this finding to physiological responses. At a theoretical level, our results show that attentional bias for threat causally influences emotional reactivity to a stressor across all three systems -- verbal, behavioral, and physiological.

ii. Generalisability to information processing

Nevertheless, as such, these observations cannot sustain the conclusion that this emotional change can be unambiguously attributed to the selective attentional processing produced by the training **(Hypothesis 3)**. As argued by MacLeod et al. (2009a), this conclusion requires that studies confirm predicted changes on a task that reliably measures the mediating cognitive process. MacLeod et al. (2009a) also argue that the magnitude in change in the mediating process should predict the magnitude of improvement on clinical measures. To address the first requirement, in all studies of the present thesis, we included an independent measure of attentional bias for threat. With

the exception of results from Studies 5 and 6, attention bias was modified as intended. Further, as noted by MacLeod et al. (2009a), it is possible that attention training modifies selective processing of the specific stimuli encountered within the training procedure without necessarily exerting a more general impact on the information from which these training stimuli were drawn. Results from the present dissertation guard us against this hypothesis as designs of Studies 1, 4, and 7 included an independent measure of attention bias, which was a spatial cueing task with words, rather than a dot-probe task with faces as proposed during training. This suggests that the training procedure exerts a general impact on the selective processing of threatening information and is not limited to the training stimuli.

It should be noted that, except for Study 3 in which we used angry faces, all our studies included disgust face in the training task. That suggests that disgust faces is relevant for retraining biases in social anxiety. This is congruent with recent findings showing that socially anxious individuals rate disgust faces as more negative than the anger faces, whereas non-anxious and generalized anxious do not rate the two emotions differently (Amir, Najmi, Bomyea, & Burns, 2010). However, these authors found that these effects only appear for pictures of Caucasian faces and not for Asian face. Because their sample only included Caucasian participants, it is plausible that their effects are due to an in-group advantage in identification of facial expressions. In the present dissertation, results from Study 3 suggest that attention bias modification generalize to out-group facial identification. However, both the training and the assessment tasks included mixed race facial expressions. A challenge for the generalization issue would be

to examine whether training for in-group facial expression generalizes to out-group facial expression and vice versa.

In the same vein, we only examined the generalization in the visual modality, neglecting biases in other perceptual modalities (e.g. auditory or somesthetic). Yet, emotional responses mobilize all the facets of the organism, all modalities being necessary for adaptive responses. Presently, we do not know whether change in the abnormalities in the processing of emotional visual information extend to other perceptive modalities. Further, recent research has documented significant cross-modal interactions (Jepma, Wagenmakers, Band & Nieuwenhuis, 2009; Karns & Knight, 2009). For instance, the audiovisual processing of emotions produces a crossmodal facilitation effect, characterized by shorter response latencies and enhanced performances relative to the categorization of either faces or voices (de Gelder and Vroomen, 2000; Kreifelts et al., 2007). In the same vein, ERP studies demonstrated that multimodal integration of emotional stimuli occurs very early (110–200ms) after stimulus presentation, suggesting automaticity (Pourtois et al., 2000). With respect to our suggestion that attentional retraining exerts a general impact on the selective processing of the emotional information, a future challenge is to explore whether the malleability of attentional bias in one modality causally impacts on multimodal processing of emotion and on the cross-modal integration.

Regarding the second requirement of MacLeod et al. (2009a), we performed mediational analyses examining whether change in attentional bias (difference score from baseline to post-training) mediates change in anxiety symptoms (difference score from baseline to post-training). This mediational effect was observed in Studies 1, 3, and 4.

Further, in Studies 1 and 4 that used a spatial cueing task rather than a dot-probe task, reduction in latency for identifying probes during invalid threat trials mediated reduction in anxiety during threatening situation. In Study 3, mediational analyses revealed that decreased vigilance for threat, indexed through a probe discrimination task, mediated reduction in self-reported fear of negative evaluation and physiological reactivity. Results from Studies 5 and 6 are less consistent. However, as we already pointed out, one cannot exclude the possibility that the effects in these two studies are related to the absence of attentional bias for threat at baseline and/or to a difference in the nature of the sample.

Considered together, these results suggest that attention training particularly impacts on latencies to identify probes during invalid threat trials. As mentioned in the General Introduction, previous works have suggested that reaction time for invalid threat trials is related to the capacity to disengage attention from socially threatening word (e.g., Amir et al. 2003; Fox et al., 2001). We may therefore conclude that the attention training works as intended. Regarding theoretical models of anxiety, our findings are consistent with the model of Rapee and Heimberg (1997). According to these authors, in a social situation, attentional bias for threat may lead to negative evaluation which, in turn, further results in physiological, cognitive, and behavioral components of anxiety that subsequently retroactively loops into the negatively biased mental representations and, therefore, perpetuate the cycle of anxiety. In Study 3, we observed that decreased attentional bias for threat leads to reduced physiological reactivity to stressors and decreased fear of negative evaluation. Therefore, it may be that training socially anxious individuals to attend to nonthreatening cues may interrupt the vicious cycle postulated by

Rapee and Heimberg (1997), creating a snowballing cascade of potential social encounters that foster elimination of their social fears. However, there was no evaluation of the impact of attention training on all the different facets of this model (e.g., mental representations) in the present dissertation, which prevents us to draw any solid conclusion about this hypothesis.

10.1.3. Which components of attention bias are involved in the maintenance of anxiety?

One of the main goals of this dissertation was to examine how attentional bias for threat may be causally involved in the maintenance and/or installation of anxiety. As exposed in the General Introduction, different theoretical accounts were formulated. According to Mogg and Bradley (1998), an attentional bias towards threat may be considered as a maintenance factor of anxiety because if the initial allocation of attention to threat is followed by avoidant behaviors, extinction to conditioned stimulus aborts and anxiety is maintained. Congruently, according to the Foa and Kozak's model (1986), only attentional avoidance of threat stimuli is a core maintenance factor of anxiety disorder. In contrast, others have proposed that the critical mechanism through which attentional bias for threat operates as a maintenance factor may be the delayed disengagement from threat (e.g., Eysenck et al., 2007)

i. Training to attend away from threat or toward threat?

It is clear that our data are not in line with the prediction of Foa and Kozak (1986) that fear reduction will be hampered when attention is directed away from the feared stimulus (**Hypothesis 4**). Our findings apparently diverge from the hypothesis of Foa and Kozak (1986) that the inhibition of detailed processing of threatening stimuli is the core deficit of anxiety, which is reflected in avoidance of threatening stimuli. According to these authors, attention training appears to stand in striking contrast to the goal of exposure, namely to facilitate emotional processing of threat-relevant stimuli by attending to it (e.g., Foa, Huppert, & Cahill, 2006).

A review of the extant empirical literature however depicts a more complex picture. Although some studies have found that attentional focus during exposure facilitate fear reduction (e.g., Grayson, Foa, & Steketee, 1982; Kamphuis & Telch, 2000; Mohlman & Zimbarg, 2000), others have found that attentional distraction (e.g., playing to a game) produces greater fear reduction (e.g., Grayson et al., 1982; Johnstone & Page, 2004; Oliver & Page, 2003; 2008). As pointed by Amir et al. (2008), these results suggest that not all forms of attention avoidance are antitherapeutic and that avoidance from threatening stimuli, and more precisely the improvement of the ability to disengage attention from threat, may facilitate reduction of emotional response to threat. One possible explanation for the discrepancy between these results is that attending to non-threat may be a relevant therapeutic tool to reduce emotional responses that are primarily related to anxiety, but not to fear.

Fear has been defined as stimulus specific (e.g., LeDoux, 1992; Marks, 1969), characterized by a phased response to an aversive, immediately threatening stimulus. In contrast, anxiety is not associated with a specific discrete cue but rather by the

apprehensive anticipation of upcoming potential threats (Bouton et al., 2001; Grillon, 2002; Grillon & Davis, 1997). As we already tackled, results of attention training are less conclusive for fear-response, such a specific phobia (e.g., Reese et al., 2010; Van Bockstaele et al., 2011b). In contrast, studies from the present dissertation as well as previous studies from other laboratories (e.g., Amir et al., 2008; 2009; See et al., 2009; Schmidt et al., 2008) evidenced that attention training is efficient in reducing anxiety.

One explanation is that individuals with a more specific fear have a vigilance-avoidance pattern of attention such that relative to no fearful individuals they initially locate fear-related stimuli faster but subsequently divert their attention from these stimuli (Pflugshaupt et al., 2005; Mogg & Bradley, 2002). This early vigilance may serve to heighten anxiety whereas the later avoidance maintains fear. In contrast, recent data suggest that anxiety is more characterized by a difficulty to disengage attention from threat than by a vigilance-avoidance pattern of attention (e.g., Amir et al., 2003; Fox et al., 2001). Fox et al. (2001) propose that the ability to disengage from threat cues may serve as a protective factor from anxiety whereas an inability to effectively disengage from threat may serve to maintain or exacerbate anxiety. They postulate that the tendency to dwell on threat cues may contribute to anxious worrying. Regarding social anxiety, Buckner et al., (2010) suggest that it may be that the difficulty in disengaging attention from socially threatening stimuli increases the tendency of socially anxious individuals to engage in negative apprehension, which may in turn activate memories of prior experiences of negative evaluation. According to these authors, it may also be that the difficulty in disengaging attention from threat results in constant anxiety by creating a vicious cycle in which anxiety is increased as the individuals dwell on threatening

stimuli. Consistent with these notions, results from the present dissertation reveal that improving the ability to disengage attention from threat causally decreases anxiety. Conversely, Study 7 suggests that training individuals to dwell on threat causally reduces their ability to disengage attention from it and leads to increase anxiety during threatening stimulation.

ii. *How does it work: Disengagement from threat or vigilance for non-threat?*

The previous results did not allow to clearly specify which components of attention is causally involved in the maintenance of anxiety. As pointed by Cisler and Koster's model (2010), attentional bias towards threat may comprise facilitated attention to threat, delayed disengagement from threat, and attentional avoidance of threat. A major issue is that there is uncertainty regarding the mechanisms that mediate the reduction of anxiety via attention training.

As aforementioned, changes in the independent attentional bias task administered before and after the training included in our studies do not allow to solve this issue. Indeed, results from Studies 1, 2, and 4 including a spatial cueing task suggest that improvement in the ability to disengage attention from threat (i.e., reaction times for invalid threat trials) are the process involved in attention training. In contrast, results from Study 3 using a probe discrimination task suggests that the development of a vigilance for non-threat may be the critical process involved in attention training.

This hypotheses competition is very similar to prior debates in the field. According to Amir et al. (2008), the improvement in the ability to disengage attention

from threat mediates the reduction of emotional reactivity to stressor. Congruently, Studies 1 and 2 suggest that attention training reduces anxiety because it improves the ability to disengage attention threat. Hence, disengagement difficulty would be the underlying process mediating attentional bias for threat in the probe detection and probe discrimination paradigms. An alternative account is based on the results of MacLeod et al. (2002) and Li et al. (2008). According to this explanation, the development of a counter-bias during training, in which attention is oriented towards non-threat cues, constitutes the active mechanism. For instance, Li et al. (2008) have observed that training socially anxious individuals to focus on positive faces reduces bias toward threatening faces, and also increases attentional bias towards non-threat cues. Similarly, results from Study 3 suggest that attention training reduced anxiety because it fostered a bias favoring attention to non-threat stimuli (i.e., the creation of a counter-bias). The therapeutic benefits of attention training would thus result from orienting attention towards non-threat cues (or creating a vigilance bias for non-threat).

However, previous paradigms do not allow to determine the process of change. Conclusions on the active attentional ingredient underlying the efficacy of attention training were only inferred from observed change on indirect tasks assessing change in attentional bias from before to after training. In Study 4, we directly addressed this question by crossing the presence/absence of disengagement from threat and allocation to non-threat in four different attention training conditions. Again, results were consistent with the disengagement hypothesis, training benefits were observed only for participants trained to *disengage attention from threat cues* and those trained to *disengage from threat cues and re-engage to non-threat cues* (**Hypothesis 5**).

At a fundamental level, these findings show the utility of distinguishing the different features of attentional bias. They clearly bolster the argument that the difficulty in disengaging attention from threat is causally involved in the maintenance of the disorder (e.g., Amir et al., 2003). As we presented above, Fox et al. (2001) propose that the inability to effectively disengage from threat may serve to maintain or increase anxiety. These findings are clearly in line with the models of Williams et al. (1997) and Eysenck et al. (2007). For instance, Williams et al. (1997, p. 309) suggested that *the tendency to maintain attention allocated toward threat may prolong any episode of emotional disorder*.

10.1.4. Does improvement in executive attentional control mediate reduction in delayed disengagement from threat?

In the General Introduction, we developed the issue of the involvement of executive attentional control in the advent of the benefits from attention bias modification. According to Klumpp and Amir (2010), attention training may be efficient by increasing executive attentional control, which may inhibit threat processing. Previous attention training studies did not include systematic testing of the general executive attentional processes hypothesis. However, Klumpp and Amir (2010) studied a group of moderately socially anxious individuals, and, in addition to the standard training to attend to non-threat and the no-contingency conditions, they included a third training condition in which participants were trained to attend to threat. After a single-session of training, individuals who were trained to attend to threat and those trained to attend away from

threat reported less anxiety in response to an impromptu speech compared to individuals in the non-contingency training. Klumpp and Amir concluded that training in either direction (toward or away from threat) bolsters top-down executive attentional control in ways that may foster the ability to control anxiety. They argue that their data are in line with the idea that improving the executive attentional control may be the critical factor to reduce anxiety.

Results from Study 3 completely diverge from these findings. Indeed, we observed that training social phobics to attend to non-threatening stimuli reduces self-report, behavioral, and physiological measures of social anxiety. But, those trained to attend to threatening stimuli or to alternatively attend to both showed no such benefits. However, none of these two studies nor previous studies in the field has directly assessed the executive control for non-emotional stimuli before and after attention training. Therefore, it remains unclear whether the Amir and Klumpp's effect effectively result from increased executive attention control. Indeed, the study did not include any such measurement. Moreover, recent evidence suggests that executive attention control is more than a merely unifactorial construct. For instance, Fan and his collaborators (e.g., Fan et al., 2002; Posner & Rothbart, 2007) demonstrated that it integrates at least three independent attention networks: alerting, orienting, and executive attention.

In Study 5, we directly assessed these three independent networks before and after attention training. *Our prediction was that training anxious individuals to attend to non-threat should lead to improvement in executive attentional control that mediates the reduction of delayed disengagement from threat, whereas training to attend to threat should not (Hypothesis 6).*

Different hypotheses were tested. First, as argued by Eldar and Bar-Haim (2010) and Browning et al. (2010), improvement in the ability to disengage attention from threat induced by attention training may result from increased top-down executive control. Then only subjects who were in the attend to non-threat conditions should demonstrate improvement in the ability to disengage from threat, reductions in anxiety as well as an improved performance in executive attention network. In contrast, if as Klumpp and Amir (2010) have argued, attention training is effective because of increased attentional control regardless of the direction of attention, then subjects in either the attend to threat or attend to non-threat conditions should demonstrate reductions in anxiety as well as an improved performance in executive attention network.

Results from Study 5 show that subjects in either the attend to threat or attend to non-threat conditions demonstrated reductions in self-reported and behavioural anxiety. Further, regardless of the direction of attention during the training, increased executive attention control were also observed. Regarding orienting and alerting networks, no such changes were observed. These findings are in line with the idea of Klumpp and Amir (2010) suggesting that attention training may be efficient by increasing attentional control, which may inhibit threat processing. These findings are, however, in striking contrast with results from Study 3, in which we did not replicate findings of Klumpp and Amir (2010).

Different explanations may account for this discrepancy between Studies 3, 5 and Klumpp and Amir results. First, performing the ANT is a resource demanding-task. It may be that performing both the two sessions of attention training and assessment as well as the two sessions of ANT measurement leads to a transitory improvement in executive

attentional control among all participants. Consistently, some recent studies have reported that massively mobilizing executive attentional resources is associated with a decrease in psychological distress (e.g., Bomyea & Amir, 2011; Heeren, Van Broeck, & Philippot, 2009). However, this explanation remains untested. Further investigations are needed to better understand these effects. Second, one cannot exclude the possibility that the changes in the executive attention network are the result of a low test-retest reliability commonly observed among measures assessing such functions. Indeed, recent works revealed that performance on task assessing executive function improved with repeated administrations (e.g., Basso, Bornstein, & Lang, 1999; Ishigami & Klein, 2010). For instance, Ishigami and Klein (2010) repeatedly administered the ANT to a sample of young adults. They reported that participants became better at ignoring irrelevant information and at disengaging from attended locations over time. To overcome this potential test-retest problem, further investigations directly manipulating executive processes are clearly needed (see below for further details). Third, as we already mentioned, one cannot exclude the possibility that our effects are related to the absence of attentional bias for threat at baseline. In the study of Study 3, participants strongly exhibited an attentional bias for threat at baseline, whereas this was not the case in the study depicted in Study 6. Unfortunately, Klumpp and Amir (2010) did not report this information. Finally, in Study 6 as well as in Klumpp and Amir's study, participants were only moderately socially anxious. In contrast, those of Study 3 had generalized social phobia. As we already stated, it may be that both attending towards threat and attending to non-threat had a genuine beneficial impact on circumscribed social fear, whereas training to attend to non-threat only impact social anxiety (see the previous point in

which we discussed the difference between fear and anxiety). In absence of a non-contingency group, it remains impossible to exclude this possibility.

In Study 7, because some cognitive models posit that inhibition plays an important role in the phenomenon of delayed disengagement from threat (e.g., Eysenck et al., 2007), we assessed the ability to inhibit a prepotent response before and after the standard attention training and a no-contingency condition. We predicted that attention training would lead to improvement in the ability to inhibit prepotent response, which in turn would lead to improvement in the ability to disengage attention from threat. Although participants trained to attend to non-threat stimuli reported reductions in self-reported assessment of the fear of being negatively evaluated, we failed to find any effect of attention training on the inhibition of a prepotent response. However, we did not find any effect of attention training on the ability to disengage from threat. Again, one cannot exclude the possibility that our effects are related to the absence of attentional bias for threat at baseline. Further, regarding the assessment of the ability to inhibit a prepotent response, we used the Hayling task. We now realized that the Hayling task exhibits a better reliability in the assessment of the ability to inhibit a prepotent response in people with brain damages (such as tumors, strokes, acquired brain injury, dementia) than in healthy people (e.g., Burgess & Shallice, 1996). Moreover, as argued by Eysenck and Derakshan (2011), it is important for research in the context of information-processing bias to use conceptually simple tasks that reflect a specific process as purely as possible. The Hayling task, including semantic knowledge, certainly cannot fulfill this latter condition. Furthermore, the anti-sacade task was identified by Miyake et al. (2000) as such a task among healthy people. In this task, a visual cue is presented to the left or the

right of the fixation point, and the instruction are to make an eye movement to the opposite side as quickly as possible. The latency of the first saccade to the correct side is measured. There is also a control task (the pro-saccade task), in which the instructions are to fixate the cue when it appears.

As a corollary, these data suggest that processes mediating the impact of attention training on anxiety may be more complex than commonly assumed. Despite these preliminary data, the general attentional control hypothesis must wait for experimental manipulations in clinical and subclinical samples. Perhaps the first step in this direction should be to examine whether an attention training protocol that utilizes non-affective stimuli, such as geometric shapes improves delayed disengagement from threat, which in turn, reduces anxiety.

10.1.5. Attentional bias for threat, not only a maintenance factor, but also a vulnerability factor

Within the cognitive models taking account attentional bias for threat, only one of the cognitive models of anxiety we reviewed explicitly states that anxiety disorders may stem from attentional bias (i.e., Bar-Haim et al. (2007). At an empirical level, only few studies have examined the hypothesis that individual differences in attentional bias for threat can causally impact on vulnerability to anxiety through a modified response to subsequent stressor. Although MacLeod et al. (2002) and Eldar et al. (2008) reported evidence in favor of this hypothesis, it remains unclear how this effect occurs. For instance, these two studies included a probe discrimination task as a measure of

attentional bias for threat, which is less than ideal for distinguishing among subcomponents of attentional biases (i.e., difficulties to disengage from threatening stimuli vs. facilitated attention orientation for threatening stimuli).

Study 7 directly addressed this issue. In accordance to Bar-Haim et al.'s hypothesis (2007), our findings suggest that attentional bias for threat contributes to the increase of anxiety during a stressor. They are consistent with a diathesis-stress conceptualization of information-processing bias that frames the latter as a latent vulnerability factor having little or no effect on anxiety until the individual encounters a stressor (e.g., Beck, 1987; MacLeod, Campbell, Rutherford, & Wilson, 2004). According to Gross' model (2002), if attention acts as an initial filter on the processing of environmental cues, then modulating selective attention to threat would be expected to allow a modified subsequent emotional information processing. Further, regarding the nature of the attentional bias feature sustaining these effects, our results indicate that there was only an increase in reaction times for invalid threat trials, thereby bolstering the argument that the difficulty in disengaging attention from threat may be causally involved in the development of emotional vulnerability.

However, overly enthusiastic conclusions about the requirement of a reduced ability to disengage from threat in the development of emotional vulnerability need to be tempered as we failed to report significant mediation of change in reaction time for invalid threat trials on change in vulnerability to stressors in response to attention bias induction. However, as pointed out by MacLeod et al (2009), formal mediational analysis sets a pretty high standard given that the measure of attentional bias may not be acutely sensitive at an individual level. Typically, these assessments have been developed to

discriminate the average level of cognitive bias exhibited by groups of participants differing, for example, in clinical status. They have not undergone the psychometric refinement required to ensure that they can accurately and reliably distinguish one individual from another. Further, the low internal reliability of these instruments, especially in non-clinical sample, provides little reason to feel confident about their capacity to do so (e.g., Mauer & Borkenau, 2007; Schmukle, 2005).

Further, a very recent paper must temper our enthusiastic conclusions about the requirement of disengagement (Hirsch, MacLeod, Mathews, Sandher, Siyani, & Hayes, 2011). These authors sought to induce different types of selective attention to threat by using a task that required participants to switch between two types of decision concerning the same stimulus word: an affective decision requiring semantic access (good or bad?) and non-semantic structural decision (upper or lower case letters?). Participants were randomly allocated to one of four conditions. Two conditions were designed to induce differential biased selective attentional engagement with threat meanings. This involved participants to repeatedly switch from structural to affective decisions for one particular valence of stimuli, with some participants required to consistently make this switch only for threat words (a first condition that encouraging selective engagement with threat meanings), and other being required to consistently make this switch only for non-threat words (a second condition discouraging selective engagement with threat meanings). The two other conditions were designed to induce differential biased attentional disengagement from threat meanings. This involved participants to repeatedly switch from affective to structural decisions for one particular valence of stimuli, with some participants being required to consistently make this switch only for threat words (a third

condition encouraging selective disengagement from threat meanings), and others being required to consistently make the switch only for non-threat words (a fourth condition discouraging selective disengagement from threat meanings). They observed that variability in selective attentional engagement with threat, but not variability in attentional disengagement from threat, effected upon negative intrusions among a sample of non-anxious participants. They interpreted their data as implying that only biased attentional engagement with threat meanings causally influences the tendency to worry by affecting the degree to which selective attention is drawn towards negative aspects of the situation that serve to trigger negative thoughts.

Different explanation may account for the discrepancy between these findings, pointing the causal role selective engagement to threat, and ours, pointing the causal role of the difficulty to disengage from threat. First, it could be that the processes implied in the vulnerability to intrusive thoughts are different from those involved in the vulnerability to anxiety in response to ostracism. Second, it is important to note that attention to the spatial locus of a threat stimulus is not necessarily the same as attention to the threatening meanings of this stimulus. For instance, previous research has focused on the verbal-analytic nature of intrusive thoughts and has suggested that verbal materials may have more impact on mood than anxiety (for a review, see Watkins, 2008). Third, it may also be that features of attentional bias for threat involved in the vulnerability to stressor are different from those involved in the maintenance of the disorder. According to Hirsch et al. (2011, p. 27), selective attentional engagement to threat meanings is assumed to be the critical causal factor in the installation of anxiety. In Study 4, we directly addressed this question by crossing the presence/absence of disengagement from

threat and allocation to non-threat in four different attention training conditions. Results suggest that the difficulty in disengagement from threat is a critical causal factor in the maintenance of anxiety. Unfortunately, in Study 7 we did not realized such crossing on the presence/absence of disengagement from threat and allocation to non-threat. Therefore, one cannot exclude that our training build up a biased engagement toward threat that lead to vulnerability to stressor. Future studies should further investigate this question.

Beyond the previous discrepancy, the demonstration that attentional bias causally contributes to anxiety disposition by influencing anxiety vulnerability to stressor does not refute the possibility that the inverse direction may operate as well. For instance, it remains feasible that the extended experience of anxiety may also causally impact on attentional bias for threat. While our results only target one possible cause that may lead to anxiety disposition, there is good evidence that variability in anxiety results from multiple causes. Hence, a promising issue for future research would be the investigation of potential candidates explaining the development of attentional bias for threat.

One potential candidate is classical conditioning. Indeed, several classical conditioning studies, in which a neutral stimulus (CS+) is paired with an unconditioned stimulus and a second neutral (CS-) is never paired with this latter, have shown that learning fear through this procedure leads to an attentional bias for CS+ relative to the CS- following the fear conditioning (e.g., Koster et al., 2004; Van Damme, Crombez, Eccleston, & Goubert, 2004). In the same vein, Pischek-Simpson, Boschen, Neumann, and Waters (2009) demonstrated, trough a classical conditioning paradigm, that attentional bias for threat face only appears for threat faces previously conditioned. The

findings confirm the interplay between learning-based mechanisms and attentional biases. Finally, this study questions earlier concepts that Pavlovian conditioning occurs in isolation from changes in cognitive variables, thereby providing a reason to consider including Pavlovian conditioning within a cognitive framework (Dawson et al., 1982).

One alternative potential candidate is genetic preparedness. A polymorphism of the 5-HTT gene (5-HTTLPR) results in two variants: a short and a long allele. The serotonin transporter (5-HTT) facilitates reuptake of serotonin from the synaptic cleft. Studies have reported that the short allele is linked with increased self-reports of trait-anxiety and neuroticism (Lesch et al., 1996). In a seminal study, Caspi et al. (2003) found that the short allele increased the risk of depression and suicidability, but only if the subjects had experienced serious stressful life events. More recently, studies have consistently reported that the short allele is linked with attentional bias toward threat (e.g., Beevers, Gibb, McGeary, & Miller, 2007; Fox, Ridgewell, & Ashwin, 2009; Osinsky et al., 2008). Further, Beevers, Wells, Ellis, and McGeary (2009) demonstrated that the short allele is specifically linked with the difficulty in disengaging attention from threat and not with facilitated attention towards threat. Congruently, it should be noted that very recent findings reported that individuals with the low allelic expression (i.e., Short/Short, Short/Long) of the 5-HTTLPR gene exhibited a stronger acquisition of attentional bias for threat when they are trained to attend to threat than those with the high allelic expression (i.e., Long/Long) of the gene (Fox, Zougkou, Ridgewell, Garner, 2011).

It now seems that while specific genes are unlikely to be linked in a direct way to psychopathology, they do moderate the impact that the environment has on stress

sensitivity (Caspi & Moffit, 2006; Hariri, 2009; Uher, 2009; for a meta-analysis, see Karg, Burmeister, Shedden, & Sen, 2011) and provide evidence for a gene-by-environment interactions. Fox et al. (2011) proposed that the short version of the allele may increase sensitivity to the environment in a more general way so that adverse environments will lead to bad outcomes, thereby suggesting that this gene polymorphism may not be a vulnerability genotype but a plasticity genotype (e.g., Belsky & Pluess, 2009; Homberg & Lesch, 2011). The 5-HTTLPR short variant may, therefore, acts as a plasticity gene that renders individuals more susceptible to environmental influences for worse. It is, therefore, unsurprising that short allele carriers usually demonstrate increased attentional bias for threat, which has been confirmed in a recent meta-analysis, and increased amygdala reactivity to threat-related stimuli (Munafo, Brown, & Hariri, 2008).

Further, with respect to the previous candidate we proposed, a recent study showed that short allele carriers are faster than long allele homozygotes to pick up fear responses in a fear-conditioning paradigm (Lonsdorf, Weike, Nikamo, Schalling, Hamm, & Ohman, 2009). These findings support the notion that people with this genotype are more sensitive to fear-related cues in the environment. Because fear learning may be a primary mechanism through which attentional biases for threat develop (see before), it could be speculated that this may be one mechanism through which the short allele carriers acquire a bias toward the more negative aspects of the environment.

10.2. Potentials mechanisms of the attention bias modification benefits

Although our data suggest that disengagement from threat appears as a critical process in reducing anxiety, the underlying mechanisms remain to be investigated. Different but not mutually exclusive potential mechanisms are discussed in this section.

10.2.1. Learning theories

Learning theories provides a useful framework to understand the etiology and maintenance of emotional disorders, especially anxiety disorders (e.g., Craske, Hermans, & Vansteenwegen, 2006; Hermans, Craske, Mineka, & Lovibond, 2006; Mineka & Zinbarg, 2006). In a typical cued conditioning paradigm, a neutral stimulus (conditioned stimulus, CS) is repeatedly followed by an aversive stimulus (unconditioned stimulus, US). After a number of pairing, the CS becomes a reliable predictor of the US and starts eliciting anticipatory fear responses (conditioned response).

According to Mowrer's two-stage model (1939, 1960), operant avoidant behaviors (i.e., negative reinforcement) are developed to reduce the anxiety or discomfort evoked by the various conditioned stimuli; these responses are maintained by their success in doing so. This model suggests that, alongside classical conditioning that explains how stimuli become emotional provoker, operant behavior may also be involved in the maintenance of anxiety. We already pointed out the potential involvement of classical conditioning in the development of attentional bias for threatening cues, we now discuss the potential involvement of operant conditioning in the malleability of attentional bias for threatening stimuli.

Regarding attention training, it may be that instrumental positive reinforcement of behavior occurs because that tasks are designed to reward the desired response (e.g., attending to a benign stimulus), either because doing so makes performance easier and more fluent or because feedback is provided (i.e., a correct anticipation of the condition under which the probe appears). Therefore, although the inclusion of an independent measure of attentional bias before and after training guard us against the problem of potentially learning a responses rule that requires no attentional change, one cannot exclude that change in participants' responses to the probe task would be that they master the task and that this mastering experience constitutes a positive reinforcement, increasing the likelihood to do this behavior.

In the same vein, it might be that the experience of mastering attention constitutes a source of self-efficacy. As developed by Bandura (1988), people's beliefs in their coping capabilities affect how much anxiety they experience in threatening or difficult situations, as well as their level of motivation to confront to these situations. According this author, perceived self-efficacy to exercise control over stressors plays a central role in anxiety arousal.

Consistent with this hypothesis, Klumpp and Amir (2010) found that, after a single-session of training, individuals who were trained to attend to threat and those trained to attend away from threat reported less anxiety in response to an impromptu speech compared to individuals in the control condition in which there were no contingency between probes and cues. However, results from the present dissertation are less conclusive. Study 3 does not replicate these findings. In contrast, Study 5 revealed that subjects in either the attend to threat or attend to non-threat conditions demonstrated

reductions in self-reported and behavioural anxiety. Although the fact that there was no change in attentional bias in this study constitutes a severe limitation, it may be that, among individuals exhibiting a low-level of social anxiety, this improvement in self-efficacy would lead to a decreased anxiety. Because we did not include a non-contingency condition in this latter study, it does not allow to address this specific question.

In order to more directly examine whether attention training lead to emotional change because it favors positive reinforcement, future studies may include a feedback about response accuracy for each trial and experimentally manipulate it (right or wrong). Similarly, future studies should also include an assessment of the self-efficacy beliefs about performing task and compute whether change in this measure (from pre- to post-training) mediate reduction in anxiety. Further, future research could directly manipulate the emotional valence of the probe. Indeed, if attention training is efficient because it positively reinforces the behavior of attending to non-threat, benefits should be only observed among participants for which the probe was positive because that positively reinforces the behavior of attending to non-threat. In contrast, aversive probes should not lead to such benefits, because that positively punishes the behavior of attending to non-threat.

Moreover, if the operant conditioning rules apply to attention training, characteristics of instrumental learning should be encountered in attention training. For instance, spaced sessions of instrumental learning produce more robust learning than massed sessions do (e.g., Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). As we noted in Study 3, a similar phenomenon seems to occur during attention training. Indeed, larger effect size on clinical change was observed when training sessions are spaced rather than

massed. Similarly, as See, MacLeod, and Bridle (2009) observed, spacing sessions may enhance their efficacy.

In sum, the analogy between attention training procedure and operant conditioning principles seems relevant for the understanding of basic processes underlying attention training. However, there was no direct examination of these questions in the present dissertation, which prevents us to draw any solid conclusion about these hypotheses. They constitute a promising challenge for future research in the field of attention training.

10.2.2. Is attention training the automation of a new habit?

According to Shiffrin and Schneider (1977), automatic processing refers to a processing that is effortless, capacity free, unintentional, and outside of conscious control, whereas strategic or controlled processing refers to processing that is effortful, capacity-limited, and subject to voluntary control. Regarding the theoretical models we presented in the general introduction, there are discrepancies regarding the stage of information processing at which attentional biases for threat are postulated to occur. On the one hand, some cognitive models of anxiety posit that attentional bias for threat only result from automatic processing (e.g., Mogg & Bradley, 1998; Williams et al., 1988). According to these models, early attention to threat may lead to enhanced detection of threat and later stages, such as attentional avoidance, may maintain or even enhance anxiety states because habituation is impaired. On the other hand, numerous models posit that attentional bias for threat result from a mixture of both strategic and automatic

processing. Most of these models postulate that the mechanisms of facilitated attention toward threat are automatic, whereas delayed disengagement comes from strategic processing (e.g., Cisler & Koster, 2010). At a more functional level, Öhman (1996) postulated that, although threat detection mechanism is primarily automatic, some strategic feedback loop might be involved in the maintenance of the attentional bias for threat (e.g., memory system). It should be also noted that some of these models specifically predict that automatic attentional bias toward threat could be overridden by strategic effort (e.g., Eysenck, 2007; Mathews & Mackintosh, 1998).

What does the present dissertation say about the involvement of controlled versus automatic processing during attention training? First, while automatic processing is outside of conscious control, controlled processing is subject to voluntary control. Therefore, the level of awareness of the cognitive bias modification may be examined. Some authors (e.g., Koster et al., 2009; MacLeod et al., 2009b) have promoted the idea that change may be achieved implicitly through the modification of cognitive habits, without conscious reference to the training phase. For instance, in attempting to define the bias modification paradigms, Koster et al. (2009) suggested that the targeted bias represents a pattern of processing selectivity that appears to operate automatically. Automation of the new attentional style seems to be the final pathway to change. Nevertheless, at an empirical level, the question remains unsettled. Indeed, most of the attention training studies have relied on participants' implicit learning of the intended contingencies between probes and cues location. Further, some studies have even added a certain amount of non-contingent trials in order to ascertain that the intended cue-target contingencies do not become obvious (e.g., Amir et al., 2008). Similar inclusion was

realized in the studies of the present dissertation (see Studies 2, 3, 5, 6, and 7). In the same vein, some recent investigations have examined the effect of explicitly communicating the training contingency. Krebs, Hirsch, and Mathews (2010) found that attention training procedure is more effective following explicit instructions about the contingency between cues and targets than without these instructions. With respect to the associative learning, these data converge with some previous findings on evaluative conditioning showing that awareness of the CS-US associations may be required for changing valence of a stimulus (e.g., Pleyers, Corneille, Luminet, & Yzerbyt, 2007). However, in a study delivering the same attention training task either with explicit information on the contingency between cues and probes or with no such information, MacLeod et al., (2009b) reported that benefits from attention training are stronger in the latter condition. Unfortunately, there was no such manipulation in the present dissertation, which prevents us to draw any conclusion on this question. However, similarly to some previous studies (e.g., Amir et al., 2009), at debriefing interview, a vast majority of the participants from ours studies who receive the training with a contingency between cues and probes reported that they believe they had been assigned to the non-contingency condition. Future research should further examine this question.

Second, another important point regarding the question of automaticity is the involvement of volitional top-down control or not. In an ERP experiment, Eldar and Bar-Haim (2010) found that attention training reduced P2 and P3 amplitudes and increased N2 amplitude in response to the onset of threat stimuli. They interpreted their data as implying that attention training module late strategic processes rather than processes of early attention orienting. However, in our point of view, this finding does not preclude

that attention training might not be under volitional control. At least, these results suggest that change induced by attention training target processes that are not capacity-free. In the same vein, Koster et al. (2010) found that attention training influences late (1500 ms) rather than early (30 or 100 ms) stages of threat processing.

Recent neuroimaging research also cast light on the contribution of strategic stage of information on attention bias modification. Browning et al. (2010) showed that prefrontal cortical regions mediate attention training. They suggested that, because the prefrontal cortex is, among others, implicated in volitional top-down control, their finding may argue against automatic effects. However, as pointed out by Hertel and Mathews (2011), the effects was observed during test trials, when target detection required attention to the alternate location to that induced during training. Therefore, it may be that volitional control is implemented only when participants have to voluntarily override the practiced responses. As suggested by Hertel and Mathews (2011), a prediction that remains to be tested is whether a similar pattern of activation during training that counteracts preexperimental bias would decrease toward the end of the training trials and thereby constitutes evidence for a newly trained habit. Further, one could argue that the brain regions in which they observed change from before to after attention training are not only involved in volitional top-down control but also, for instance, in self-referential processing (e.g., D'Argembeau et al., 2007; van der Meer, Costrafreda, Aleman, & David, 2010).

Considered together, these points heighten that the issue of automaticity remains unsolved. However, beyond these classic dichotomy between automatic versus strategic, fundamental research (e.g., Jacoby, 1991; McNally, 1995) has depicted a more

complicated situation that initially thought by Shiffrin and Schneider (1977). More precisely, it has been shown that attributes of automaticity do not all apply to attention selective processing of threat (e.g., Mathews & MacLeod, 1986). As argued by McNally (1995), attentional biases are automatic in the sense of being involuntary, but not in the sense of being capacity-free. Therefore, examining whether bias modification effects appear when participants' cognitive resources are depleted through experimental manipulation constitute a future challenge for research on the field. Further, the meaning of automatic has itself been the subject of debate (e.g., Moors & De Houwer, 2006; Santangelo, Ho, & Spence, 2008). In many cases, it has been agreed that core features of automaticity includes operations in parallel, minimal resource requirements, and occurring below the threshold of conscious awareness. In our point of view, future attention training studies should gain to further investigate each separately. For instance, regarding parallel processing, one issue much addressed using the visual search paradigm (see General Introduction) has been the extent to which threatening stimuli is determined by near zero additional cost from increasing the numbers of distracters. For instance, Öhman, Flykt, and Esteves (2001) used threatening and neutral pictures presented in arrays of either 2x2 or 3x3, and participants were instructed to search for the discrepant pictures (either neutral in array of threat or the reverse combination). Results indicated that threatening pictures were located more quickly than the non-threatening ones and no slowing was found on the 3x3 array compared to 2x2 one. Using a visual search task before and after the training, future attention training should examine whether attention training normalize search slope for threatening stimuli (i.e., in the meaning of becoming similar to performance of non-threatening stimuli). In the same vein, in order to

investigate whether attentional bias malleability occurs below the threshold of conscious awareness, future experiments could design attention training procedure in which pictures are subliminally presented. If attention training does not require conscious awareness, the effects should be still present. Finally, regarding the issues of resource consumption, attentional blink paradigm (see the General Introduction) could be included before and after the training. Indeed, as we pointed out in the General Introduction, research suggested that this paradigm appear relatively appropriate to examine whether threatening stimuli recruit more attentional resources than non-threatening stimuli.

10.2.3. Does attention training require change in higher-order mechanism or in early perceptual mechanism?

A very similar question to the previous one pertains to the implication of higher-order versus early perceptual mechanisms in attention training. One relevant area of investigation addresses the role of top-down executive attention control in the maintenance of attentional biases for threatening stimuli (e.g., Cisler & Koster, 2010; Derryberry & Reed, 2002; Eysenck et al., 2007). Cisler and Koster (2010, p. 209) defined it as an *individual difference variable that refers to individuals' ability to regulate their attention allocation*. Very similarly, Posner and Rothbart (2000) proposed an effortful control that refers to individual differences in the ability to engage executive processes to override dominant responses.

According to Eysenck et al. (2007), top-down executive attention control can be construed as a top-down regulatory ability, such that it inhibits the bottom-up influence of

emotional distracters. This notion is based on previous findings that attentional control modulates the difficulty in disengaging attention from threat. For instance, Derryberry and Reed (2002) have found that high-trait anxious individuals reporting poor attention control exhibited delayed disengagement from threat at 500 ms. In contrast, those who reported good attention control did not exhibit such effect. Similar findings were observed using rapid serial visual presentation task (e.g., Peers & Lawrence, 2009).

At a neural level, studies have reported that cortical structures centered around the prefrontal cortex and its functionally-related structures (i.e., anterior cingulate cortex and orbitofrontal cortex) may mediate delayed disengagement from threat through individual difference in the ability to down-regulate the influence of limbic structures and maintain attention on task-relevant stimuli (e.g., Bishop, Duncan, Brett, and Lawrence, 2004; Miller & Cohen, 2001). Prefrontal cortex may also mediate attentional avoidance, given that emotion regulation strategies also constitute top-down regulatory processes. Recent studies have reported that employing emotion regulation strategies (e.g., distraction, re-appraisal) results in increased prefrontal activity and reduced amygdala activity while watching aversive movies (e.g., Eippert et al., 2007; Ochsner et al., 2004). These data converge in suggesting that the ability to regulate attention allocation (regardless of the emotional valence of the stimuli) may moderate the degree to which attention can be disengaged from threat.

What does the present dissertation say about the involvement of top-down executive attention control in bias modification paradigm? In Study 3, we found that attention training towards non-threat reduced attentional avoidance towards threat. As we developed in the General Introduction, anxious individuals exhibit attentional avoidance

at late stages of processing. At a functional level, research has suggested that attentional avoidance may occur because anxious individuals are attempting to *voluntarily down-regulate* negative affect via distraction (Koster, Verschuere, et al., 2005; Mogg et al., 2004; Pflushaupt et al., 2005). Therefore, one can suggest that attention training may facilitate such attempt.

More impressively, most of the studies from the present dissertation as well as those from previous studies (e.g., Amir et al., 2008, 2009) report that the components of induced-change in attentional bias for threat that mediate the impact of attention training on reduced emotional reactivity to stressors are the changes in disengagement from threat. Given the evidence linking difficulty in disengagement from threat with prefrontal cortical regions, that are typically involved in higher-order control (e.g., Bishop, 2009), it may be that attention bias modification impacts on high-order mechanism.

In contrast, a wealth of data has suggested that bottom-up processes may be also involved in attentional bias for threat. More precisely, it has been observed that enhanced amygdala activity is associated with automatic facilitated attention for threat (e.g., Whalen et al., 2004). For instance, Vuilleumier and his collaborators (Dolan & Vuilleumier, 2003; Vuilleumier, Armory, Driver, & Dolan, 2001) demonstrated that subliminally presented or unattended stimuli enhance amygdala activity. However, results from the present dissertation do not provide evidence that attention bias modification decreases facilitated attention for threat. Indeed, the data from spatial cueing task does not revealed any significant change from pre- to post-training in validly cued threat trials for participants who undergo the attention training. However, as demonstrated by Pessoa (2005), it is important to note that early bottom-up influence of

threatening stimuli on amygdala activity may depend on the availability of attentional resources, implying that early perceptual process of threat does not operate completely without top-down processes.

As aforementioned, the hypothesis that attention bias modification modulated top-down process is consistent with previous accounts that the activation of any volitional top-down processes decreases emotional response. This reciprocal inhibition hypothesis is corroborated by neuroimaging studies reporting that prefrontal cortex and functionally-related structures can down-regulate emotion-relevant limbic structures, thus providing a top-down influence (Miller & Cohen, 2001; Myers & Davis, 2002; Quirk, Garcia, & Gonzalez-Lima, 2006; Sotres-Bayon, Cain, & Ledoux, 2006). In regard to our data, however, it remains unclear whether improvement in the ability to disengage attention from threat through attention bias modification deactivates, or at least reduces, amygdala activity. Congruently, in Study 5, we found that attention training improves higher cognitive control (i.e., executive conflict network of the ANT), and that this latter change was positively associated with reduction in behavioral anxiety during the speech performance. Against this prediction are the results of Browning et al. (2010) showing that attention bias modification procedure only enhanced activity from prefrontal cortical regions. However, this effect was observed during a probe task when target detection required attention to the alternate location. Therefore, it may be that intentional control is implemented only when participants have to voluntarily override the practiced responses.

A prediction that remains to be tested is whether bias modification facilitates deactivation of amygdala activity through enhancement of top-down control. Further, it may be that some potential changes in bottom-up processing mediate the effects of top-

down processing on delayed disengagement from threat. For instance, although previous research reported that socially anxious individuals do not show better detection of threatening facial expression (e.g., Schofield, Coles, & Gibb, 2007) or bias to evaluate facial expression more negatively (Philippot & Douilliez, 2005), recent findings have reported that socially anxious participants processes early bottom-up configural information (i.e., low spatial frequencies information from eyes, nose, and mouth regions) differently than did the non-anxious participants (Langner, Becker, Rinck, 2009).

It could be examined whether attention training leads to decreased amygdala activity during the presentation of masked and unmasked threatening stimuli. Alternatively, it has been evidenced that amygdala is automatically elicited by perceptually low-spatial-frequency (LSF) threatening information, but is “blind” to threatening high-spatial-frequency HSF expressions (e.g., Alorda, Serrano-Pedraza, Campos-Bueno, Sierra-Vazquez, & Montoya, 2007; Holmes, Winston, & Eimer, 2005; Pourtois, Dan, Grandjean, Sander, & Vuilleumier, 2005; Vuilleumier, Armony, Driver, & Dolan, 2003). Therefore, it could also be tested whether attention training leads to decreased amygdala activity during the presentation of LSF threatening stimuli, in comparison to non-threatening one. Because the former is a typical bottom-up process (e.g., Vuilleumier et al., 2003), if attention bias modification requires change in such process, amygdala activity should be decreased from pre- to post-training. Further, because it could be that, as predicted by Cisler and Koster’s model (2010), difficulty in disengaging from threat results from a too strong influence of bottom-up processing (i.e., threat detection mechanism, amygdala) on attention control (i.e., prefrontal regulatory

process and functionally-related structures). A future challenge for research in the field would be to examine whether changes in bottom-up processing (e.g., amygdala reactivity to LSF threatening stimuli) mediate the effects of the attention bias modification on changes in disengagement from threat and attention control.

10.3. Implications for applied clinical psychology

10.3.1. Feasibility of attention training as a clinical intervention

The meta-analysis of Hakamata et al. (2011) as well as the findings presented in this dissertation suggest a promising perspective for clinical intervention: Could attention training constitute a stand-alone treatment for anxiety? As pointed up by Bar-Haim (2010), attention training may have several advantages over traditional treatment of anxiety because of ease of delivery. First, the computer-based interface of attention training could bring therapy into a more attractive format. This progress is congruent with a recent series of studies showing that the efficacy of computerized-based cognitive and behavioral interventions for anxiety with minimal therapist-contact are not necessarily less effective than therapist-assisted treatment (for a review, see Newman, Szkodny, Llera, Przeworski, 2011). Second, because it is relatively cheap, attention training opens up the possibility of reaching potential patients who usually do not have access to psychological treatment or medication, through web-based protocols and software installation. Third, because it can be delivered remotely and self-paced in ways that suit the patient, MacLeod et al. (2009a) pointed out that attention training seems particularly

suitable, through boosting sessions, for ongoing post-treatment use to minimize relapse rates and enhance maintenance of treatments gains. Finally, as suggested by Bar-Haim (2010), some specific advantage mentioned above makes this treatment particularly appealing for children and adolescents. Congruently, recent applications of such procedure have evidenced convincing results (e.g., Bar-Haim, Morag, & Glickman, 2011).

Nevertheless, overly enthusiastic conclusions need to be tempered on several points. First, given the empirical variability across our studies (e.g., Studies 3 and 5), we feel that the use of such attention training procedure in clinical setting is premature. For instance, it remains unclear whether attention training is only beneficial for anxious individuals with facilitated attention toward threat, a delayed disengagement from threat, or even for anxious and non-anxious without any attentional bias. Further, the unreliability of the attentional bias assessment also constitutes a strong limitation to solve the question of indication. Indeed, as we already pointed out, the most frequently used measures of attentional bias exhibited poor psychometric properties and could also account for some inconsistency between our studies. For instance, Schmukle (2005) assessed the reliability of the dot-probe task and found, both the pictorial and verbal version, had neither good split-half reliability nor good test-retest reliability. In the same vein, Salemink et al., (2007) found a non-significant correlation between attentional biases indexed through two versions of the dot-probe task (a probe detection and probe discrimination). The same conclusion can be drawn for the emotional Stroop task (e.g., Strauss, Allen, Jorgensen, & Cramer, 2005). However, to our knowledge no study to date has examined the psychometric properties of the emotional spatial cueing task. In our

opinion, before using such tasks in the context of clinical setting and be able to reliably assess inter-individual differences in attentional bias, improving the reliability of the commonly used measures of attentional bias or developing new and more reliable ones is critically needed.

Further, uncertainty remains about the credibility and acceptability of such procedure by patients in real life. Recently, Beard, Weisberg, and Primack (in press) conducted qualitative interviews with 10 socially anxious primary care patients to examine attitudes toward and initial impressions of such computerized bias modification training. Participants were asked about their opinion on feasibility, credibility, acceptability, and clinical utility. Participants frequently expressed a lack of understanding about how the program would help to deal with anxiety. Participants also reported that the procedure needs to be improved regarding its treatment rationale and credibility. However, as we developed above, we should also keep in mind that the issue of the effect of explicitly communicating the training contingency to the participants is still in debate (Krebs et al., 2010; MacLeod et al., 2009b).

In the same vein, the issue of the feasibility of attention training as a clinical treatment also requires to compare the effects of attention training program to more conventional therapeutic interventions for anxiety. Unfortunately, to date, there is no published research in which the therapeutic effect of attention training is compared to effects of cognitive behavior therapy or psychopharmacological treatment. In our point of view, these issues should be exhaustively investigated before introducing attention training procedure in clinical practice.

Finally, a future challenging question will be the examination of how attention

training program interacts with the conventional process of change delivered in the treatment of anxiety, which is, in the case of anxiety disorders, extinction. In order to reduce cued fear in humans, standards extinction procedures have been proved to be successful (Craske et al., 2006; Vervliet, Vansteenwegen, & Eelen, 2004). Generally, nonreinforced presentations of the CS that was previously paired with the US extinguish the phased conditioned fear responses.

Although, as we already heightened, attention training may appears to stand in striking contrast to the goal of extinction, namely to facilitate emotional processing of threat-relevant stimuli by attending to it (e.g., Foa, Huppert, & Cahill, 2006), a review of the extant empirical literature depicts a more complex picture (see before) and suggest that not all forms of attention avoidance are antitherapeutic.

Attention training and extinction process share some similar active ingredients of clinical change. A wealth of studies pointed out the importance of the medial prefrontal cortex in suppressing conditioned fear (for a review, see McNally, 2007). Further, a series of studies provided evidence of a reciprocal relationship between the medial prefrontal cortex and the amygdala (e.g., Quirk, Garcia, & Gonzalez-Lima, 2006; Milad & Quirk, 2002; Shin et al., 2004). As suggested by McNally (2007, p. 755), the aforementioned studies imply that any intervention that can boost activity in the medial prefrontal cortex during exposure to threatening stimuli, such as attention training, may yield therapeutic benefits. Nevertheless, this prediction should be further examined. Future clinical studies should also investigate how attention training may facilitate extinction of CS. If this possibility is real, that will generate a future challenge for applied clinical psychology. For instance, as pointed out by Milad and Quirk (2002), such

rationale suggests that targeted stimulation of the medial prefrontal structures via high-frequency repetitive Transcranial Magnetic Stimulation (HF-rTMS; i.e. activating local neural activities) in anxious patients may further facilitate extinction. It has been also evidenced that the activity of such prefrontal regions can be increased over time using a repetitive training with an executive task (Olesen, Westerbeg, & Klingberg, 2004). Recently, using such procedure, Bomyea and Amir (in press) reported that such training decreased intrusive negative thought, which is a very common symptom of anxiety disorders, within a sample of undergraduate students. There seems to be room for exciting new experimenting and applied investigation.

10.3.2. Toward a transdiagnostic approach of the use of cognitive bias modification

Although the present dissertation mainly focuses on attentional bias for threatening stimuli in social anxiety, Hakamata et al.'s (2010) meta-analysis revealed that attention training lead to beneficial effects across different anxiety disorders. Beyond anxiety, recent works also suggested that such procedure may also lead to benefits across different emotions and problems. For instance, some recent studies have reported promising results showing that training to attend to positive words or pictures may reduce depressive symptoms among dysphoric individuals (e.g., Baert, De Raedt, Schacht, & Koster, 2010; Wells & Beevers, 2010). Similar promising results were found for addictive behaviors. For instance, two recent studies examined the utility of attentional bias reduction as an adjunct treatment for heavy drinking, and both found some evidence for beneficial effects, including a reduction in the amount of alcohol consumed (Fadardi

& Cox, 2009), or an increase in the amount of time that patients remained abstinent before relapsing to drinking (Schoenmakers et al., 2010).

Considered together, these findings suggest that such procedure may be considered within a transdiagnostic approach. The transdiagnostic approach states that there are key cognitive and behavioral processes responsible for eliciting and maintaining symptoms and these are shared across psychological disorders (Fairburn, Cooper, & Shafran, 2003; Harvey, Watkins, Mansell, & Shafran, 2004). In this approach, a process is defined as an aspect of cognition (e.g., attention, memory, thought, reasoning) or behavior (e.g., avoidance, safety behaviours) that may contribute to the maintenance of psychological disorders.

After examining five broad cognitive behavioral processes (i.e., attention, memory, reasoning, thought, and behavior), Harvey et al. (2004) concluded that a series of specific processes could be defined as a definite transdiagnostic process. The process examined in this dissertation, attentional bias for threatening stimuli was classified as a definite transdiagnostic process. Indeed, attentional bias for concern-related material has been observed among individuals with anxiety (see the meta-analysis of Bar-Haim et al., 2007), depression (e.g., Caseras, Garner, Bradley, & Mogg, 2007; Kellough, Beevers, Ellis, & Wells, 2008; Leyman, De Raedt, Vaeyens, & Philippaerts, 2011), insomnia (e.g., Woods, Marchetti, Biello, & Espie, 2009), substance-related disorders (for a review, see Field & Cox, 2008), or eating disorders (Shafran, Lee, Cooper, Palmer, & Fairburn, 2007).

Furthermore, the transdiagnostic approach hypothesizes that these definite transdiagnostic processes causally contribute to the development and/or maintenance of

symptoms. The results of the present dissertation are clearly consistent with these criteria. First, through results from Studies 1 to 4, we reported that attentional biases for threatening stimuli are causally involved in the maintenance of social anxiety symptoms. Similarly, studies from other fields of research provide very convergent findings among mild depressive symptoms (e.g., Baert et al., 2010; Wells & Beevers, 2010), generalized anxiety disorder (e.g., Amir et al., 2009), obsessive-compulsive symptoms (e.g., Najmi & Amir, 2010), and alcohol consumption (e.g., Fadardi & Cox, 2009). Further, results from the Study 7 are consistent with the hypothesis that attentional bias may be causally involved in the installation of the symptoms. However, we only examined this phenomenon in response to socially threatening material. There was no evaluation of such phenomenon for other emotional material (e.g., alcohol-related stimuli) in the present dissertation, which prevents us to draw any solid inference about this notion.

This recent transdiagnostic approach has direct implication for the treatment of psychological disorders. Indeed, an advantage of a transdiagnostic approach is that it might eventually lead to treatment components that are effective across a wide range of disorders. Already, certain psychological intervention seem to be developing this promise, including, for instance, mindfulness training (Baer, 2003) and the Unified Treatment for emotional disorders (Barlow, Allen, & Choate, 2004). Assuming that attentional bias is a transdiagnostic process, a critical implication of this model is adapting the attention training paradigm to serve a transdiagnostic treatment. The fact that differences exist between individuals in term of the content on which attentional bias occurred may be taken into account by therapists (Harvey et al., 2004), especially in the selection of idiographic stimuli.

Using the same rationale, recent studies also shed light on other cognitive bias modification techniques. Cognitive bias modification refers to procedures designed to change particular styles of cognitive processing that are considered as contributing to the maintenance of disorders, using systematic practice in an alternative processing style (Koster, Fox, MacLeod, 2009). As with attention training, interpretation bias modification (e.g., Beard & Amir, 2008; Mathews & Mackintosh, 2000) and memory bias modification (e.g., LeMoult, Hertel, & Joorman, 2010; Raes, Williams, & Hermans, 2009) were developed. In the same way that attention training, modifying these cognitive biases has been shown to produce beneficial changes in subclinical and clinical samples. Although preliminary data are appearing (e.g., Amir, Bomyea, & Beard, 2009; White et al., 2011), examining how multiple forms of information processing biases work conjointly to cause and maintain symptoms constitutes a promising challenge for future research. At an applied level, if different information-processing biases may be involved in the maintenance of disorders, the type of cognitive bias modification that is needed to reduce symptoms depends of each individual's initial level of information processing bias. For instance, only for individuals with a strong initial memory bias, memory training should be applied. Likewise, attention training should be applied for those who show initial attentional bias.

10.4. General conclusions: The return to the models

Attention bias modification is a recent procedure that allows examining the causal involvement of attentional bias for threat on the maintenance of anxiety. We examined

which attentional bias's features are involved in this phenomenon and how top-down processing modulates it.

We have obtained converging evidence that the critical feature of attentional bias for threat in the maintenance of anxiety is the phenomenon of delayed disengagement from threat. Consistent with Cisler and Koster (2010), we have evidenced that difficulty in disengaging from threat may occur independently of facilitated attention because the modification of the former does not impact on the latter one. At a theoretical level, our findings provide support to the hypothesis that attentional bias for threat may be causally involved in the maintenance of the disorder (i.e., Eysenck et al., 2007; Mogg & Bradley, 1998; Williams et al., 1997), and decipher the nature of the attentional bias's feature involved in this phenomenon.

Regarding Öhman's hypothesis (1996; 2005) that biological preparedness may account for the impact of attentional bias for threat on emotional reactivity, we have proposed that variability in the 5-HTTLPR gene may account for this effect. Unfortunately, we did not include assess the polymorphism of this gene in the present dissertation. Future experiments may include DNA collection and investigate whether the impact of a transitory installation of an attentional bias for threat on emotional reactivity to stressor is moderated by the presence of a low-expression of the gene.

We also provided evidence that the maintenance of anxiety is not the result of a vigilance-avoidance pattern of attention (Pflugshaupt et al., 2005; Mogg & Bradley, 2006). According to that view, early vigilance may serve to heighten anxiety whereas the later avoidance maintains anxiety. Our data are not consistent with this view and indicate that the delayed attentional disengagement from threat appears as a relevant candidate for

the maintenance of anxiety. Similarly, our data does not converge with the hypothesis of Foa and Kozak (1986) that the inhibition of detailed processing of threatening stimuli is the core deficit of anxiety, which is reflected in avoidance of threatening stimuli and that fear reduction will be hampered when attention is directed away from the feared stimulus (e.g., Foa, Huppert, & Cahill, 2006). We proposed that the phenomenological difference between fear and anxiety can partly explain the paradox.

According to some models, attentional bias toward threat could be overridden by strategic effort (e.g., Eysenck, 2007; Matthews & Mackintosh, 1998). More predominantly, some theoretical models suggest that the difficulty in disengagement may occur because of generally poor regulatory top-down attention control (i.e., Cisler & Koster, 2010; Eysenck et al., 2007). One may thus expect that change in attention training may be mediated by change in top-down attention control. We have also drawn attention on the hypothesis that some potential changes in bottom-up processing might mediate the effects of top-down processing on delayed disengagement from threat. Indeed, as predicted by Cisler and Koster's model (2010), difficulty in disengaging from threat may be the result of a too strong influence of bottom-up processing (i.e., threat detection mechanism, amygdala) on attention control (i.e., prefrontal regulatory process and functionally-related structures).

Finally, we provide evidence to the prediction of Bar-Haim et al., (2007) that *anxiety disorders may stem from attentional bias for threat*. We also pointed out that the development of attentional bias for threat leads to specific difficulty in disengaging from threat, which in turn, lead to increase emotional reactivity.

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