Published in final edited form as:

Behav Res Ther. 2012 May ; 50(5): 350–358. doi:10.1016/j.brat.2012.02.015.

Attention Training to Reduce Attention Bias and Social Stressor Reactivity: An Attempt to Replicate and Extend Previous Findings

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Abstract

Cognitive theories suggest that social anxiety is maintained, in part, by an attentional bias toward threat. Recent research shows that a single session of attention modification training (AMP) reduces attention bias and vulnerability to a social stressor (Amir, Weber, Beard, Bomyea, & Taylor, 2008). In addition, exercise may augment the effects of attention training by its direct effects on attentional control and inhibition, thereby allowing participants receiving the AMP to more effectively disengage attention from the threatening cues and shift attention to the neutral cues. We attempted to replicate and extend previous findings by randomizing participants ($N = 112$) to a single session of: a) Exercise + attention training (EX + AMP); b) Rest + attention training (REST + AMP); c) Exercise + attention control condition (EX + ACC); or d) Rest + attention control condition (REST + ACC) prior to completing a public speaking challenge. We used identical assessment and training procedures to those employed by Amir et al. (2008). Results showed there was no effect of attention training on attention bias or anxiety reactivity to the speech challenge and no interactive effects of attention training and exercise on attention bias or anxiety reactivity to the speech challenge. The failure to replicate previous findings is discussed.

Cognitive theories posit that anxiety disorders such as social anxiety disorder are maintained, in part, by an attentional bias toward threat (Clark & Wells, 1995; Mogg & Bradley, 1998). Socially anxious individuals exhibit an attentional bias toward threat by, for example, scanning their environment for signs of potential negative evaluation from others,

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such as frowning or expressions of boredom (Rapee & Heimberg, 1997), and by having difficulty disengaging their attention from such indicators (Buckner, Maner, & Schmidt, 2010). Attention bias is thought to result in hyperarousal and increased anxiety as well as preventing individuals from gathering disconfirming evidence for their fears (Heimberg, Rapee, & Turk, 2002; Rapee & Heimberg, 1997).

Attention bias in social anxiety has been assessed primarily with computerized probe tasks that use either socially threatening facial expressions (e.g., Gilboa-Schechtman, Foa, & Amir, 1999; Pishyar, Harris, & Menzies, 2004) or words (e.g., Amir, Elias, Klumpp, & Przeworski, 2003; Asmundson & Stein, 1994) as stimuli. For instance, Amir et al. (2003, 2008) have employed a modified version of the Posner paradigm (Posner, 1980) to measure attention bias. This task involves 192 trials presenting threatening or neutral word cues for 600 ms followed by a probe (an asterisk) in either the initial cue word location or the opposite location of the cue word. Of the 192 trials, 128 are valid (i.e., the probe is positioned in the same location as the previous cue word), 32 are invalid (i.e., the probe is positioned in the opposite location as the previous cue word), and 32 are uncued. Participants are asked to click either the right or left mouse button, corresponding to the location of the probe; differences in response latencies to invalid social threat trials versus invalid neutral trials are considered indicative of attention bias (Amir et al., 2008). This operationalization is consistent with extant work suggesting that impaired attentional control, particularly in terms of disengagement and shifting, may underlie the attention bias towards threat observed in socially anxious individuals (Amir et al., 2003; Derryberry & Reed, 2002; Koster, Crombez, Verschuere, & De Houwer, 2006).

In order to target attention bias and corresponding social anxiety, Amir and colleagues (2008) developed an Attention Modification Program (AMP) based on the dot probe paradigm created by MacLeod, Mathews, and Tata (1986). AMP is a relatively brief (i.e., 20 minutes) computer-delivered protocol designed to enhance attention disengagement from socially threatening facial expressions. Evidence from three investigations provides preliminary support for the use of attention training with socially anxious individuals (i.e., Amir et al., 2008; Amir et al., 2009; Schmidt, Richey, Buckner, & Timpano, 2009). Amir et al. (2008) initially tested the effects of a single-session AMP on response to a subsequent social stressor with a socially anxious undergraduate sample. They assessed for attention bias to threat and state anxiety before and after the one-session AMP or placebo. The placebo condition (Attention Control Condition; ACC) differed from the AMP only in that the probe replaced disgust and neutral expressions with equal frequency and therefore did not train patients to disengage from the socially threatening cue and attend instead to the neutral cue. Following the experimental manipulation and the assessment of attention bias, all participants engaged in a social stressor task involving a videotaped speech they were told would be evaluated for its quality. As compared to the control group (ACC), the experimental group (AMP) demonstrated significant improvements in attentional bias ($d = 0.41$) as well as reduced state anxiety ($d = 0.46$) subsequent to the social stressor. Notably, groups did not differ in state anxiety immediately following the attention training; groups only differed in anxiety in response to the subsequent stressor. Therefore, attention training may modify vulnerability to anxiety rather than anxiety directly. Indeed, mediation analyses indicated that changes in attention bias accounted for the reduced state anxiety post-stressor (Amir et al., 2008). Interestingly, there appeared to be no evidence of attention bias in this sample prior to training (AMP or ACC). Specifically, at pre-training, response latency to invalid social threat stimuli appeared no different from response latency to invalid neutral words; this difference was only evident at post-training (see Figure 1; p. 865). Hence, rather than reducing a *bias*, it appears that improvements in disengaging from socially threatening cues may be important to reducing vulnerability to anxiety in this study.

Schmidt et al. (2009) extended the findings of Amir and colleagues (2008) with an eight-session protocol for patients with generalized SAD. Specifically, patients were randomly assigned to receive either attention training (AMP) or attention control (ACC) two times per week, for four weeks. Each session lasted approximately 20 minutes and consisted of brief contact (i.e., less than five minutes) with a research assistant who delivered instructions, followed by the AMP or ACC. Similar to the findings reported by Amir and colleagues, the effect sizes for the advantage of attention training over attention control on anxiety symptoms were significant and in the medium range (i.e., $d = 0.35$ and 0.52 , for post-treatment and follow-up, respectively). Importantly, 72% of the experimental group, compared to 11% of the placebo group, no longer met diagnostic criteria for SAD at post-treatment; these differences were also evident at the four-month follow-up assessment, in which 64% (AMP group) versus 25% (ACC group) were in remission (Schmidt et al., 2009). Unfortunately, this study did not examine whether these differential effects on anxiety reduction were indeed mediated by attention bias reduction.

Evidence for attention bias reduction as a mediator of the effects of AMP on social anxiety symptoms was provided by Amir and colleagues (2009). This study, which utilized the same design and procedures employed by Schmidt and colleagues (2009), replicated the finding that 8 sessions of AMP outperforms 8 sessions of ACC in terms of reductions symptoms of social anxiety, but also observed a significant relation between reductions in symptoms and attention bias change. However, similar to their prior investigation (Amir et al., 2008), there appeared to be no evidence for attention bias in this sample at baseline (i.e., the mean response latency to invalid social threat words appeared comparable to that for invalid neutral words), but merely shorter response latency to invalid social threat words among participants in AMP as compared to those in ACC at posttreatment (see Figure 3; p. 969). Thus, instead of attention bias reduction, increased ability to disengage from socially threatening cues may account for social anxiety symptom reduction in this study.

Taken together, these initial findings represent promising evidence for the efficacy of attention training for social anxiety. AMP has been associated with clinically meaningful changes in social anxiety symptoms. At the same time, there is room for improvement, thus calling for considering strategies that could augment the efficacy of AMP. Importantly, these investigations also raise questions regarding the importance of pretreatment attention bias levels. That is, the studies by Amir and colleagues (2008, 2009) provide no evidence suggesting that pretreatment bias is relevant to the effectiveness of the intervention. Given the proposed role of attention bias in social anxiety, one may hypothesize that the effects of AMP may be more meaningful among individuals who present with attention bias.

The present study aimed to build upon previous work in two meaningful ways. First, we aimed to replicate the study by Amir and colleagues (2008). In addition to testing whether one-session AMP would reduce attention bias and reactivity to a social stressor, we examined whether these hypothesized changes varied as a function of attention bias pre-training. Specifically, we hypothesized that improvements on the two measures would be greater among individuals presenting with attention bias relative to those who do not present with attention bias. Second, we tested the hypothesis that aerobic exercise would augment the effects of AMP. This hypothesis was guided by research showing that moderate-intensity (i.e., 65–70% of maximum heart rate) aerobic exercise bouts ranging from 20–60 minutes have been associated with enhanced inhibition (Tomprowski, 2003). For example, acute bouts of exercise have been associated with improved performance on the Stroop color-word interference task, which requires participants to state the ink color of a word naming a different color (e.g., *red* presented in blue ink) and thus involves inhibiting attention to the task-irrelevant word in order to identify the task-relevant color (e.g., Ferris, Williams, & Shen, 2007; Hogervorst, Riedel, Jeukendrup, & Jolles, 1996; Lichtman & Poser, 1983;

Sibley, Etnier, & Le Masurier, 2006). Similarly, exercise has been shown to improve performance on the Paced Auditory Serial Addition Test, which requires inhibiting attention to a calculated numerical sum in order to attend to the next digit in a presented series (Tomporski, Cureton, Armstrong, Kane, Sparling, & Millard-Stafford, 2005). It is possible that exercise improves attentional control through increased brain levels and uptake of growth factors including brain-derived neurotrophic factor (BDNF), insulin-like growth factor 1 (IGF1), and vascular endothelial growth factor (VEGF; Llorens-Martín, Torres-Alemán, & Trejo, 2008). However, growth factor mediation of improved cognitive performance following exercise may only apply to long-term exercise applications (rather than after only a single bout of exercise). Exercise has also shown to elevate norepinephrine, which in turn, is associated with enhanced cognitive performance (Cahill, Prins, Weber, & McGaugh, 1994; Jacob, Zouhal, Gratas-Delamarche, Bentue-Ferrer, Berthon, & Delamarche, 2003; McGaugh, 2000; Southwick, Davis, Horner, Cahill, Morgan, Gold et al., 2002). Additionally, exercise may increase attentional control via psychological processes such as the efficient allocation of energy involved in executive attention processes (Tomporski, 2003). Regardless of the specific mechanisms underlying the observed findings, these results suggest that exercise enhances attentional control, which is the fundamental target of attention training. Therefore, individuals who receive attention training after exercise may be more likely to engage in the task with improved inhibition such that they can benefit from the training of disengaging from threat cues more effectively than individuals who do not exercise before attention training.

To test study hypotheses, we randomly assigned socially anxious undergraduates to one of four conditions: 1) Exercise + attention training (EX + AMP); 2) Rest + attention training (REST + AMP); 3) Exercise + attention control condition (EX + ACC); or 4) Rest + attention control condition (REST + ACC). Participants first completed a 20-minute, moderate-intensity acute exercise bout at 65–70% of maximum heart rate (or they rested) and then received the AMP (or ACC), followed by a speech stressor task. Attention bias was assessed before and after exercise (or rest) and following the AMP (or ACC); and state anxiety was measured before and exercise (or rest), following the AMP (or ACC), and after the speech stressor.

Method

Participants

Participants were 112 adults who scored in the elevated range of the Liebowitz Social Anxiety Scale—Self-Report (LSAS-SR; Baker, Heinrichs, Kim, & Hofmann, 2002), i.e., greater than a score of 26. This cut-off score for elevated social anxiety was selected in an effort to replicate the procedures implemented by Amir and colleagues (2008), who indicated that a score of 26 is greater than one standard deviation above the mean for individuals with no Axis-I disorders ($M = 10.2$, $SD = 9.3$; Fresco et al., 2001; Rinck & Becker, 2005). Participants were recruited from an undergraduate psychology subject pool and received course credit for their participation.

Inclusion and exclusion criteria for the study were adopted to ensure the safety of participants engaging in exercise and to ensure that participants did not have severe psychopathology that was more important to treat than elevated social anxiety or that would interfere with individuals' ability to complete the protocol. Inclusion criteria included: age between 18 and 65, resting blood pressure <160 systolic and/or 100 diastolic (individuals currently being treated for hypertension and meeting these criteria were eligible), body mass index (BMI) < 40 kg/m², responses to Physical Activity Readiness Questionnaire (PAR-Q-Revised; Thomas, Reading, & Shepard, 1992) indicated that no conditions were present that would render exercise inappropriate, and willingness and ability to provide informed

consent and comply with the requirements of the study protocol. Exclusion criteria included: current severe major depressive disorder, high suicide risk, substance use disorders, current or past psychotic disorders of any type, bipolar disorder (I, II, or NOS), eating disorders, current psychotherapeutic treatment for mood or anxiety disorders, taking PRN (i.e., “as needed”) anxiolytic medications on the day of the experimental session, for women, current pregnancy, plans to become pregnant in the next year, or breast-feeding.

Procedure

The procedures are outlined in Figure 1. Phase I of the screening process involved administering the LSAS-SR to undergraduate students in the psychology subject pool during their class time. Those students scoring greater than 26 on the measure were then invited to participate in the second phase of screening. Phase II of screening consisted of informed consent and the following assessments: the PAR-Q, vital signs, demographics, and the SCID-NP. During informed consent, participants were told that the purpose of the study was to investigate the relationship between exercise, response speed, and behavior. They were informed that everyone would be randomly assigned to receive either exercise or rest and that all participants would complete computer tasks and a behavioral assessment.

Following phase II of screening, participants were randomly assigned to one of the four study conditions. The sample was stratified based on fitness¹ (since fitness has been identified as a moderator of cognitive response to exercise; e.g., Heckler & Croce, 1992; Tomporowski, 2003) in order to control for the influence of fitness level. During the experimental phase of the session, participants first completed baseline assessments (i.e., STAI-Trait, BDI-II, STAI-State, and Attention Bias Assessment Task) followed by exercise or rest for 30 minutes (20 minutes of exercise with 5-minute warm-up and cool-down periods). Participants then again completed the STAI-State and Attention Bias Assessment, followed by the AMP or ACC. The STAI-State and Attention Bias Assessment Task were repeated after the AMP (or ACC), and participants were then informed that the behavioral assessment consisted of a 5-minute speech (following a 2-minute preparation period) that would be video-recorded and subsequently rated for quality by graduate students. After this speech stressor task was completed, the STAI-State was administered for the fourth time. The total duration of the session was approximately 3.5 hours.

Tasks

Exercise condition—Participants assigned to receive exercise completed 20 minutes of supervised, moderate-intensity (i.e., 65–70% of maximum heart rate) treadmill exercise. This dose was selected based on extant work linking this dose to enhanced inhibition (Tomporowski, 2003). Exercise began with a 5-minute warm-up at progressively increasing speed until the target heart range was reached. Participants then trained at the target heart rate for 20 minutes, after which they completed a 5-minute cool-down, during which the speed was gradually reduced, and participants then stretched.

Rest condition—In order to match the timing involved in the procedures for the exercise condition (i.e., 5-minute warm-up, 20-minute exercise bout, and 5-minute cool-down), participants assigned to the rest condition rested for 30 minutes.

¹Cardiorespiratory fitness was estimated using the non-exercise test model reported by Jurca et al. (2005). This model estimates a metabolic equivalent (MET) level of cardiorespiratory fitness² based on the individual's gender, age, body mass index (BMI), resting heart rate, and physical activity category. For the present study, we used the IPAQ to classify participants' physical activity level according to the five-category scale employed by Jurca and colleagues (Jurca et al., 2005).

Attention modification program—The Attention Modification Program (AMP) in the present study was identical to the AMP used in Amir et al. (2008) and was developed based on the dot probe paradigm created by MacLeod et al. (1986). The AMP involves a 20-minute, computer-delivered protocol designed to enhance attention disengagement from socially threatening facial expressions. Facial pictures of eight individuals (four female, four male) were selected from the Japanese and Caucasian facial expressions of emotion (JACFEE) and neutrals (JACNeuF) standardized sets (Matsumoto & Ekman, 1989). Stimuli consisted of a total of 16 pictures (one neutral and one social disgust picture per eight individuals).

Participants first see a fixation cross (+) presented for 500 ms in the center of the computer screen. Next, two faces of the same person are presented for 500 ms with one face 3 cm from the top of the screen and the other 1.5 cm below that top image (face). Both faces were centered horizontally and 17.5 cm from the left edge of the screen and each face was 3.75 cm tall by 5 cm wide.

Following the facial stimuli, a probe (either the letter *E* or *F*) appears in the previous location of one of the faces. Participants are asked to identify the particular letter as quickly as possible by pressing the left computer mouse button to indicate their selection of the letter *E*, or the right button to indicate the letter *F*. Each trial begins immediately following the participants' response with the presentation of the fixation cross, as described.

The probe always replaces the location of the neutral face on trials that include both neutral and disgust faces; this requires participants to disengage attention from the threatening cue location and shift attention to the neutral cue location in order to identify the probe as quickly and accurately as possible. The AMP involves 160 trials, 32 of which include neutral faces only in order to minimize the possibility of deducing the intended training paradigm. The other 128 trials consist of one disgust face and one neutral face in which participants are trained to disengage attention from the threat cue (i.e., the disgust face) and shift attention to the previous location of the neutral cue (i.e., the neutral face).

Attention control condition—The Attention Control Condition (ACC), as reported in Amir et al. (2008), is identical to the AMP. However, the probe replaces the neutral and disgust faces with equal frequency on trials that include a disgust face. Therefore, participants are not trained to disengage attention from the threat cue and to shift attention to the neutral cue.

Speech stressor—We employed an established social stressor paradigm (Amir et al., 2008; Hofmann, Newman, Ehlers, & Roth, 1995; Smits, Powers, Buxkamper, & Telch, 2006). Specifically, participants were asked to speak on a controversial topic (e.g., abortion, corporal punishment, nuclear power) after a brief, 2-minute preparation period in which they could write notes. Participants were informed that a graduate student would subsequently rate the quality of their videotaped speech, and they were then asked to speak for 5 minutes without their prepared notes or until they elected to stop. Consistent with Amir et al. (2008), anxiety reactivity was operationalized as pre-to post-stressor change on the STAI.

Measures

Attention bias—We employed a modified version of the Posner paradigm to assess attention bias, as reported by Amir and colleagues (2003, 2008). Specifically, this task involves 192 computerized trials presenting socially threatening (e.g., embarrassed, stupid, humiliated) or neutral word (e.g., dishwasher, tile, hanger) cues in a box either to the left or right of a fixation cross. Cues consist of a total of 16 words (eight social threat and eight neutral words). After the word cue disappears, a probe (*) appears in either the cue location

or the location opposite of where the cue word appeared. Participants are instructed to press a button to indicate the location of the probe (left or right box). Of the 192 trials, 128 are valid (i.e., the probe appears in the same location as the cue), 32 are invalid (i.e., the probe appears in the opposite location as did the cue), and 32 are uncued (i.e., the probe appears without a preceding word). Attention bias is demonstrated by longer response latencies to invalid social threat trials versus invalid neutral trials (Amir et al., 2008). Similar to Amir et al. (2008), our measure of attention bias allowed a test of generalization of any changes in attention to a different task (Posner vs. dot probe) and different stimuli (words vs. pictures).

Depression—The Beck Depression Inventory-II (BDI- II; Beck, Steer, & Brown, 1996) was used to assess depression. The BDI-II is a commonly used psychometrically sound 21-item self-report inventory designed to measure severity of depression symptoms over the past two weeks (Steer & Clark, 1997).

Social anxiety—The Liebowitz Social Anxiety Scale—Self-Report (LSAS-SR; Baker et al., 2002) was used to assess social anxiety. This is the self-report version of a 24-item scale that provides separate scores for fear and avoidance in a variety of social and performance situations. The LSAS-SR has shown excellent psychometric properties (Baker et al., 2002; Fresco et al., 2001).

State-trait anxiety—The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used to assess state-trait anxiety. The STAI is a widely used measure of state and trait anxiety and is comprised of the State Scale and the Trait Scale. Each scale includes 20 items rated on a 4-point Likert scale. The STAI has demonstrated sound psychometric properties (Barnes, Harp, & Jung, 2002).

Axis-I disorders—The Structured Clinical Interview for DSM-IV Axis-I disorders-Non-Patient Edition (SCID-NP; First, Spitzer, Gibbon, & Williams, 2002) was administered to assess psychiatric exclusion criteria. The SCID-NP was conducted by graduate students who had received extensive training in the administration and scoring of SCID interviews. The training involved a series of steps starting with the review of SCID training tapes, followed by the observation of at least six SCID administrations and the administration of at least six SCID interviews with a trained interviewer. Each interview was reviewed with the last author (a licensed psychologist). A random selection of 10% ($N = 11$) of all audio-recorded interviews was examined by an independent trained rater and revealed no cases of disagreement.

Data Analytic Strategy

Power analysis—An a priori power analysis was conducted to determine the appropriate sample size for testing hypotheses with the primary outcome variable, attention bias. The power analysis indicated that a sample of 112 participants would yield adequate power (i.e., 80%) to detect a small effect size ($f = 0.10$) at $p < 0.05$ using a repeated measures ANOVA with two between-subject factors and three within-subject factors (G*Power 3.0.10; Faul, Erdfelder, Lang, & Buchner, 2007).

Data cleaning—Prior to all analyses, descriptive statistics were computed to identify variables that varied significantly by condition at baseline in order to subsequently enter them as covariates in all analyses. Additionally, descriptive statistics were examined to determine whether or not the dependent variables met the assumptions of normality. As all of the response latency variables violated the assumptions of normality, these variables were log-transformed to achieve normal distributions prior to conducting analyses.

In accordance with the procedures outlined in Amir et al. (2008), response latencies for inaccurate trials on the Attention Bias Assessment Task were eliminated. Trials in which participants pressed the keyboard button corresponding to an incorrect location of the probe were considered inaccurate (e.g., pressing the button corresponding to the left side of the computer screen for probe locations on the right side of the screen). Two percent of the trials were subsequently eliminated. Also consistent with Amir et al.'s (2008) procedures, outliers in response latencies (less than 50 ms and greater than 1,200 ms) were eliminated, which represented 1% of the remaining trials.

Hypothesis testing—Hypotheses were tested using a repeated measures analyses of variance (ANOVA) framework, and the assumptions of repeated measures ANOVA (i.e., normality of the distributions of the dependent variables; sphericity; and homogeneity of error variances) were tested to ensure appropriate interpretations of the data. First, we examined whether demographic variables and scores on measures completed at baseline varied as a function of condition. Variables that were significantly different among groups were included as covariates in the main analyses. Second, in order to isolate the efficacy of exercise for enhancing the effects of AMP on attention bias, we first tested the effects of exercise on attention bias changes from pre- to post- exercise/rest or prior to AMP/ACC. To this end, we performed a 2 (Exercise: EX, REST) $\times$ 2 (Word Type: social threat, neutral) $\times$ 2 (Time: pre-exercise, post-exercise) $\times$ 2 (Validity: valid, invalid) ANOVA on response latencies during the modified Posner paradigm with repeated measurement on the last three factors. Third, we tested the effects of exercise for augmenting attention training on attention bias changes from pre- to post AMP/ACC and reactivity to social stressor. In these two separate analyses (i.e., attention bias change, reactivity to stressor), response latencies during the modified Posner paradigm and STAI-S scores (i.e., pre and post speech), respectively, we subjected to a 2 (Exercise: EX, REST) $\times$ 2 (Attention Training: AMP, ACC) $\times$ 2 (Word Type: social threat, neutral) $\times$ 2 (Time: pre-AMP, post-AMP) $\times$ 2 (Validity: valid, invalid) ANOVA with repeated measurement on the last three factors. Finally, in order to examine whether the effects of AMP and its interaction with exercise on attention bias and stressor reactivity would vary as a function of attention bias at baseline, we repeated the last set of analyses with attention bias at baseline as an additional predictor. Here, we first tested the effects of the continuous measure of attention bias, as defined by difference between the mean response latency to invalid social threat words and the mean response latency to invalid neutral words, and the dichotomous index of attention bias, as operationalized by presence or absence of a positive difference between the mean response latency to invalid social threat words and the mean response latency to invalid neutral words.

Results

Sample Characteristics at Baseline

Table 1 reports the sample characteristics at baseline by condition. Ages ranged from 18 to 48 years ($M = 19.87$; $SD = 3.15$), and the sample was 81.5% female. Thirty-two per cent of the sample was diagnosed with a primary Axis-I disorder including: social anxiety disorder (10.7%); major depressive disorder (6.3%); specific phobia (3.6%); alcohol abuse (2.7%); generalized anxiety disorder or depressive disorder NOS (1.8%); or adjustment disorder, past binge eating disorder, past anorexia, or anxiety disorder NOS (0.89%). On average, the sample reported elevated levels of social anxiety as indexed by the LSAS-SR ($M = 50.25$; $SD = 16.10$), but the majority did not meet threshold for a social phobia diagnosis (89.3%). As evidenced by no significant positive difference between the mean response latency to invalid social threat words and the mean response latency to invalid neutral words ($M_{diff} = -.418$; $SD_{diff} = 39.58$; $F(1,110) = 1.24$, $p = .268$)², the sample did not exhibit an attention bias

at baseline. Interestingly, this difference score was not significantly correlated with the LSAS-SR score, $r = .102$, $p = .288$.

Group differences were not found on demographic variables or on measures of social anxiety or trait anxiety completed prior to the experimental procedures. However, a significant between-group difference existed for BDI-II scores, $F(1, 108) = 11.22$, $p < .01$, so we entered baseline BDI-II scores as a covariate in all analyses.

Manipulation Checks

Exercise—Mean heart rates for each of the four heart-rate readings collected during the 20-minute exercise bout ranged from 136.80 to 139.29 beats per minute, with standard deviations ranging from 7.14 to 13.14. These values are consistent with the average 65–70% of maximum heart rate range of 130–140 beats per minute calculated for participants.

Speech length—Speech lengths among the four conditions were compared to determine whether differences might exist that could reflect varying intensities of the speech stressor task and that could account for variation in anxiety reactivity to the task. Results indicated that there were no differences between groups regarding the length of participants' speeches ($M = 2$ min, 44 s, $SD = 1.64$ vs. $M = 2$ min, 50 s, $SD = 1.64$ vs. $M = 2$ min, 48 s, $SD = 1.63$ vs. $M = 2$ min, 36 s, $SD = 1.45$, for EX + AMP, REST + AMP, EX + ACC, and REST + ACC, respectively).

Attention Bias Changes After Exercise/Rest Manipulation

Figure 2 represents response latencies to invalid social threat, valid social threat, invalid neutral, and valid neutral trials from pre- to post- exercise/rest and by experimental condition. There were no significant interactions with the Exercise term, but there were main effects for Time, $F(1, 109) = 8.50$, $p < .005$, which indicated that participants' response latencies decreased with repeated assessment, and Validity, $F(1, 109) = 32.53$, $p < .001$, which reflected participants' shorter response latencies to valid vs. invalid trials.

The Singular and Combined Effects of AMP and Exercise on Attention Bias

Figure 3 represents response latencies to invalid social threat, valid social threat, invalid neutral, and valid neutral trials from pre- to post- AMP/ACC and by experimental condition. The selection of timepoints in this analysis reflects the time span in which both exercise and attention training effects could conceivably interact: after exercise and before and after attention training (i.e., pre-AMP and post-AMP). There were no significant interactions involving the Exercise or Attention Training terms, but there was again a main effect for Validity, $F(1, 106) = 24.01$, $p < .001$, which reflected participants' shorter response latencies to valid vs. invalid trials.

Table 2 reports on the continuous measure of attention bias, as defined the difference between the mean response latency to invalid social threat words and the mean response latency to invalid neutral words, as a function of assessment occasion and condition assignment. Consistent with our a priori specified analyses above, post-hoc analyses of this continuous measure of attention bias also showed no significant effect of attention training on attention bias. More specifically, the pre- to posttraining attention bias did not vary significantly as a function of AMP/ACC condition assignment (among participants in the rest condition and among participants in the exercise condition), or exercise/rest condition

²One individual evidenced a mean difference of -520 ms, reflecting a deviation of >3 SDs from the mean. We removed this outlier from all analyses involving this continuous attention bias score.

assignment (among participants in the AMP condition and among participants in the ACC condition).³

The Singular and Combined Effects of AMP and Exercise on Stressor Reactivity

Figure 4 depicts anxiety reactivity to the speech stressor task by condition. Again, the ANOVA did not yield significant interactions involving the Exercise or Attention Training terms, but merely a main effect of Time, $F(1, 105) = 24.95, p < .001$, which indicated that participants' anxiety increased from pre- to post-speech stressor task.

Moderating Effects of Baseline Attention Bias on Attention Bias and Stressor Reactivity

Our moderator analyses yielded no significant interactions between the dichotomous or continuous baseline attention bias term and the Exercise or Attention bias terms on attention bias or speech reactivity. The ANOVA with attention bias as the dependent variable did yield a significant 4-way interaction of Time X Word Type X Validity X Continuous Attention Bias, $F(1, 107) = 62.83, p < .001$. As can be seen in Figure 3, this significant interaction is not suggestive of an advantage of AMP over ACC in terms of reducing attention bias. Instead, the results indicate that response latency to invalid social threat words (and invalid neural words) did not improve in either AMP- or ACC-treated individuals. Probing of this significant 4-way interaction may provide useful insight regarding the nature of change in response latencies to neutral vs. threat and invalid vs. valid words with repeated assessments. However, we believe that describing this effect in the present report detracts from the main objectives of the study.

Discussion

The purpose of the present study was to replicate and extend previous work suggesting that attention training can reduce attention bias and subsequent vulnerability to psychological stressors. To this end, we conducted an experiment with sufficient statistical power to detect small effects of attention training with or without exercise on attention bias and anxiety reactivity to a speech task in socially anxious adults. We used identical assessment and training procedures to those employed by Amir et al. (2008). Our findings did not support the hypotheses. Specifically, there were no singular effects of attention training on attention bias or anxiety reactivity and no interactive effects of attention training and exercise on attention bias or anxiety reactivity, nor did these hypothesized effects vary as a function of attention bias at baseline.

Our hypotheses were based on the findings reported by Amir et al. (2008). Replication of these findings in the present study would have been shown by greater reductions in attention bias and anxiety reactivity in the REST + AMP condition relative to the REST + ACC condition. One possible explanation for our findings is that we did not fully replicate the methodology employed by Amir et al. (2008). Although we used identical assessment and training procedures and a comparable sample, we included three instead of two assessments of attention bias. The rationale for adding a third assessment was to isolate the possible augmentation effects of exercise. It seems unlikely, however, that the addition of one assessment time point would reduce the effects of attention training on attention bias.

It is important to consider the possibility that the failure to observe effects of attention training may be specific to single-session training. AMP investigations with longer protocols (e.g., Amir et al., 2009; Schmidt et al., 2009) have produced larger effects than single-

³In order to examine the possibility that the findings would be different for individuals in the clinical range of social phobia, we reran the analyses limiting the sample to individuals who met a previously established empirical cutoff of 30 on the LSAS (Rytwinski et al., 2009). The pattern of the findings was identical to that observed with the full sample.

session investigations (e.g., Amir et al., 2008; Klumpp & Amir, 2010), and findings from Hakamata et al.'s (2010) recent meta-analysis indicate that the number of attention training sessions is associated with reductions in attention bias. Although Amir et al. (2008) observed changes in attention bias on the Posner task after a single session of training, this low dose may not produce effects that are strong enough to generalize to a different task and stimuli in a reliable manner. Inadequate dosing may also be the factor that explains a lack of exercise effects in the present study. Here, we should also consider the fact that we employed a college sample, which comprises individuals who may not benefit as much from the proposed effects of exercise (i.e., improved cognitive functioning) relative to individuals who are functioning at a lower cognitive level. Furthermore, we expected exercise to augment the effects of attention training due to increasing attentional control. While exercise represents a potentially useful augmentation strategy that is relatively straightforward to implement (e.g., easy to disseminate, non-pharmacological; Otto, Church, Craft, Greer, Smits, & Trivedi, 2007; Smits, Powers, Utschig, & Otto, 2007), we acknowledge, especially in light of the findings, that it may not offer an advantage over more direct methods of increasing attentional control, such as the Paced Auditory Serial Addition Test (PASAT) training (Gronwall, 1977; Tomporowski et al., 2005; Westerberg et al. 2007).

The repeated assessment of attention bias prior to attention training provided some interesting information. Indeed, the largest improvements in response latencies were seen prior to instead of following attention training. These dramatic changes observed prior to training cause some concern regarding the reliability of the modified version of the Posner paradigm to assess attention bias. As to its validity, it is interesting that we did not observe a significant correlation between social anxiety severity and the difference between the mean response latency to invalid social threat words and the mean response latency to invalid neutral words. This finding indicates that the measure may not reliably capture attention bias. This limitation of the Posner paradigm has been noted by others (Weierich, Treat, & Hollingworth, 2008). For example, the fact that the cue stimulus disappears prior to the presentation of the probe in the modified Posner task results in individuals disengaging their attention from the location of a previously-presented threat cue instead of disengaging their attention from the actual threat cue itself (as would be the case in "real-world" social settings in which socially anxious individuals are hypothesized to have difficulty disengaging their attention from threat stimuli that are present, rather than absent, at that moment). This aspect of the modified Posner task may be problematic for capturing an accurate measure of attention bias in terms of disengagement from threat (Weierich et al., 2008).

Similarly, the stimuli selected for examinations of visual attention processes may not correlate highly with stimuli present in naturalistic settings (Weierich et al., 2008), and some evidence indicates that word cues may produce a less sensitive index of attention bias than facial expression cues among non-clinical samples of individuals with elevated social anxiety (e.g., Pishyar et al., 2004). It has also been suggested that tasks comparing attentional processes with threat and neutral (and/or positive) cues may assess sensitivity to the negative valence of stimulus cues rather than anxiety responses to threat unless negative, non-threat cues are also included to control for reactivity to negatively valenced stimuli (cf. Keil & Ihssen, 2004; Weierich et al., 2008). Future research could address these limitations by using alternative versions of the Posner task that assess attention bias with stimulus cues that remain visible during the presentation of probes so that participants could disengage from threat cues that remain present, similar to real-world experiences. Additionally, negatively valenced non-threat cues could be incorporated to control for sensitivity to negative stimuli, and facial stimuli (different from those included in the AMP) instead of word cues could be considered as well.

In sum, the present findings reflect a failure to replicate the previous findings of Amir et al. (2008) in which attention training was associated with reductions in attention bias and anxiety reactivity in socially anxious individuals. Additionally, the current study found no evidence for exercise as an augmentation strategy to attention training. This study provides an important contribution to the preliminary evidence-base for attention training as a novel treatment strategy for anxiety in that it emphasizes the continued need for replication and guides future work on the assessment of attention bias as well as methods to ameliorate it.

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Highlights

- The study attempted to replicate a previous study (Amir et al., 2008) that has formed the basis of a number of clinical studies evaluating attention training for anxiety disorders
- Using a comparable sample and identical methods to the Amir et al. (2008) study, the results of the present study provide no support for attention training to reduce attention bias or anxiety reactivity to social stressor
- The study did not provide support for using aerobic exercise to augment the effects of attention training on attention bias or anxiety reactivity to social stressor
- This study provides an important contribution to the preliminary evidence-base for attention training as a novel treatment strategy for anxiety in that it emphasizes the continued need for replication and guides future work on the assessment of attention bias as well as methods to ameliorate it.

Figure 1.
Overview of study procedures.

Figure 2.

Response latency as a function of word type and validity before and after exercise/rest and by experimental condition.

Note. EX = exercise; AMP = Attention Modification Program; ACC = Attention Control

Figure 3.

Response latency as a function of word type and validity before and after AMP/ACC and by experimental condition.

Note. EX = exercise; AMP = Attention Modification Program; ACC = Attention Control

Figure 4. State anxiety scores before and after the speech stressor by experimental condition.
Note. EX = exercise; AMP = Attention Modification Program; ACC = Attention Control

Table 1

Sample characteristics by study condition

Variable	EX + AMP (N=28)	REST + AMP (N=28)	EX + ACC (N=28)	REST + ACC (N=28)
Female, N (%)	23 (82.1)	22 (78.6)	24 (85.7)	22 (78.6)
Age, M (SD)	19 (1.0)	21 (5.9)	19 (0.9)	20 (1.2)
Social phobia, N (%)	2 (1.8)	4 (3.6)	6 (5.4)	0 (0)
Axis-I diagnosis, N (%)	6 (5.4)	14 (12.5)	10 (8.9)	6 (5.4)
BDI-II, M (SD)	5.43 (4.9)	12.93 (9.62)	9.96 (9.37)	7.75 (5.55)
LSAS-SR, M (SD)	49.3 (16.6)	49.0 (15.3)	53.5 (18.3)	49.3 (14.3)
STAI-T, M (SD)	37.3 (10.4)	44.2 (13.7)	37.6 (11.6)	36.9 (9.1)

Note. EX = Exercise; AMP = Attention Modification Program; ACC = Attention Control Condition; BDI-II = Beck Depression Inventory-II; LSAS-SR = Liebowitz Social Anxiety Scale—Self-report; STAI-T = State-Trait Anxiety Inventory—Trait version.

Table 2

Attention Bias Changes as Function of Time and Experimental Manipulation

Assessment	Exercise		Rest	
	AMP (N=28)	ACC (N=28)	AMP (N=28)	ACC (N=28)
Baseline				
<i>M (SD)</i>	-11.0 (37.2)	4.9 (26.0)	-15.9 (41.8)	4.1 (34.0)
Pre-Training				
<i>M (SD)</i>	5.2 (34.0)	1.8 (29.8)	12.3 (34.1)	-.7 (22.1)
Post-Training				
<i>M (SD)</i>	-10.4 (39.1)	-7.3 (39.9)	-4.0 (34.2)	.7 (22.6)

Note. Attention bias is defined as the difference between the mean response latency to invalid social threat words and the mean response latency to invalid neutral words; EX = Exercise; AMP = Attention Modification Program; ACC = Attention Control Condition; Shaded section represents data relevant to the replication of the Amir et al. (2008) study.