Effects of attention training on self-reported, implicit, physiological and behavioural measures of spider fear

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ABSTRACT

Cognitive theories hold that biased attention to threat plays a prominent role in the development and maintenance of anxiety disorders. In support of this view, attention training has been shown to affect emotional reactivity. An important limitation of most attention training studies is that they almost exclusively rely on self-report measures to assess changes in fear. In the present study, we trained attention towards or away from spiders. We assessed not only self-reported spider fear, but also implicit associations, physiological, and behavioural measures of spider fear. Although we successfully changed the attentional processing of spiders, attention training had no effect on any of the outcome variables. These results indicate that changes in attentional bias are not necessarily associated with changes in fear, suggesting that attention training may be unsuitable as a clinical intervention for spider fear.

Many cognitive theories on anxiety assume that a number of cognitive biases are core features of anxiety disorders (Beck, Emery, & Greenberg, 1985; Eysenck, 1992; Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1997). For instance, according to the schema-based model of Beck and colleagues, anxious individuals are characterized by the chronic activation of danger schemata, which exert a strong influence on information processing. As a result, these individuals will be more likely to interpret ambiguous situations as threatening, recollect threatening events from memory, and preferentially orient to threatening information in their environment. This preferential allocation of attention towards threatening stimuli is commonly referred to as attentional bias, and has been empirically demonstrated in a large number of studies (for a recent meta-analysis, see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van Ijzendoorn, 2007). Importantly, attentional bias has been claimed to be not just an epiphenomenon of anxiety, but also to maintain or exacerbate anxiety (Bar-Haim, 2010; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mogg & Bradley, 1998; Williams et al., 1997).

In order to address the claim that attentional bias is causally linked to anxiety, MacLeod et al. (2002) investigated whether experimentally induced changes in attentional bias are associated with changes in anxiety. To this end, they used a modified version of the visual probe task (MacLeod, Mathews, & Tata, 1986). In the standard version of this task, two cue stimuli are presented simultaneously on two spatially different locations of a computer screen. Within the context of anxiety, one of these cues is typically negative or threatening, whereas the other cue is typically neutral or positive. After the disappearance of the cues, a target stimulus appears on either the same location (congruent trials) or on the opposite location (incongruent trials) as the threatening cue. Participants are required to respond as quickly and as accurately as possible to the location or to the identity of the target. Attentional bias towards threatening information can then be derived from faster reaction times on congruent trials compared to incongruent trials. MacLeod et al. (2002) adapted this task in order to experimentally change attentional bias by manipulating the proportion of congruent and incongruent trials. In the attend towards threat group, the proportion of congruent trials was increased, whereas in the attend away from threat group, the proportion of incongruent trials was increased. After a single training session with this adapted task, participants in the attend towards threat group not only developed an attentional bias towards threat, but also reported higher levels of emotional distress during a subsequent stress task compared to the attend away from threat group. These findings indicate that an increase in attentional bias towards threat may increase the vulnerability to experience anxiety. More recently, the
reduction of attentional bias has been shown to decrease symptoms of social anxiety (Amir, Beard, Taylor et al., 2009; Amir, Weber, Beard, Bomyea, & Taylor, 2008; Li, Tan, Qian, & Liu, 2008; Schmidt, Richey, Buckner, & Timpano, 2009) and generalized anxiety disorder (GAD: Amir, Beard, Burns, & Bomyea, 2009; Hazen, Vasey, & Schmidt, 2009).

Although these results are promising, a number of considerations require further investigation. First, it is unsure whether attentional bias modification programmes are effective for the reduction of more specific types of anxiety disorders, such as spider or snake phobia. For instance, Harris and Menzies (1998) succeeded in either increasing or decreasing attentional bias towards spiders. However, these changes in attentional bias were not associated with any changes on self-report measures of spider fear. More recently, Reese, McNally, Najmi and Amir (2010) assigned spider fearful participants to either an attentional bias reduction training condition or to a control condition, and they found that the training was successful in reducing attentional bias. Nevertheless, both the training group and the control group showed similar decreases in self-reported spider fear and behavioural avoidance of a spider.

Second, attentional training studies have thus far relied mostly upon self-report measures to assess changes in fear (MacLeod, Koster, & Fox, 2005). Lang (1968; 1993; Bradley & Lang, 2000) indicated that fear is not a unitary construct. They argued that emotions are expressed in three different response systems. First, fear can be expressed through language (i.e., the cognitive-verbal system), such as verbal expressions of feelings. Second, fear can be expressed through overt behaviour, such as fleeing or freezing. Finally, fear can be expressed through physiological responses, such as changes in heart rate and increased skin conductance. Importantly, responses on these three systems are often loosely related, and changes in one system do not necessarily imply changes in the other systems. Therefore, all three systems should be measured in order to obtain a complete picture of the fear response (Lang & Cuthbert, 1984). To our knowledge, only three studies have addressed the effects of attentional training on overt behaviour. Amir et al. (2008) found that socially anxious participants who followed an attentional retraining programme performed better on a speech task than socially anxious participants in a control condition. Reese et al. (2010), however, did not find an effect of attentional retraining on behavioural avoidance of a spider. Finally, Eldar, Ricon and Bar-Haim (2008) found that children who were trained to attend to angry faces showed more anxious behaviours (e.g., negative head movements) during a stress task compared to children who were trained to attend to neutral faces. Physiological effects of attentional training have thus far only been investigated at the neural and endocrine level. Browning, Holmes, Murphy, Goodwin and Harmer (2010) showed that attentional training can modify neural systems involved in attentional control, but not the amygdala. Eldar and Bar-Haim (2010) reported evidence that training attention away from pictures of angry faces in anxious individuals changed evoked brain potentials to the onset of these stimuli (i.e., smaller P2, P3 and N2 amplitudes) compared to placebo training. These changes are argued to reflect decreased emotional processing of threat and increased attentional control following attentional training. In a study of Dandeneau, Baldwin, Baccus, Sakellarpoulo and Puussner (2007), attentional training resulted in lower cortisol release in response to stress. Still, the bulk of attention training studies have focused exclusively on self-reported changes in fear, and no study to date has assessed changes in all three response systems within one sample.

In the present study, we used a modified dot probe task to train participants to either attend towards or away from spiders. We investigated the effects of this attentional manipulation on attentional bias, on self-reported fear of spiders, on physiological fear responses, and on behavioural avoidance. We used the Fear of Spiders Questionnaire (FSQ; Szymanski & O’Donohue, 1995) to assess the cognitive-verbal fear system. Skin conductance and heart rate were recorded in a picture viewing paradigm (Bradley, Cuthbert, & Lang, 1993) to assess the physiological fear system. A Behavioural Approach Test (BAT) in which participants were asked to move their hand as close as possible towards a spider, was used to assess the behavioural fear system. In addition, because self-report measures are known to be susceptible to a number of confounds (e.g., social desirability and limited conscious accessibility of the construct under investigation; see De Houwer, 2006), we also investigated the effects of attentional retraining procedures on an implicit measure of attitudes towards spiders using an Implicit Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998). We decided to examine changes in implicit attitudes towards spiders because it has been hypothesized that negative automatic associations that remain active after treatment may constitute a risk factor for relapse or return of fear (Teachman & Woody, 2003). If attentional bias is indeed causally related to fear, changes in attentional bias should lead to changes in fear. More specifically, training attention away from spiders should reduce emotional responsiveness to spiders, whereas training attention towards spiders should increase emotional responsiveness to spiders.

1. Method

1.1. Participants

Sixty-eight students (14 men, M age = 19.81, SD = 1.90, range = 18–24) participated in this experiment in exchange for € 10. All participants were informed that the experiment contained spider-related stimuli and they all signed an informed consent prior to the experiment.

1.2. Apparatus and materials

The experiment was programmed using the INQUISIT Millisecond 2.0 (2007) software package and was run in a sound-proof laboratory. The behavioural approach test was conducted in a separate room. Physiological signals were recorded with a Coulborn Lablincl DNA card, running Psychophysiological Recordings software (PSPHR; De Clercq, 2009). ECG was recorded using three Ag/AgCl electrodes with a diameter of 8 mm filled with KJ-jelly and placed in lead II configuration. The ECG was filtered (band pass: 8–40 Hz) and digitized at 500 Hz (Jennings, Berg, Hutcheson, Obrist, Porges, & Turpin, 1981). Skin conductance was measured using a constant voltage (0.5) and two Ag/AgCl electrodes with a diameter of 8 mm. The electrodes were filled with KJ-jelly and were attached on the thenar and hypothenar eminences of the non-dominant hand (Stern, Ray, & Quigley, 2001). Skin conductance was digitized at 10 Hz. The psychophysiological data were analyzed off line using Psychophysiological Analysis (PSPHA; De Clercq, Verschuere, De Vlieger, & Crombez, 2006).

1.3. Questionnaires

State and trait anxiety were assessed with the Dutch translations of the State and Trait Anxiety Inventory (STAI-S and STAI-T; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983; van der Ploeg, Defares, & Spielberger, 1980). These questionnaires each consist of 20 statements, scored on a four-point Likert scale. The state version assesses the level of anxiety an individual experiences at this moment in time, whereas the trait version assesses a more general susceptibility to experience emotional distress or anxiety. In the
present study the Cronbach’s alpha coefficient was 0.86 for the STAI-S and 0.93 for the STAI-T.

We used the Dutch translation of the Fear of Spiders Questionnaire (FSQ; Szymanski & O’Donohue, 1995; Muris & Merckelbach, 1996) as a measure of participants’ self-reported fear of spiders. This questionnaire consists of 18 items, and each item is scored on an eight-point Likert scale ranging from zero to seven. The Cronbach’s alpha coefficient in the present study was 0.96 on both assessment points.

1.4. Dot probe task

The dot probe task was modelled after Amir et al. (2008). Throughout the dot probe task, there were four different trial types. First, on congruent trials, the target appeared at the location that was previously occupied by a spider picture. Second, on incongruent trials, the target appeared at the opposite location of the one that was cued by the spider picture. Third, on neutral trials, the target was preceded by a pair of neutral pictures. Finally, we tried to encourage participants to focus on the centre of the screen during fixation by including digit trials. On these trials, the fixation cross was after 1000 ms replaced by a briefly (100 ms) presented digit ranging from one to three. Participants were required to indicate which number they had seen, and had to guess if they had not seen anything.

All stimuli in this task were presented on a black background. Each trial started with the presentation of a white fixation cross in the centre of the screen. Two grey rectangles (6 cm high by 7 cm wide) were presented above and below the fixation cross for 500 ms. The distance between the fixation cross and the centre of the grey rectangles was 4.5 cm. Cues and targets were presented at the centre of the grey rectangles. Six spider pictures were selected from the internet, and twelve neutral pictures (IAPS ratings: valence: $M = 5.00, SD = 0.94$; arousal: $M = 2.54, SD = 1.78$) depicting random household objects, were selected from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 2005; the IAPS has been validated for the population under investigation by Verschueren, Crombez and Koster, 2001). All cue pictures were adjusted to the size of the grey rectangles. For each congruent or incongruent trial, one of six neutral pictures was randomly assigned to one of the spider pictures. The remaining six neutral pictures were paired with each other in a random manner and were presented on the neutral trials. The cue pairs were presented for 500 ms, followed by a 20 ms grey rectangle mask and a target. The target was either the letter ‘E’ or the letter ‘F’, and it remained on the screen until a response was given. Participants were required to respond as quickly and as accurately as possible to the identity of the target by pushing the “1” or the “3” key of the numeric pad of a standard AZERTY keyboard with the index and middle finger of their dominant hand. Each target (‘E’ and ‘F’) was presented equally often and appeared equally often above and below the fixation cross. The intertrial interval was 500 ms.

The dot probe task consisted of four phases. First, in a practice phase, we presented 24 neutral trials and 3 digit trials, in order to acquaint participants with the task at hand. Second, in the pre-training assessment phase, we presented 48 congruent trials, 48 incongruent trials, 24 neutral trials and 6 digit trials. This phase of the dot probe task allowed us to assess participants’ initial attention bias towards spiders. Third, in the attention modification phase, the dot probe task differed according to the group to which participants were assigned. In the avoid threat group, we presented 288 congruent trials, 72 neutral trials and 18 digit trials, divided over three separate blocks. In the attend threat group, we presented 288 congruent trials, 72 neutral trials and 18 digit trials, also divided over 3 blocks. Finally, the dot probe in the post-training assessment phase was identical to the one that we used in the pre-training assessment phase.

1.5. Implicit association test

For the target categories of the IAT, we selected a new set of eight spider pictures and eight flower pictures (6.2 cm high by 7.4 cm wide) from the internet. The attribute categories consisted of eight positive words (English translation: CHEERFUL, GIFT, HOLIDAY, PARTY, PLEASURE, PRESENT, SUMMER, and WARMTH) and eight negative words (English translation: AVERSION, DEATH, DISEASE, FUNERAL, HATE, MISFORTUNE, PAIN, and WAR). Labels were “spider” and “flower” for the target categories, and “positive” and “negative” for the attribute categories. In each block, the relevant labels were shown in the upper left and right corners of the screen. All stimuli were presented in the centre of the screen and remained on the screen until a response was given. Participants were required to respond as quickly and as accurately as possible to the category of each stimulus by pressing the “4” or the “6” key on the numeric pad of a standard AZERTY keyboard with the index and middle finger of their dominant hand.

In line with Greenwald Nosek and Banaji (2003), the IAT consisted of 7 blocks. Each block started with the presentation of the relevant labels for 3 s. The labels remained on the screen throughout the entire block. In the first block, the attribute categorization was practiced by presenting each word twice. The assignment of the response keys to either positive or negative words was counter-balanced across participants. In the second block, each picture was presented twice in order to practice the target categorization. Spiders were categorized by pressing the key that was paired with the negative words in the first block, whereas flowers were assigned to the other key. In the third block, the compatible category mapping (spider-negative versus flower-positive) was practiced. This block consisted of 32 trials, and each word and each picture was presented once. The fourth block was the compatible test block. In this block, each word and each picture was presented twice, for a total of 64 trials. The fifth block consisted of 32 target categorization trials, presenting each flower and each spider picture twice. However, we reversed the response mapping for the target categories, assigning spider pictures now to the “positive” key and flower pictures to the “negative” key. In the sixth block, the incompatible categorization was practiced (spider-positive versus flower-negative). In this block, we presented each word and each picture once, for a total of 32 trials. The seventh and last block was the incompatible test block. This block consisted of 64 trials, in which each word and each picture was presented twice. Throughout the entire task, trials were presented in a random order, and the intertrial interval was 350 ms.

1.6. Physiological fear responses

Physiological fear responses were assessed in a picture viewing paradigm (Bradley et al., 1993) that consisted of two neutral buffer pictures followed by four spider pictures (IAPS pictures: 1200, 1220, 1230, and 1240; IAPS rating: Valence: $M = 3.93, SD = 1.90$; Arousal: $M = 5.34, SD = 2.29$), four generally threatening pictures (1030, 1302, 6241, and 6880; IAPS rating: Valence: $M = 3.99, SD = 1.93$; Arousal: $M = 5.22, SD = 2.31$) and four neutral pictures (7031, 7035, 7080, and 7150; IAPS rating: Valence: $M = 4.87, SD = 1.04$; Arousal: $M = 2.41, SD = 1.73$). Pictures were presented in four blocks, and each block contained one spider picture, one generally threatening picture and one neutral picture. Pictures were randomly assigned to different blocks, and each picture was presented only once. Within each block, pictures were presented in random order. Pictures were presented in 6 s (ISI = 11–15 s), they measured 14.7 cm wide by 11.1 cm high, and they were presented in the centre of the screen.
1.7. Behavioural approach test (BAT)

For the BAT, we used the slough of a juvenile Brazilian salmon pink bird eater (Lasiodora parahybana) of 7 cm wide by 11 cm long (legs included). The slough was placed on the lid of a cardboard box, filled with sand. The abdomen was carefully prepared, so that participants could not see that it in fact was a slough. When participants entered the room, the spider was covered under a cardboard box. Participants were informed that the box contained a large living bird spider, but that it was not dangerous and not aggressive. When participants confirmed that they wanted to continue, they were asked to place their right hand on the table, at a distance of 130 cm from the box. Then, the box was removed and participants slid their hand towards the spider as far as they thought was comfortable. There was no time limit for the approach. The experimenter recorded the minimal distance between the participants’ hand and the spider and the time needed to reach this distance. After the actual approach, participants were guided back to the first laboratory, and they indicated on five separate 9-point Likert scales (1 = not at all to 9 = very much) to what extent they felt afraid, disgusted and aroused during the BAT, to what extent they worried during the BAT, and to what extent they experienced the BAT as intense.

1.8. General procedure

Upon arrival in the laboratory, participants were informed that the experiment would contain pictures of spiders and they were shown an example of a spider picture. All participants then signed the informed consent. Participants were seated at approximately 50 cm from the computer screen and the physiological devices were attached.

The entire experiment consisted of three phases: (1) the pre-training phase, (2) the attentional training phase, and (3) the post-training phase. Participants started the experiment by completing the STAI-T and the STAI-S. Then, the pre-training assessment phase started. Participants carried out the practice version and the assessment version of the dot probe task, followed by the FSQ, the IAT, and the measurement of physiological fear responses. Then, the attentional training phase started. Participants were randomly assigned to one of two conditions. In the avoid threat group, participants carried out the attend threat training version of the dot probe task. In the avoid threat group, participants completed the avoid threat version of the dot probe task. Participants were not informed about this manipulation. After completion of the training version of the dot probe task, the post-training assessment phase started. This phase was identical to the pre-training assessment phase, with the exception that participants now also carried out the BAT. First, participants completed the assessment version of the dot probe task, followed by the FSQ, the IAT, and the measurement of their physiological fear responses. Then, participants were given a brief introduction on the BAT, in which it was stressed that they could end the BAT at any time and that they were by no means obliged to even start with the BAT. Then, participants were guided to another room where the BAT was conducted. Finally, participants completed the short questionnaire about their experiences during the BAT.

2. Results

2.1. Scoring and outliers

For the dot probe task, we did not analyze the data of neutral trials and training blocks because these data do not allow for the calculation of attentional bias scores. We applied the scoring procedure described by Reese et al. (2010) on the data of the pre- and post-training assessment phases. First, we excluded trials with errors (4.40%). Next, we excluded trials with response latencies lower than 200 ms and higher than 1000 ms (3.49%). Finally, we excluded trials with response latencies deviating more than two standard deviations from each individual’s mean (4.30%). From the remaining trials, we calculated attentional bias scores for both the pre- and post-training assessment phase by subtracting the mean reaction time on congruent trials from the mean reaction time on incongruent trials. Positive scores indicate an attentional bias towards spiders, whereas negative scores indicate attentional avoidance of spiders. The data of two participants were excluded because they made too many errors (participants’ scores = 14.77% and 13.83% errors, group mean = 4.22% errors, SD = 2.70). The data of one additional participant were excluded because of overall slow responding (participants’ average latency = 880 ms, group mean = 612 ms, SD = 67.45). Inclusion of these data did not alter the pattern of results.

For the IAT, we calculated the conventional Log measure (Greenwald et al., 1998). For this measure, we excluded trials with errors, trials of all the practice blocks, and the first two trials of each test block. Latencies larger than 3000 ms were recoded to 3000, and latencies smaller than 300 ms were recoded to 300 ms. Finally, latencies were log-transformed and the IAT-effect was calculated by subtracting the mean reaction time on the compatible test block from the mean reaction time on the incompatible test block. Negative scores indicate that the individual more easily associates spiders with negative words relative to positive words, and hence that the individual has a negative attitude towards spiders compared to flowers.

We used PSPHA (De Clercq et al., 2006) to detect r-peaks in the ECG, to calculate the difference between them and to correct for artefacts. Interbeat intervals were converted to beats per minute per real-time epoch (1 s). Next, we subtracted mean heart rate in the 3 s preceding the onset of the picture from mean heart rate in the 6 s after the onset of the picture. For SCRs, PSPHA was used to calculate the difference between the highest and the lowest value in the time window between one and 5 s after the onset of the picture. Scores smaller than 0.05 μS and negative scores were taken as non-responses and were set to zero. To correct for skewness, the data were square root-transformed prior to analysis (Dawson, Schell, & Fillion, 2000).

For the BAT, the minimal distance between the participants’ hand and the spider was used as the primary outcome variable, with higher scores indicating greater avoidance. We also calculated the speed of the approach by dividing this distance by the time that the participant took to reach the minimal distance. For one participant, we were unable to calculate the speed because he/she immediately stopped the BAT (i.e., after less than 1 s). For this participant, the distance between the hand and the spider was scored as the maximum, i.e. 130 cm.

2.2. Group characteristics

Average state anxiety of the final sample of 65 participants was 35.97 (SD = 6.45); average trait anxiety was 38.28 (SD = 9.66). State and trait anxiety did not differ significantly between the two attention groups, both Fs < 1.84, both ps > 0.17. The average score on the pre-training FSQ was 38.84 (SD = 26.43), which is similar to previous research using the FSQ in an unselected sample (e.g., Huijding & de Jong, 2006). Before the training phase, our sample showed attentional avoidance of spiders, t(64) = 2.37, p < .05, and participants had a more negative implicit attitudes towards spiders compared to flowers, t(64) = 11.92, p < .001.

2.3. Effect of attentional training on attentional bias

A repeated measures ANOVA on the attentional bias scores with experiment phase (pre-training vs. post-training) as a within
subjects factor and attention group (attend vs. avoid) as a between subjects factor revealed significant main effects of attention group, $F(1, 63) = 24.52$, $p < .001$, and of experiment phase, $F(1, 63) = 5.92$, $p < .05$ (see Fig. 1). More importantly, the interaction between attention group and experiment phase was also significant, $F(1, 63) = 32.20$, $p < .001$, Cohen’s $f = 0.71$.\(^1\) Follow-up contrast comparisons showed that both groups did not differ significantly in the pre-training phase, $F(1, 63) < 1$, but they did differ after the training phase, $F(1, 63) = 36.89$, $p < .001$, Cohen’s $d = 1.50$. After the training phase, the attend group had developed a significant attentional bias towards spiders, $t(31) = 3.92$, $p < .001$, whereas the avoid group showed significant avoidance of spiders, $t(32) = 6.66$, $p < .001$. Follow-up contrast comparisons confirmed that this interaction indicates that the attend group showed an increased attentional bias towards spiders from pre to post-training, $F(1, 31) = 19.46$, $p < .001$, Cohen’s $d = 0.79$, whereas the avoid group showed greater attentional avoidance from pre to post-training phase, $F(1, 32) = 14.93$, $p < .005$, Cohen’s $d = 0.64$. In sum, these results clearly indicate that our training manipulation was successful in changing attentional bias.

2.4. Effect of attentional training on self-reported fear of spiders

A repeated measures ANOVA on the FSQ-scores with experiment phase as a within subjects factor and attention group as a between subjects factor revealed that the crucial interaction was not significant, $F(1, 63) = 1.50$, $p = .23$, Cohen’s $f = 0.15$, indicating that there was no effect of the training manipulation on self-reported fear (see Table 1). There was no main effect of attention group, $F < 1$, but there was a significant main effect of experiment phase, $F(1, 63) = 12.63$, $p < .005$, Cohen’s $d = 0.44$, illustrating that scores on the FSQ decreased from pre-training to post-training.

2.5. Effect of attentional training on implicit spider attitudes

We conducted a repeated measures ANOVA on the log IAT scores, with experiment phase as a within subjects factor and attention group as a between subjects factor (see Table 1). This analysis revealed that the crucial interaction was not significant, $F < 1$, $p = .32$, Cohen’s $f = 0.12$. There was a marginally significant main effect of experiment phase, $F(1, 63) = 3.12$, $p = .08$, Cohen’s $d = 0.22$, indicating a more negative implicit attitude before the training compared to after the training. The main effect of attention group did not reach significance, $F < 1$.\(^2\)

2.6. Effect of attentional training on physiological fear responses

We conducted two separate repeated measures ANOVAs on the SCR data and the heart rate data, with experiment phase and picture (spider, general threat or neutral) as within subjects factors and attention group as a between subjects factor (see Table 1). For the SCRs, the crucial three-way interaction was not significant, $F < 1$.\(^1\) For heart rate, the crucial three-way interaction was not significant, $F(2, 62) < 1$, $p = .58$, Cohen’s $f = 0.14$. There was a significant main effect of picture, $F(2, 62) = 6.33$, $p < .005$. The interaction between experiment phase and picture type was also significant, $F(2, 62) = 4.03$, $p < .05$, Cohen’s $f = 0.36$. Follow-up contrast comparisons showed that before the training, SCRs were higher for generally threatening and spider pictures compared to neutral pictures, $F(1, 64) = 15.87$, $p < .001$, Cohen’s $d = 0.48$, and $F(1, 64) = 9.28$, $p < .005$, Cohen’s $d = 0.38$, respectively. There was no difference between the SCRs for generally threatening pictures and spider pictures, $F < 1$. After the attentional training phase, there were no differences between the three picture types, all $Fs < 1$.

For heart rate, the crucial three-way interaction was not significant, $F(2, 62) < 1$, $p = .58$, Cohen’s $f = 0.14$. There was a significant main effect of picture, $F(2, 62) = 6.62$, $p < .05$. Follow-up contrast comparisons showed that heart rate was slower for spider pictures compared to neutral pictures, $F(1, 64) = 6.88$, $p < .05$, Cohen’s $d = 0.33$. There were no differences between spiders and generally threatening pictures, $F(1, 64) = 1.86$, $p = .18$, and between generally threatening and neutral pictures, $F(1, 64) = 1.59$, $p = .21$. No other effects were significant, all $Fs < 2.39$, all $ps > 0.09$.

2.7. Effect of attentional training on behavioural avoidance

An independent samples $t$-test on the BAT distance score with attention group as a between subjects factor revealed no effect of attention group, $t(63) < 1$, $p = .65$, Cohen’s $d = 0.11$ (see Table 1). In a similar analysis on the speed scores also did not show this effect, $t(62) < 1$, $p = .68$, Cohen’s $d = 0.10$. Finally, none of the analyses of the five BAT self-report rating scales revealed a significant difference between both attention groups, all $ts < 1$, all $ps > 0.50$, all Cohen’s $ds < 0.17$.

2.8. Supplementary analyses

Because it is possible that attentional retraining is effective only in highly fearful individuals, we repeated the analyses using the pre-training FSQ-score as a covariate. The addition of this variable did not change the overall pattern of results, and none of the crucial interaction effects of pre-training FSQ with experiment phase and attention group reached significance. We also conducted a repeated measures MANOVA with experiment phase as a within subjects factor and attention group as a between subjects factor, and the FSQ, the IAT, SCRs and changes in heart rate in response to spiders as dependent variables. This multivariate analysis revealed only

\(^1\) Effect sizes for simple contrasts were estimated with Cohen’s $d$. According to Cohen (1988), values from 0.20 represent small effects, values from 0.50 represent medium effects and values of 0.80 and larger represent large effects. Effect sizes for interaction effects were estimated using Cohen’s $f$, with values from 0.10 representing small effects, values from 0.25 representing medium effects and values from 0.40 representing large effects. We calculated $f$ using the following formula:

$$f = \sqrt{\frac{\chi^2}{n}}$$

\(^2\) We also calculated the IAT-effect using the D600 as described by Greenwald et al. (2003). The main differences between the conventional log measure and the D600 are the inclusion of the practice blocks, the application of an error penalty and the correction for large dispersion. The results with the D600 mirrored the results obtained with the log measure.
Scores on the FSQ, IAT, Heart Rate, SCR and BAT as a Function of Experiment Phase and Attention Group.

### Table 1

<table>
<thead>
<tr>
<th>Attend Group</th>
<th>Pre-Training M (SD)</th>
<th>Post-Training M (SD)</th>
<th>Avoid Group</th>
<th>Pre-Training M (SD)</th>
<th>Post-Training M (SD)</th>
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<tr>
<td>FSQ</td>
<td>35.81 (24.53)</td>
<td>33.69 (25.13)</td>
<td>41.76 (28.22)</td>
<td>37.39 (27.83)</td>
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<td>−0.07 (0.05)</td>
<td>−0.08 (0.06)</td>
<td>−0.08 (0.04)</td>
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<td>Heart Rate (bpm change)</td>
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<tr>
<td>Spider</td>
<td>−0.28 (1.24)</td>
<td>−0.09 (1.11)</td>
<td>−0.30 (1.51)</td>
<td>−0.31 (1.30)</td>
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<td>General Threat</td>
<td>0.01 (1.28)</td>
<td>0.06 (1.41)</td>
<td>−0.05 (1.28)</td>
<td>−0.21 (1.34)</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>−0.18 (1.24)</td>
<td>0.01 (1.35)</td>
<td>0.18 (1.39)</td>
<td>0.72 (1.63)</td>
<td></td>
</tr>
<tr>
<td>SCR (μS change)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spider</td>
<td>0.26 (0.25)</td>
<td>0.20 (0.17)</td>
<td>0.30 (0.27)</td>
<td>0.22 (0.18)</td>
<td></td>
</tr>
<tr>
<td>General Threat</td>
<td>0.31 (0.23)</td>
<td>0.23 (0.22)</td>
<td>0.28 (0.25)</td>
<td>0.23 (0.18)</td>
<td></td>
</tr>
<tr>
<td>Neutral</td>
<td>0.19 (0.20)</td>
<td>0.19 (0.16)</td>
<td>0.17 (0.13)</td>
<td>0.22 (0.19)</td>
<td></td>
</tr>
<tr>
<td>BAT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Distance (cm)</td>
<td>− −</td>
<td>19.88 (37.13)</td>
<td>− −</td>
<td>15.94 (32.88)</td>
<td></td>
</tr>
<tr>
<td>Speed (cm/sec)</td>
<td>− −</td>
<td>14.47 (11.12)</td>
<td>− −</td>
<td>13.25 (12.24)</td>
<td></td>
</tr>
<tr>
<td>Arousal</td>
<td>− −</td>
<td>5.53 (2.09)</td>
<td>− −</td>
<td>5.39 (2.14)</td>
<td></td>
</tr>
<tr>
<td>Afraid</td>
<td>− −</td>
<td>4.53 (2.51)</td>
<td>− −</td>
<td>4.36 (2.38)</td>
<td></td>
</tr>
<tr>
<td>Disgust</td>
<td>− −</td>
<td>3.97 (2.69)</td>
<td>− −</td>
<td>3.91 (2.75)</td>
<td></td>
</tr>
<tr>
<td>Worry</td>
<td>− −</td>
<td>4.28 (2.39)</td>
<td>− −</td>
<td>4.70 (2.63)</td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td>− −</td>
<td>4.84 (2.32)</td>
<td>− −</td>
<td>4.88 (2.70)</td>
<td></td>
</tr>
</tbody>
</table>

**bpm** – beats per minute.

A significant main effect of experiment phase, $F(4, 60) = 4.86, p < .005$, reflecting the decreases on the FSQ, the IAT and the SCRs from the univariate tests that we reported above. There was no multivariate main effect of attention group, nor a significant interaction, both Fs < 1. Finally, we also calculated difference scores between pre- and post-training scores on all outcome measures. The attentional bias change score did not correlate significantly with the change scores of any of the outcome measures, nor did it correlate with any of the BAT measures, all rs between −0.13 and 0.14, all ps > 0.27.

### 3. Discussion

According to influential contemporary models of anxiety, attentional bias towards threatening stimuli is causally related to anxiety. By targeting attention bias, attentional training programmes aim to reduce anxiety. To date, research on attentional training has relied near exclusively on self-report measures as a primary outcome measure. This is the first study to investigate the effects of attentional training towards or away from spiders on self-reported, implicit, physiological and behavioural measures of spider fear. Our results clearly demonstrate that the training procedure was successful in inducing an attentional bias towards spiders in one group and away from spiders in the other group. In both attentional training conditions, self-reported and implicit spider fear as well as physiological fear responses decreased after training. However, apart from the change in attentional bias, we failed to find any group differences on any of the outcome measures.

Given the null findings, it is important to first consider the validity of the current study before addressing the implications of these findings. One could argue that our null-results are caused by methodological shortcomings. For instance, it is possible that our training manipulation was too short or not strong enough to produce significant changes on our outcome measures. Contrary to this explanation, we used a training procedure that was — with the exception of the stimulus materials — nearly identical to the procedure used by Amir et al. (2008), who found reduced symptoms of social anxiety and generalized anxiety disorder as a result of attention training. Amir et al. (2008) even found these effects after a single training session of 160 trials whereas we used 288 training trials. Furthermore, the training in our study did prove effective in changing attentional bias. Moreover, the effect size of the change in attentional bias in the current study was large, suggesting that the attention training was effective. This result is crucial for the current study, because it validates the training manipulation (MacLeod et al., 2009). Another methodological issue concerns the size of our sample. It is possible that our null-result is caused by a lack of statistical power. However, our sample size was similar (MacLeod et al., 2002) and even larger (Amir, Beard, Burns et al., 2009; Amir, Beard, Taylor et al., 2009; Hazen et al., 2009; Li et al., 2008; Reese et al., 2010; Schmidt et al., 2009; See, MacLeod, & Bridle, 2009) than most studies on attention training within the context of fear and anxiety. Using G*Power 3 (Faul, Erdfelder, Lang, & Buchner, 2007), we conducted a power analysis to investigate what range of effect sizes we should have picked up, given our current sample size, the correlations between pre- and post-training measurements and the conventional value of 0.80 for minimal statistical power. This analysis showed that our sample was large enough to detect experiment phase x attention group interactions with minimum values for Cohen's $f$ of 0.05 for the FSQ, 0.17 for the IAT, 0.21 for SCRs to spiders, 0.26 for heart rate changes to spiders and a main effect of attention group in the BAT with a value for Cohen's $d$ of 0.62. Hence, overall, our sample size was adequate to detect medium to large effects, but may have missed small effects. However, the meta-analysis of Hakamata et al. (2010) shows that attentional avoidance training on average has a medium to large effect ($d = 0.61$) on other measures of anxiety. Importantly, our null findings should be seen in light of the null findings reported by Harris and Menzies (1998) and Reese et al. (2010). Together with these previous findings, our results point to important boundary conditions for attention training. So far, attention training has been shown effective to reduce social anxiety and generalized anxiety disorder (GAD) (e.g., Amir et al., 2008; Amir, Beard, Burns et al., 2009). These diverging results point to important differences between different anxiety disorders.

Anxiety disorders can be put on a continuum with disorders characterized by broad anxiety states elicited by many stimuli on the one end and specific fear states in response to highly specific stimuli on the other end (i.e., GAD > social anxiety disorder > specific phobias). In GAD, threat responding is broadest, whereas in specific
phobia, threat responding is limited to a relatively clear and well-defined category of stimuli or situations (Barlow, 1988; Craske & Waters, 2005; Rachman, 1998). This conceptualisation is related to theorising by Lang and colleagues (Cook, Melamed, Cuthbert, McNeil, & Lang, 1988; Cuthbert et al., 2003; Lang & McTeague, 2009), who have established these differences between anxiety disorders repeatedly in human startle reflex research. The startle reflex is potentiated when individuals are in a fearful or negative state (Lang, Bradley, & Cuthbert, 1990). Lang and McTeague (2009) showed that fear-potentiated startle was largest in participants with specific phobias, smaller in socially anxious people and smallest in people suffering from GAD. Combining this view with the results of attention training studies, it may be that attention training is effective only in disorders that are marked by high levels of anxiety (e.g., GAD, PTSD and PD) rather than fear (e.g., snake phobia, fear of flying).

Importantly, the results of attention training in social phobia do not contradict this hypothesis. Indeed, the samples of Amir, Beard, Taylor et al. (2009) and Schmidt et al. (2009) consisted of participants suffering from generalized social anxiety. Amir et al. (2008) did not specify whether their sample consisted of generalized or circumscribed social phobics, but their primary outcome measure was the STAI-S, which is a measure of anxiety rather than a measure of specific fear. Finally, and most compellingly, Li et al. (2008) found that attention training successfully reduced scores on a measure of anxiety in general social interactions, but it did not effectively change scores on measures of more specific fears, such as fear of being watched or fear of being evaluated. In sum, it seems that attention training may be more effective in reducing anxiety than it is in reducing fear.

As such, this new insight may be helpful in explaining the results from a recent fear conditioning experiment. Van Bockstaele, Verschueren, De Houwer and Crombez (2010) found that extinction of a conditioned fear response was less pronounced if participants attended away rather than towards a signal of threat. The authors interpreted their findings in line with emotional processing theory of exposure therapy (Foa & Kozak, 1986), which holds that attending towards the object of threat is necessary for fear reduction. However, their findings are also in line with the fear-anxiety distinction and the notion that attention training may be restricted to changing anxiety.

Interestingly, in line with the results of Reese et al. (2010), we found overall (i.e., training unrelated) decreases in self-reported spider fear, implicit spider fear and SCRs in response to spider pictures. These changes in fear could be explained by mere exposure to spider-related stimuli. Indeed, all participants in our experiment were exposed to a wealth of spider-related stimuli. Also, it is possible that the overall decrease in self-reported fear is due to demand effects. All participants probably knew that the experiment was related to spider fear, and some may have hypothesized that the goal of the experiment was to reduce this fear. Hence, these participants may have reported lower levels of spider fear on the post-training assessment of the FSQ. Furthermore, the more positive implicit spider associations after than before training may have resulted from practice with the IAT rather than from genuinely less negative associations as a result of the attentional manipulations (Greenwald et al., 2003). A no-training control group could account for these problems.

A limitation of the current study is the relatively short duration of the attentional training phase. It is possible that attention training effects are only apparent after longer or more extensive training sessions. Indeed, attention training sometimes comprises hundreds of trials, spread over multiple session and different days (e.g., Amir, Beard, Burns et al., 2009; Amir, Beard, Taylor et al., 2009). Perhaps a more extensive training is needed to change specific fears such as fear for spiders. Nevertheless, in the study of Reese et al. (2010) who also focused on fear for spiders, there were no differences between participants trained to avoid spiders and control participants, despite a total of 768 training trials. More importantly, a recent meta-analysis found that the extent of training did not moderate the effect of attention training on anxiety measures (Hakamata et al., 2010). Thus, there is currently no empirical evidence that longer, multi-session training manipulations would produce stronger effects than brief single-session training manipulations. Another limitation of the present study concerns the post-training assessment of attentional bias (with 48 congruent and 48 incongruent trials). This phase followed immediately after the training phase and may hence have neutralized possible effects of the attentional training on the other outcome measures. This limitation is somewhat inherent to attentional training research, because convincing proof of a change in attentional bias is considered a prerequisite for the discussion of the effects of attentional training on other measures of psychological functioning (MacLeod, Koster, & Fox, 2009). One possible solution is to assess attentional bias on several points in time after the training phase (e.g., immediately after the training and at the very end of the experiment). If the correlations between the attentional bias scores on these different time points are high, it can be assumed that the change in attentional bias was maintained during the post-training measurement of other outcome variables. A third limitation of this study concerns the use of different spider pictures in the different outcome measures. It is possible the training manipulations were effective in changing spider fear, but only for those pictures that were used during the training. However, such a lack of generalization across different stimuli would be problematic for the use of attentional avoidance training as a clinical practice, because it is impossible to train fearful individuals to avoid every single fear-related stimulus.

In sum, our study shows that changes in attentional bias do not necessarily produce changes in self-reported, implicit, behavioural and psychophysiological measures of spider fear, indicating that attention training may be unsuitable to change spider fear. More broadly, our results indicate that the effectiveness of attention training may differ for the different anxiety disorders on the fear-anxiety continuum. Attention training may be useful to reduce anxiety, but not fear.

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References
