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Attention training toward and away from threat in social phobia: Effects on subjective, behavioral, and physiological measures of anxiety

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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.

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

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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 et al. (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, Sakellaropoulo, 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. (2011) 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 (2009) 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.

Method

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.

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 Fig. 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, Amorin, & Lépine, 1998). One assessor administrated 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

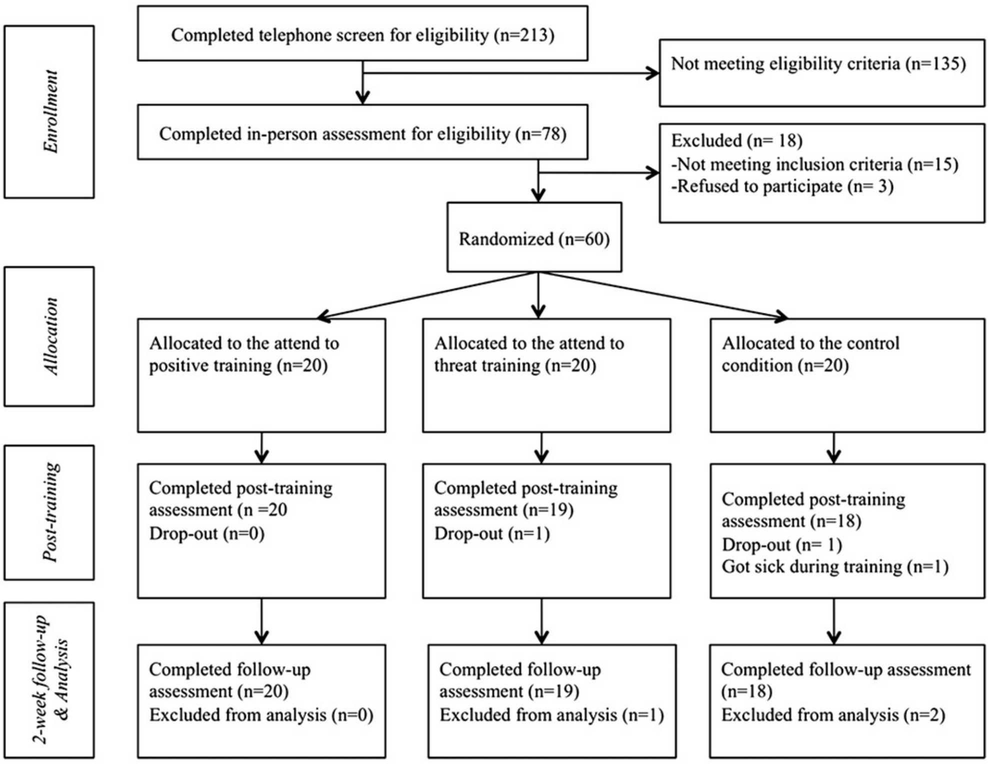

Fig. 1. Flowchart depicting passage of participants through the study.

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.

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.

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

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.

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 × 2 positions × 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 min. 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-min 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 min 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 video recorded.

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 .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 μΩ/V, with a 10-Hz low-pass filter and a .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 .01% of the data, were taken as non-responses and, as recommended by Dawson et al. (1990), were set to .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 face-pairs × 2 positions × 2 arrow's directions × 3 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 min.

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 Fig. 2.

Data analyses

To assess for changes in self-reported anxiety, we computed separate 3 (Time; baseline, post-training, follow-up) × 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) × 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.

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.

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, $F(2, 56) = .69$, $p = .50$, $\eta_p^2 = .03$.

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: $t(17) = 1.91$, $p < .05$].

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

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).

Change in attentional bias

The ANOVA revealed a significant Time × 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, $p < .01$.

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.

Self-reported measures of social anxiety

For the LSAS, the ANOVA only revealed a significant Time × 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 × 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.

Emotional responses to a speech task

Subjective response

For the SUDS rating provided during the speech task, the ANOVA revealed a significant Time × 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

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.

(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 × 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, $p = .99$. Data appear in Table 4.

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 × 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.

Mediational analyses

To examine whether changes in attentional bias mediated changes in self-report, behavioral, and physiological reactivity to the social stressor, 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: 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 = .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 = −.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.

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

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 (amplitudes in μs)	.12 (.05)	.11 (.13)	.13 (.11)	.02 (.04)	.11 (.08)	.11 (.07)

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.

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 nonthreat 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. (2009), this conclusion requires that researchers confirm the predicted changes on a task that reliably measures the mediating cognitive process. Moreover, MacLeod et al. (2009) 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 (2009) second requirement. Mediational 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 mediational 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., Heeren, Peschard, & Philippot, in press; 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 toward 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 toward 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 non-anxious 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 (2011) found that, in a single-session design, disengagement from threat is more important than allocation to nonthreat. Perhaps after receiving extensive training, socially anxious people may learn to attend to nonthreatening 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., 2009, 2008; 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, our sample size was small, limiting the statistical power of our mediational analysis. Second, we used only skin conductance as an index of physiological reactivity. Future research should incorporate other measures, such as heart rate and cortisol release. Third, 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. Fourth, 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. Fifth, 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 generalizability 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.

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