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ORIGINAL ARTICLE

Cognitive Bias Modification for Social Anxiety: The Differential Impact of Modifying Attentional and/or Interpretation Bias

Eric S. Yeung[1] · Louise Sharpe[1]

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Abstract
Cognitive Bias Modification (CBM) refers to the modification of cognitive biases, such as selectively attending to threatening information or interpreting information in a threatening way. CBM for attention (CBM-A) and interpretation (CBM-I) are efficacious in reducing anxiety vulnerability and anxiety symptoms. However, little research has investigated the potential synergies of these interventions. This study aimed to determine the relative efficacy of CBM-A, CBM-I, and combined CBM for reducing social anxiety symptoms and attenuating anxiety vulnerability in response to a social stressor task. Participants ($N=116$) were randomly allocated to receive CBM-A, CBM-I, combined CBM, or placebo. Results revealed that CBM-I reduced negative interpretation bias and social anxiety symptoms. Furthermore, CBM-I improved speech performance on a social stressor task. However, CBM-A procedures did not modify attentional biases or anxiety vulnerability. These findings support the efficacy of CBM-I for social anxiety; however, no evidence for the efficacy of CBM-A was found, nor was the combined cognitive bias hypothesis supported in this study.

Keywords Social anxiety · Attentional bias · Interpretation bias · Threat · Cognitive bias modification

Introduction

Social anxiety is characterised by anxiety about social situations in which one may be evaluated. Cognitive-behavioural theories of social anxiety have long posited that socially anxious individuals selectively attend to socially threatening information, and interpret ambiguous social information in a negative manner (Clark and Wells 1995; Rapee and Heimberg 1997). The 'combined cognitive bias hypothesis' (Hirsch et al. 2006), which derives from cognitive-behavioural models, suggests that in social anxiety, the negative self-imagery that people hold increases anxiety. This anxiety leads people to interpret their performance negatively and over-attend to ambiguous or critical feedback which in turn increases anxiety and negatively impacts social performance. Hence, attentional and interpretation biases are thought to influence each other and lead to a cascade of processes that reinforce social anxiety in the longer term. That is, individuals with social anxiety exhibit a threat-related attentional bias and a negative interpretation bias, both of which are hypothesised to interact with each other in the development and maintenance of social anxiety. On the basis of these theories, interventions to modify these cognitive processes—named Cognitive Bias Modification (CBM)—have been developed (MacLeod and Mathews 2012).

Broadly, in the literature, CBM has most often been used to modify attentional biases (CBM-A) or interpretation biases (CBM-I). Further, CBM has been used either to reduce the anxiety response to a subsequent stressor (i.e., improve anxiety vulnerability) or to reduce anxiety symptoms. Meta-analyses have confirmed that CBM-A reduces anxiety vulnerability with moderate effect sizes (Beard et al. 2012; Cristea et al. 2015; Hakamata et al. 2010; Hallion and Ruscio 2011; Heeren et al. 2015; Linetzky et al. 2015; Mogoaşe et al. 2014). Although CBM-A is also associated with significant reductions in anxiety, in all eight meta-analyses with adults, results indicated smaller effects. That is, anxiety vulnerability effects sizes for CBM-A ranged from Cohen's $d=0.37$–0.77, while for reduction in anxiety symptoms, effect sizes ranged from Cohen's $d=0.16$–0.41 (see Jones and Sharpe 2017). In contrast, meta-analyses have confirmed that CBM-I is effective in modifying anxiety symptoms (Cristea et al. 2015; Hallion and Ruscio 2011; Menne-Lothmann et al. 2014), but the efficacy of

✉ Louise Sharpe
louise.sharpe@sydney.edu.au

1 School of Psychology, The University of Sydney, Brennan MacCallum A18, Camperdown, NSW 2006, Australia

CBM-I on anxiety vulnerability was not established in the one meta-analysis that examined this effect (see Jones and Sharpe 2017 for a discussion). The combined cognitive hypothesis suggests that combining CBM-A and CBM-I would be a more effective method of improving anxiety; however, few studies in the CBM literature have used a combined training.

Two small studies with adults found that combined CBM resulted in positive changes in anxiety (Brosan, Hoppitt, Shelfer, Sillence, and Mackintosh (2011; $N=12$); Beard, Weisberg, and Amir (2011; $N=32$)), but neither compared combined CBM with CBM-A or CBM-I. Sportel, de Hullu, de Jong, and Nauta (2013) ran a larger randomized controlled trial (RCT) on adolescents ($N=240$) and failed to confirm the efficacy of combined CBM on anxiety. However, this is not necessarily surprising since there is meta-analytical evidence that CBM is not effective in youth (Cristea et al. 2015). More recently, Naim, Kivity, Bar-Haim, and Huppert (2018) conducted a randomized controlled trial investigating the relative and combined efficacy of CBM-A and CBM-I in a sample of 95 patients with Social Anxiety Disorder. Results revealed that CBM-A yielded greater clinician- and self-rated symptom reduction compared to the other conditions. Neither combined CBM nor CBM-I was associated with greater symptom reduction than that observed in the control group. Further, no changes in cognitive bias were observed for any of the groups. Since bias was not modified as intended by either intervention, and the combined groups were less effective than CBM-A alone, these results are difficult to interpret, and more research is needed before conclusions can be drawn. Further, the authors did not include a behavioural task, and the advantage of studying these factors in a laboratory setting is that one can have tighter control over variables and administer behavioural tests relatively easily.

The present study aimed to determine the relative efficacy of CBM-A and CBM-I compared to combined CBM and a placebo in reducing social anxiety and attenuating anxiety vulnerability in response to a stressor, the Social Interaction Task (SIT). We hypothesised that there would be a main effect of CBM-I on social anxiety symptoms; and that there would be a main effect of CBM-A on anxiety vulnerability. Additionally, we hypothesized that combined CBM would be more efficacious than CBM-I or CBM-A alone. We also aimed to explore the underlying mechanisms of CBM on social anxiety and anxiety vulnerability. We hypothesised that change in specific cognitive biases would mediate CBM condition and changes in anxiety outcomes.

Methods

Participants and Design

Participants were 116 undergraduate students (Mean age = 19.17 years, $SD=3.67$; 90 female) who scored ≥ 15 on the pre-screening Social Interaction Anxiety Scale (SIAS; Mattick and Clarke 1998). Participation was voluntary and in exchange for course credit. The study employed a 2 CBM-A (Present; Absent) × 2 CBM-I (Present; Absent) double-blind RCT design. Social anxiety was assessed on three occasions: Before CBM, after CBM, and after the SIT. Participants were randomized into four groups. Four letters of the alphabet (A, B, C, D) corresponding to the four conditions were assigned to a number (1, 2, 3, 4, respectively). The corresponding letters were written on a card and placed inside an opaque envelope. The numbers were randomly ordered in clusters of four using randomizer.org for each testing session, and this order was the order in which the envelopes were given to participants as they arrived. Participants and researchers were both blind to group allocation. Informed consent was obtained from all individual participants included in the study.

Measures

The State Anxiety Rating 8-item version (SAR-8; Zou and Abbott 2012) was the primary outcome measure. It was administered before and after CBM and following the SIT to assess the effect of CBM and the SIT on social anxiety. It is an 8-item self-report measure of state social anxiety. In the present sample, Cronbach's α was 0.88.

A Demographics Questionnaire was administered at baseline to ensure that there were no group differences on demographic factors.

The Depression Anxiety Stress Scales 21-item short version (DASS-21; Lovibond and Lovibond 1995) was administered at baseline to assess trait mood and anxiety. It contains three 7-item subscales assessing depression, anxiety, and stress through self-report. It has good construct validity (Henry and Crawford 2005), and Cronbach's α in the present sample was 0.87 for the Depression subscale, 0.83 for the Anxiety subscale, and 0.84 for the Stress subscale.

The 20-item Social Phobia Scale (SPS; Mattick and Clarke 1998) and 19-item SIAS were administered at baseline to assess trait social anxiety. The SIAS was also used as a screening tool due to its high discriminant validity (Peters 2000). The SPS and SIAS are two companion self-report measures assessing fear of scrutiny and fear of general social interactions respectively (Mattick and Clarke 1998). In the present sample, Cronbach's α was 0.91 for the SIAS, and 0.94 for the SPS.

The Positive and Negative Affect Schedule (PANAS; Watson et al. 1988) was administered before and after CBM to assess the effect of CBM on state mood. It contains two 10-item self-report subscales assessing positive and negative affect (Watson et al. 1988). It has excellent convergent and discriminant validity (Crawford and Henry 2004; Watson et al. 1988). In the present sample, Cronbach's α was 0.88 for the positive affect subscale and 0.87 for the negative affect subscale.

Participants were also rated on their speech performance during the SIT. The SIT was videotaped. The videotapes were coded by two researchers (both of whom were blind to the participants' allocated group) using a 17-item measure of speech performance developed by Rapee and Lim (1992). Two items ('blushed' and 'sweated') were removed as they could not be assessed due to video quality. In the present sample, Cronbach's α was 0.76 and inter-rater reliability between two blind assessors was high ($r = 0.73$, $p = 0.004$).

Materials

The video camera used was a Canon FS11 Digital Video Camcorder. The questionnaires were administered online through http://www.qualtrics.com. The computers were Dell OPTIPLEX990 with monitors approximately 18.3″ across diagonally (screen resolution 1440 × 900 pixels). Participants were seated approximately 55 cm away from the screen at computers located in each corner of the room.

CBM was administered online through a web application programmed in JavaScript. Participants saw black text in Arial 21-point font, flush-centred on a white background. Participants were unaware of the training contingency in the tasks.

CBM comprised of three phases. The pre-training and post-training test phases were used to assess cognitive bias, and the training phases were used to modify biases (or deliver placebo training). Participants were reminded of the instructions for each task on-screen immediately before each phase began, and these reminders also served as self-timed breaks. In the CBM-A and CBM-I conditions, participants were prompted with a self-timed break halfway through the training phase. All participants completed CBM-A and CBM-I test phases, and training time was matched across groups; however, groups differed with respect to the type of training phase (Fig. 1). We chose CBM- A and CBM-I procedures which had previously been used together in the few studies that have assessed a combined training condition (Brosan et al. 2011; Beard et al. 2011). See below for a full description.

The CBM-A procedure was a modified version of the Dot-Probe Task (DPT; MacLeod et al. 1986). In each trial, a fixation cross was presented centre-screen for 500 ms. Then, a word-pair (comprising of a socially threatening and neutral word) was presented for 500 ms, with one word above and one word below centre-screen, approximately 2 cm on either side. Following this, a probe (the letter 'q' or 'p') replaced one of the two words, appearing for 1500 ms or until the participant responded by pressing the corresponding key on the keyboard to indicate what the letter was. Finally, an inter-trial interval concluded the trial, comprising of a blank screen presented for 500 ms. Reaction time (RT) was recorded from probe presentation. In the active training phases, the probe always replaced the neutral word. We used a contingency of 100% to maximise any likely training effect since the contingency used in CBM-A has not been found to affect the success of CBM-A in previous meta-analyses (Jones and Sharpe 2017). In the placebo training and test phases, the probe replaced the neutral and threatening words with equal frequency.

DPT stimuli were 80 unique threat-neutral word-pairs matched for frequency, taken from previous CBM studies (Dehghani et al. 2003; Hirsch and Mathews 2000; MacLeod et al. 1986, 2002; Pishyar et al. 2004; Sharpe et al. 2012; Vasey et al. 1995, 1996). Although images are often used to elicit biases due to increased ecological validity, both meta-analyses (see Jones and Sharpe 2017) and direct comparisons (Sharpe et al. 2015) show that words result in stronger training effects in CBM-A protocols. Three different stimuli sets containing unique word-pairs were used. The stimulus presentation order within each set was randomized. Test stimuli were divided into two sets, and each test phase used a different set, with the order counterbalanced across participants. Each test set contained 20 unique word-pairs presented in four possible combinations: Probe position (upper/lower), target (neutral/threatening). The training set contained 40 unique word-pairs presented in two possible combinations: Probe position (upper/lower), target (neutral). Each word-pair was then repeated once (Combined CBM condition) or twice (CBM-A condition). In the placebo training phase, each word-pair was presented in the same four possible combinations as in the test phases.

The CBM-I procedure was a modified version of the Word Sentence Association Paradigm (WSAP; Beard and Amir 2008, 2009). In each trial, a fixation cross was presented centre-screen for 500 ms. Then, a word (representing a socially threatening or benign interpretation) replaced the cross, appearing for 1000 ms. Following this, a socially-relevant ambiguous sentence was presented for 2000 ms, or until participants responded by pressing '#1' on the keyboard if they thought the word and sentence were related, or '#0' if they thought they were not related. Finally, an inter-trial interval concluded the trial,

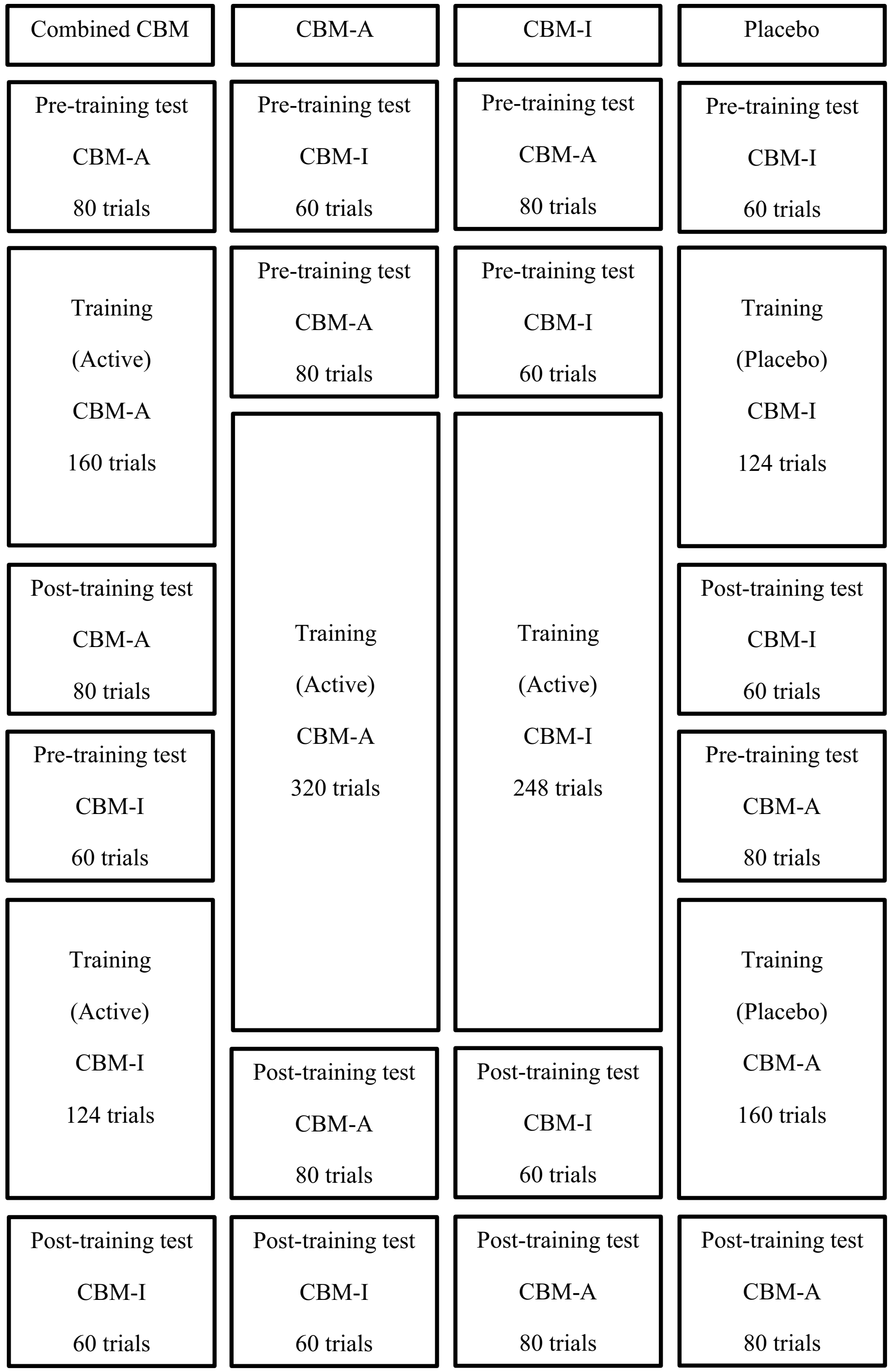


Fig. 1 CBM groups and their respective phases. [a]Order of CBM presentation (CBM-A or CBM-I first) counterbalanced across participants

with response feedback (active training phases) or a blank screen (placebo training and test phases) presented for 500 ms. RT was recorded from sentence presentation. In the active training phases, participants were given positive feedback ("You are correct!") if they interpreted sentences in a benign manner (e.g., they pressed '#1' to indicate the benign word and sentence were related) and negative feedback ("Incorrect.") if they interpreted sentences in a threatening manner (e.g., they pressed '#1' to indicate the threatening word and sentence were related). In the placebo training and test phases, no feedback was given.

WSAP stimuli were 170 unique word-sentence pairs taken from previous CBM-I studies (Beard and Amir 2008, 2009). Three different stimuli sets containing unique word-sentence pairs were used. The stimulus presentation order within each set was randomized. Test stimuli were divided into two sets, and each test phase used a different test set, with the order counterbalanced across participants. Each test set contained

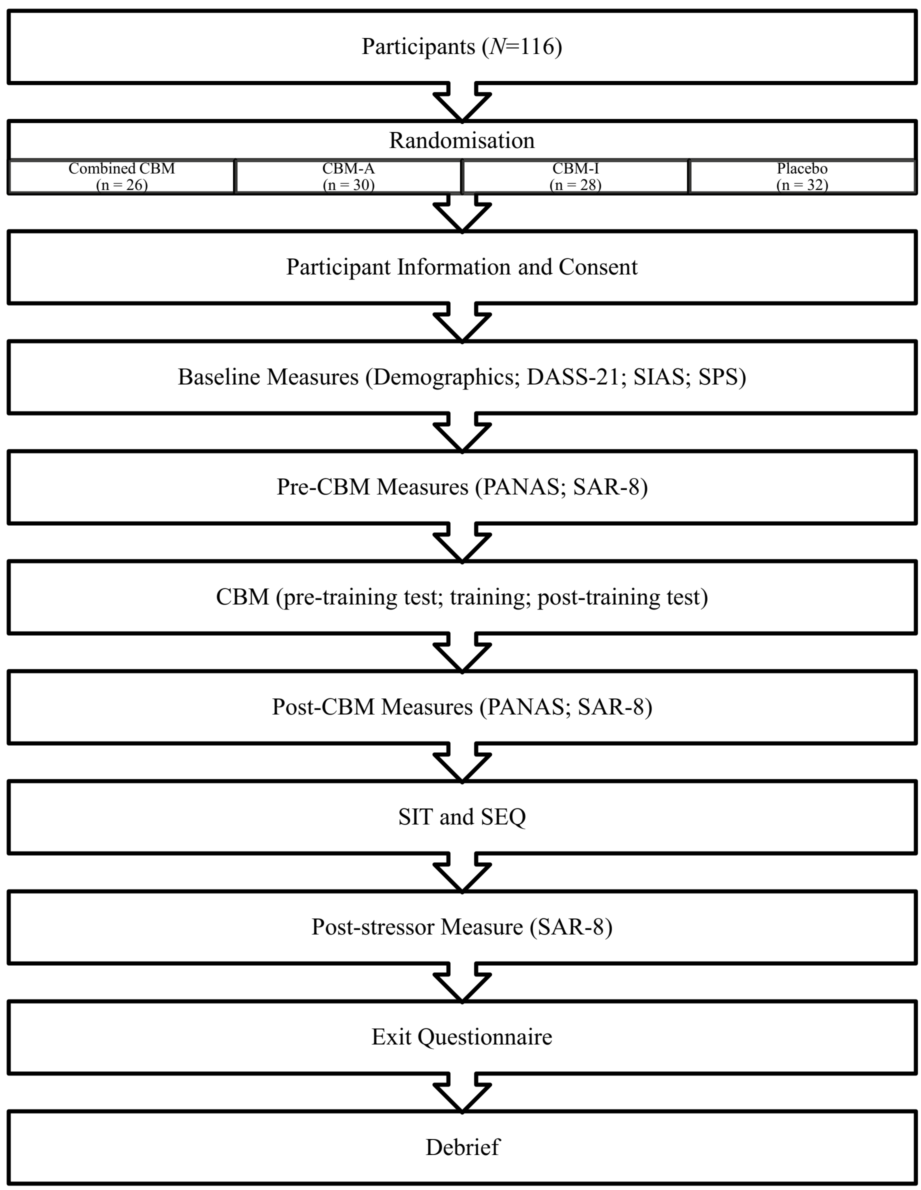
30 unique word-sentence pairs repeated once during each test phase. The training set contained 110 unique word-sentence pairs, presented once (Combined CBM and Placebo conditions) or twice (CBM-I condition), with stimuli drawn randomly from the pool of 110 word-sentence pairs to make up the remaining trials in the training phases.

Procedure

The experimental procedure is depicted in Fig. 2. The study was approved by the University of Sydney Human Research Ethics Committee and registered with the Australian New Zealand Clinical Trials Registry (ACTRN12616000598482). Participants were tested in groups of up to four. Upon arriving, participants were handed an envelope containing a letter corresponding to one of the four conditions. Next, participants read the participant information statement and provided written consent, before entering their letter into the computer, which allocated them to their designated condition. Participants then completed the demographics questionnaire and other measures before completing CBM in their assigned condition. Following CBM, the PANAS and social anxiety rating were re-administered.

Participants then completed the SIT, which was designed to induce social anxiety. Instructions were presented on-screen, with participants informed that they would be rating each other's performance on the task immediately afterwards in the Social Evaluation Questionnaire (SEQ). Participants then stood in groups of up to four around a rectangular table in the middle of the room and were given verbal instructions on the task. Participants discussed the question "Why do you think you are a good person?" and each participant

Fig. 2 Procedural flowchart diagram



was instructed to speak for one minute, with the experimenter video-recording each speaker. After all participants had spoken, they returned to their computers to complete the SEQ, then the SAR-8. Participants then completed the Exit Questionnaire to assess the acceptability of the CBM tasks. Finally, participants were debriefed and asked to guess which condition they had received.

Analysis

A power analysis was conducted using G*Power software (Version 3.1; Faul et al. 2009) and revealed that, to have 80% power to find an effect of Cohen's $d = 0.61$ (see Jones and Sharpe 2017) given an alpha level of 0.05, a total of 111 participants were needed. A series of 2 CBM-A (Present; Absent) × 2 CBM-I (Present; Absent) ANOVAs were conducted to investigate group differences in age, and scores on the DASS-21, SIAS, SPS, and PANAS. Chi square analyses were conducted to investigate group differences in gender. Significant differences that emerged were entered as covariates in subsequent analyses to ensure such differences did not account for differences between groups on outcome variables.

Data from DPT trials with RTs < 200 ms or from participants with an error rate ≥ 50% were removed. The total error rate was low ($M = 7.15\%$). Attentional bias scores were calculated by subtracting the mean RT of trials in which the probe replaces the socially-threatening word from the mean RT of trials in which the probe replaces the neutral word. A negative score indicates biased attention towards threat.

Data from WSAP trials with RTs < 200 ms were removed. Proportions of threat interpretations were calculated by dividing the number of relevant interpretations endorsed by the total number of valid trials, then multiplying this quotient by 100. Higher proportions of threat interpretations indicate a negative interpretation bias.

A series of 2 CBM-A (Present; Absent) × 2 CBM-I (Present; Absent) × (2) (Time: pre-CBM; post-CBM) ANOVAs were conducted on attentional bias scores, proportion of threat interpretations, PANAS scores, and SAR-8 scores to assess the effect of CBM on cognitive biases, mood, and social anxiety. A 2 CBM-A (Present; Absent) × 2 CBM-I (Present; Absent) × (2) (Time: pre-CBM; post-stressor) ANOVA was conducted on SAR-8 scores to assess the impact of CBM on anxiety vulnerability. A 2 CBM-A (Present; Absent) × 2 CBM-I (Present; Absent) ANOVA was conducted on speech performance ratings to assess group differences in speech performance. Where main effects for CBM group or interaction effects emerged, follow-up *t*-tests were conducted to determine whether any observed effects were specifically due to differences between a particular group and the placebo.

Cognitive bias change variables were calculated by subtracting the post-training bias measures from the pre-training bias measures for attentional and interpretation bias indices. Post-CBM change in social anxiety was calculated by subtracting the post-CBM SAR-8 scores from the pre-CBM SAR-8 scores. Anxiety vulnerability was calculated by subtracting pre-CBM SAR-8 scores from the post-stressor SAR-8 scores. A series of correlation analyses were performed between change in cognitive biases and outcome variables.

A series of Hierarchical Multiple Regression analyses were conducted to predict change in social anxiety and speech performance ratings. CBM (CBM-A; CBM-I) was entered in step 1, and change in biases entered in step 2. If results supported a potential mediation, a Sobel Test was planned to determine whether the mediation was significant.

Results

Participant Characteristics

Full data was unavailable for 17 participants, due to technical issues on one or more tasks ($n = 5$), request to withdraw ($n = 5$), and errors/invalid responses on one or more tasks ($n = 7$). Participants with partial data were kept for analysis on an intention-to-treat basis. Thus, data from all 116 participants was analysed. A Chi square analysis revealed that participants were unable to guess the condition they had been assigned to ($\chi^2_{(9)} = 8.49$, $p = 0.486$), indicating that blinding procedures had been successful.

Analysis revealed no baseline differences between groups (Table 1), except for a CBM-A × CBM-I interaction on the PANAS positive affect subscale ($F_{(1, 111)} = 8.66$, $p = 0.004$). Positive affect was not correlated with SAR-8 scores ($rs < 0.03$, $ps > 0.722$) or speech performance ratings ($r = 0.10$, $p = 0.287$), and so was not entered as a covariate. Group size was not different between groups ($F_{(1,111)} = 0.743$, $p = 0.529$) and not correlated with SAR-8 scores ($rs < 0.04$, $ps > 0.652$), but was correlated with speech performance ratings ($r = 0.20$, $p = 0.041$). Thus, group size was entered as a covariate in analyses of speech performance ratings.

Cognitive Bias

Mean attentional bias scores and mean proportion of threat interpretations are presented in Table 2. A one-sample *t*-test revealed that participants did not exhibit a threat-related attentional bias at baseline ($t_{(110)} = 0.49$, $p = 0.625$). For change in attentional bias, there were no main ($F_{(1, 106)} = 1.81$, $p = 0.182$) or interaction effects ($Fs_{(1, 106)} < 1.30$, $ps > 0.256$).

Table 1 Baseline participant characteristics

Variable	CBM-A present		CBM-A absent	
	CBM-I present	CBM-I absent	CBM-I present	CBM-I absent
	Combined CBM	CBM-A	CBM-I	Placebo
Age	18.81 (1.20)	19.07 (2.41)	20.21 (6.80)	18.66 (1.34)
Gender	20 female	25 female	22 female	23 female
DASS-21-D	7.77 (6.21)	8.93 (9.09)	7.85 (6.95)	6.31 (5.61)
DASS-21-A	6.69 (6.64)	7.80 (7.73)	6.96 (7.73)	5.94 (6.04)
DASS-21-S	7.85 (9.27)	9.27 (8.30)	10.22 (7.41)	8.00 (6.85)
SIAS	26.12 (14.28)	24.87 (11.92)	23.96 (11.11)	26.09 (11.53)
SPS	20.15 (17.69)	19.47 (14.53)	15.67 (12.47)	17.62 (13.35)
PANAS-PA	22.35 (5.83)	25.50 (7.35)	24.85 (7.90)	20.28 (6.77)
PANAS-NA	13.19 (5.00)	15.30 (5.86)	13.52 (4.88)	13.03 (4.00)
N	26	30	28	32

Standard deviations in parentheses

DASS-21-D Depression Anxiety Stress Scale 21-item version Depression subscale, *DASS-21-A* Depression Anxiety Stress Scale 21-item version Anxiety subscale, *DASS-21-S* Depression Anxiety Stress Scale 21-item version Stress subscale, *SIAS* Social Interaction Anxiety Scale, *SPS* Social Phobia Scale, *PANAS-PA* Positive and Negative Affect Schedule Positive Affect subscale, *PANAS-NA* Positive and Negative Affect Schedule Negative Affect subscale

Table 2 Mean attentional bias scores and mean proportion of threat interpretations (%) at pre-CBM and post-CBM for the experimental groups

Variable	Time	CBM-A present		CBM-A absent	
		CBM-I present	CBM-I absent	CBM-I present	CBM-I absent
		Combined CBM	CBM-A	CBM-I	Placebo
AB	Pre-CBM	0.99 (40.82)	−2.78 (22.26)	0.80 (23.82)	7.85 (34.06)
	Post-CBM	−6.42 (26.17)	0.61 (26.17)	−5.69 (25.28)	−3.17 (28.67)
IB-T	Pre-CBM	24.19 (11.33)	24.52 (10.21)	25.87 (8.84)	25.64 (10.34)
	Post-CBM	22.05 (14.01)	22.42 (11.01)	11.60 (8.75)	25.10 (11.50)
SAR-8	Pre-CBM	3.00 (4.67)	2.86 (3.88)	2.37 (4.11)	1.60 (2.65)
	Post-CBM	1.88 (3.65)	3.28 (6.10)	1.33 (1.66)	2.43 (5.12)
	Post-stressor	6.96 (8.60)	6.24 (6.77)	3.74 (4.33)	4.57 (4.95)
Speech	SIT	33.23 (6.69)	36.14 (6.08)	38.38 (6.58)	34.32 (5.51)

Standard deviations in parentheses

AB attentional bias scores, *IB-T* proportion of threat interpretations (%), *SAR-8* SAR-8 scores, *Speech* speech performance rating, *SIT* Social Interaction Task

For the interpretation bias task, the sample made more threat interpretations as a whole than benign interpretations (SMD = 7.47, $t_{(1,106)} = -5.861$, $p < 0.0005$). For change in threat interpretations, analysis revealed a main effect of Time ($F_{(1, 100)} = 19.49$, $p < 0.001$), a Time × CBM-A interaction ($F_{(1, 100)} = 5.99$, $p = 0.016$), and a Time × CBM-I interaction ($F_{(1, 100)} = 10.19$, $p = 0.002$). These effects were qualified by a Time × CBM-A × CBM-I interaction ($F_{(1, 100)} = 10.07$, $p = 0.002$). Follow-up paired-samples *t*-tests revealed that participants in the CBM-I condition made fewer threat interpretations after training compared to before ($t_{(26)} = 5.90$, $p < 0.001$). However, proportion of threat interpretations did not change after training for the other groups (*t*s < 1.47, *p*s > 0.153).

Social Anxiety

Mean SAR-8 scores are presented in Table 2. For change in social anxiety symptoms post-CBM, there was no main effect of Time ($F_{(1, 108)} = 0.39$, $p = 0.534$), nor a Time × CBM-A interaction ($F_{(1, 108)} = 0.12$, $p = 0.732$). However, there was a Time × CBM-I interaction ($F_{(1, 108)} = 5.50$, $p = 0.021$), favouring participants who received CBM-I. There was no Time × CBM-A × CBM-I interaction ($F_{(1, 108)} = 0.06$, $p = 0.814$). Follow-up paired samples *t*-tests did not reveal significant differences in any of the groups over time (all *t*s < 1.91, *p*s > 0.067).

For post-stressor anxiety vulnerability, analysis revealed a main effect of Time, indicating that on average, all participants had higher anxiety following the SIT compared to baseline ($F_{(1, 108)} = 38.33$, $p = 0.001$). There were no interaction effects ($Fs_{(1, 108)} < 2.54$, $ps > 0.114$).

Speech Performance

Mean speech performance ratings are presented in Table 2. Analysis revealed no main effects ($Fs_{(1, 103)} < 1.93$, $ps > 0.167$). However, there was a CBM-A × CBM-I interaction ($F_{(1, 103)} = 8.62$, $p = 0.004$) and an effect of group size as a covariate ($F_{(1, 103)} = 4.24$, $p = 0.042$). A one-way ANOVA confirmed that there was a significant difference between the four groups on speech performance ($F_{(3, 103)} = 3.46$, $p = 0.019$). Follow-up tests of simple effects revealed that the speech performance of those in the CBM-I group was better than those in the Combined CBM ($p = 0.003$) and Placebo ($p = 0.023$) groups, but not the CBM-A group ($p = 0.226$). There were no other differences between the groups ($ps > 0.069$).

Mediation Analyses

No significant correlations between change in biases and outcome variables were observed. Therefore, the planned mediation analyses were abandoned.

State Mood

For the PANAS positive affect subscale, there was a main effect of Time, such that all participants reported lower positive affect after CBM ($M = 17.94$, $SD = 6.50$) compared to before ($M = 23.24$, $SD = 7.30$; $F_{(1, 108)} = 86.74$, $p < 0.001$). No interaction effects were observed ($Fs_{(1, 108)} < 1.16$, $ps > 0.675$). For the PANAS negative affect subscale, there were no main ($F_{(1, 108)} = 1.45$, $p = 0.231$) or interaction effects ($Fs_{(1, 108)} < 1.55$, $ps > 0.216$).

Discussion

We aimed to investigate the specificity of CBM-I and CBM-A on anxiety and anxiety vulnerability respectively, in a group of socially anxious individuals. We hypothesized that CBM-A would impact anxiety vulnerability following a social stressor task, whereas CBM-I would impact anxiety following CBM training. Our hypotheses were partially supported. Contrary to prediction, CBM-A did not affect anxiety vulnerability. However, our hypotheses were supported for CBM-I. That is, those who received CBM-I made relative improvements in anxiety following training. Finally, there was also an effect of CBM-I on speech performance, whereby the CBM-I only group gave the most skilled speeches.

The major finding of this study was that those who received any CBM-I reduced state social anxiety following training more than those who did not, as predicted. This is consistent with a meta-analysis conducted by Menne-Lothmann et al. (2014), which found that CBM-I was effective in modifying anxiety symptoms. While these results are consistent with the available literature, it is important to note that the benefits associated with CBM-I were relative benefits. That is, the level of anxiety within each individual group (Combined CBM and CBM-I) was not significantly different before and after CBM. However, the change in anxiety differed between the groups, favouring those who received any dose of CBM-I. This benefit of CBM-I was conferred on speech performance, but only for those in the CBM-I only group. That is, the CBM-I group performed best on the speech task, and their performance was significantly better than those in the Combined CBM and the Placebo groups.

Notably, the present study is the first to show that CBM-I improves speech performance during a social stressor task. This is in contrast to Standage, Ashwin, and Fox (2009), who found that CBM-I exerted no effects on anxiety vulnerability or speech performance in a group of socially anxious participants. However, Standage et al. used a different speech task, where participants were asked to give a formal 5-min speech. Typically, these speech tasks result in high anxiety ratings, whereas in our study, the SIT was less anxiety-provoking. Thus, it may be that CBM-I improves performance in mildly anxiety-provoking situations, but not in highly anxiety-provoking situations. Future research is needed to determine whether this was the case.

One might ask why the CBM-I group was more efficacious than the combined CBM group. The likely answer to this question is dosage. That is, those in Combined CBM received *both* CBM-A and CBM-I, whereas those in CBM-A or CBM-I received twice as much CBM-A or CBM-I than those in the Combined CBM group. Therefore, if CBM-A in this study did not modify biases as intended, it is perhaps unsurprising that those who received twice as much CBM-I, benefited more, at least in terms of speech performance.

Importantly, we demonstrated that CBM-I was effective in manipulating interpretation biases, as intended. The CBM-I group made fewer threat interpretations following CBM training. However, the changes in interpretations were not associated with changes in anxiety or speech performance; therefore, we were unable to conduct mediational analyses that would have potentially confirmed the treatment mechanism.

In contrast to CBM-I, the CBM-A procedure employed in the present study failed to modify attentional bias. This finding is consistent with research reviews that have noted a pattern in the literature whereby studies that successfully modify biases also successfully modify anxiety vulnerability, whereas those where the procedure fails to modify biases do not result in changes to anxiety vulnerability (Clarke et al. 2014; MacLeod and Grafton 2016). This is an important issue in that, if CBM-A had changed attentional bias but did not change anxiety vulnerability as predicted, we could confidently assert that the process of modifying attentional biases is ineffective. However, if the procedure employed to modify biases failed to modify them, then we have not tested the theoretical premise that modifying attentional biases changes anxiety vulnerability. This does mean, however, that the procedure used for CBM-A in the present study was not efficacious and that more reliable ways of changing attentional biases are needed if CBM-A is to have clinical applications.

Interestingly, the present study's results are not consistent with Naim et al. (2018), who found that CBM-A resulted in greater symptom reduction compared to the other conditions. We did not find evidence to support CBM-A; but rather, our study found evidence to support CBM-I. That is, the CBM-I group (which received twice the dose of CBM-I compared to the other groups) performed better on the speech task and saw reductions in anxiety. There were some notable methodological differences that could account for these differing findings. Firstly, Naim et al. (2018) used a clinical sample and eight sessions of CBM in comparison to our single-session CBM protocol in an analogue population. Secondly, the tasks used to modify biases differed, such that Naim et al. (2018) used faces as stimuli in their dot-probe paradigm; and used a sentence-completion task for training interpretation biases. In their study, although neither of the CBM procedures were shown to modify the relevant process, CBM-A was found to be efficacious. In contrast, in our study, only CBM-I was shown to modify biases, and it was CBM-I that was associated with improved anxiety symptoms and speech performance. Further research is thus needed to determine which of the factors that differ between the studies may account for the differing results.

The present study's results provide some support for cognitive-behavioural theories of social anxiety (Clark and Wells 1995; Rapee and Heimberg 1997). Specifically, participants exhibited a negative interpretation bias at baseline, CBM-I modified that interpretation bias, anxiety was subsequently reduced, and speech performance improved. However, the mechanisms would have been more clearly demonstrated had the changes in interpretation bias been associated with the changes in anxiety and/or speech performance, which they were not. Furthermore, these theories also posit a role of attentional biases in social anxiety, and we did not find evidence to support this.

There was also no evidence that attentional and interpretation biases causally influenced each other, contrary to the combined cognitive bias hypothesis (Hirsch et al. 2006). Specifically, we failed to find support for the hypothesis that CBM-I procedures would modify attentional bias; or that CBM-A procedures would modify interpretation bias. Given that CBM-A failed to modify attentional biases, its failure to modify interpretation biases is unsurprising. However, the finding that CBM-I did not modify attentional bias is inconsistent with previous research, which found that CBM-I procedures modified both interpretation and attentional bias in socially anxious individuals (Reese et al. 2010). It is possible that the fact that the CBM-A and CBM-I tasks did not share a sufficient number of characteristics may have reduced the possibility of transfer effects (see Hertel and Mathews 2011).

Despite careful attention to methodology, our study had some limitations. Firstly, the failure of CBM-A procedures to modify attentional bias means that our hypotheses about the efficacy of CBM-A could not be fully tested, and that any effects of combined CBM cannot be determined. Secondly, we tested an analogue sample of undergraduate students. This is particularly notable in the impact found on speech performance, where studies that have recruited more highly anxious participants or that have used more anxiety-provoking speech tasks, have typically not found an effect of CBM-I on speech performance. Thirdly, we powered the study based on the median effect size for CBM-A and CBM-I based on the median Cohen's *d* in the Jones and Sharpe (2017) review of meta-analyses. However, it is possible that the study was underpowered to identify the interactions. Nonetheless, since CBM-A failed to change attentional biases or symptoms, lack of power is unlikely to account for the current findings. Finally, although we controlled for the number of participants in each group, variations in group size and the resulting presentation order may have affected results.

These limitations notwithstanding, the present study was a double-blind RCT that assessed the impact of two forms of CBM individually and in combination compared to a placebo on state social anxiety amongst socially anxious individuals. State social anxiety was measured before and after CBM and after the SIT, allowing us to test predictions of the impact of CBM on symptoms versus anxiety vulnerability. Although the efficacy of CBM-A was not established, we demonstrated that CBM-I reduced anxiety symptoms immediately after training. These reductions in anxiety appeared to translate into improved social performance. Although we did not find evidence that changes in interpretation biases mediated change in anxiety, this study does provide further support for the efficacy of CBM-I, but not CBM-A, in the treatment of social anxiety.

Compliance with Ethical Standards

Conflict of Interest Eric S. Yeung and Louise Sharpe declare that they have no conflict of interest.

Informed Consent All procedures performed in studies involving human participants were in accordance with the ethical standards of The University of Sydney's Human Research Ethics Committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Research Involving Animal Rights No animal studies were carried out by the authors for this article.

References

Beard, C., & Amir, N. (2008). A multi-session interpretation modification program: Changes in interpretation and social anxiety symptoms. *Behaviour Research and Therapy, 46*(10), 1135–1141. https://doi.org/10.1016/j.brat.2008.05.012.

Beard, C., & Amir, N. (2009). Interpretation in social anxiety: When meaning precedes ambiguity. *Cognitive Therapy and Research, 33*(4), 406–415. https://doi.org/10.1007/s10608-009-9235-0.

Beard, C., Sawyer, A. T., & Hofmann, S. G. (2012). Efficacy of Attention Bias Modification using threat and appetitive stimuli: A meta-analytic review. *Behavior Therapy, 43*(4), 724–740. https://doi.org/10.1016/j.beth.2012.01.002.

Beard, C., Weisberg, R. B., & Amir, N. (2011). Combined cognitive bias modification treatment for social anxiety disorder: A pilot trial. *Depression and Anxiety, 28*(11), 981–988. https://doi.org/10.1002/da.20873.

Brosan, L., Hoppitt, L., Shelfer, L., Sillence, A., & Mackintosh, B. (2011). Cognitive bias modification for attention and interpretation reduces trait and state anxiety in anxious patients referred to an out-patient service: Results from a pilot study. *Journal of Behavior Therapy and Experimental Psychiatry, 42*(3), 258–264. https://doi.org/10.1016/j.jbtep.2010.12.006.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F. R. Schneier (Eds.), *Social phobia: Diagnosis, assessment, and treatment* (pp. 69–93). New York: The Guilford Press.

Clarke, P. J. F., Notebaert, L., & MacLeod, C. (2014). Absence of evidence or evidence of absence: Reflecting on therapeutic implementations of attentional bias modification. *BMC Psychiatry, 14*(8), 1–6.

Crawford, J. R., & Henry, J. D. (2004). The Positive and Negative Affect Schedule (PANAS): Construct validity, measurement properties and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 43*(3), 245–265.

Cristea, I. A., Kok, R. N., & Cuijpers, P. (2015). Efficacy of cognitive bias modification interventions in anxiety and depression: Meta-analysis. *British Journal of Psychiatry, 206*(1), 7–16. https://doi.org/10.1192/bjp.bp.114.146761.

Cristea, I. A., Mogoaşe, C., David, D., & Cuijpers, P. (2015). Practitioner review: Cognitive bias modification for mental health problems in children and adolescents: A meta-analysis. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 56*(7), 723–734. https://doi.org/10.1111/jcpp.12383.

Dehghani, M., Sharpe, L., & Nicholas, M. K. (2003). Selective attention to pain-related information in chronic musculoskeletal pain patients. *Pain, 105*(1–2), 37–46. https://doi.org/10.1016/s0304-3959(03)00224-0.

Faul, F., Erdfelder, E., Buchner, A., & Lang, A. G. (2009). Statistical power analyses using G*Power 3.1: Tests for correlation and regression analyses. *Behavior Research Methods, 41*(4), 1149–1160. https://doi.org/10.3758/BRM.41.4.1149.

Hakamata, Y., Lissek, S., Bar-Haim, Y., Britton, J. C., Fox, N. A., Leibenluft, E.,… Pine, D. S. (2010). Attention bias modification treatment: A meta-analysis toward the establishment of novel treatment for anxiety. *Biological Psychiatry, 68*(11), 982–990. https://doi.org/10.1016/j.biopsych.2010.07.021.

Hallion, L. S., & Ruscio, A. M. (2011). A meta-analysis of the effect of cognitive bias modification on anxiety and depression. *Psychological Bulletin, 137*(6), 940–958. https://doi.org/10.1037/a0024355.

Heeren, A., Mogoaşe, C., Philippot, P., & McNally, R. J. (2015). Attention bias modification for social anxiety: A systematic review and meta-analysis. *Clinical Psychology Review, 40*, 76–90. https://doi.org/10.1016/j.cpr.2015.06.001.

Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *British Journal of Clinical Psychology, 44*(Pt 2), 227–239. https://doi.org/10.1348/014466505X29657.

Hertel, P. T., & Mathews, A. (2011). Cognitive bias modification: Past perspectives, current findings, and future applications. *Perspectives on Psychological Science, 6*(6), 521–536. https://doi.org/10.1177/1745691611421205.

Hirsch, C. R., Clark, D. M., & Mathews, A. (2006). Imagery and interpretations in social phobia: Support for the combined cognitive biases hypothesis. *Behavior Therapy, 37*(3), 223–236. https://doi.org/10.1016/j.beth.2006.02.001.

Hirsch, C. R., & Mathews, A. (2000). Impaired positive inferential bias in social phobia. *Journal of Abnormal Psychology, 109*, 705–712.

Jones, E. B., & Sharpe, L. (2017). Cognitive bias modification: A review of meta-analyses. *Journal of Affective Disorders, 223*, 175–183. https://doi.org/10.1016/j.jad.2017.07.034.

Linetzky, M., Pergamin-Hight, L., Pine, D. S., & Bar-Haim, Y. (2015). Quantitative evaluation of the clinical efficacy of attention bias modification treatment for anxiety disorders. *Depression and Anxiety, 32*(6), 383–391. https://doi.org/10.1002/da.22344.

Lovibond, P. F., & Lovibond, S. H. (1995). The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour Research and Therapy, 33*(3), 335–343.

MacLeod, C., & Grafton, B. (2016). Anxiety-linked attentional bias and its modification: Illustrating the importance of distinguishing processes and procedures in experimental psychopathology research. *Behaviour Research and Therapy, 86*, 68–86. https://doi.org/10.1016/j.brat.2016.07.005.

MacLeod, C., & Mathews, A. (2012). Cognitive bias modification approaches to anxiety. *Annual Review of Clinical Psychology, 8*, 189–217. https://doi.org/10.1146/annurev-clinpsy-032511-143052.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*(1), 15.

MacLeod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002). Selective attention and emotional vulnerability: Assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology, 111*(1), 107–123. https://doi.org/10.1037//0021-843x.111.1.107.

Mattick, R. P., & Clarke, J. C. (1998). Development and validation of measures of social phobia scrutiny fear and social interaction anxiety. *Behaviour Research and Therapy, 36*(4), 455–470.

Menne-Lothmann, C., Viechtbauer, W., Hohn, P., Kasanova, Z., Haller, S. P., Drukker, M.,… Lau, J. Y. (2014). How to boost positive interpretations? A meta-analysis of the effectiveness of cognitive bias modification for interpretation. *PLoS ONE, 9*(6), 1–26. https://doi.org/10.1371/journal.pone.0100925.

Mogoaşe, C., David, D., & Koster, E. H. W. (2014). Clinical efficacy of attentional bias modification procedures: An updated meta-analysis. *Journal of Clinical Psychology, 70*(12), 1133–1157. https://doi.org/10.1002/jclp.22081.

Naim, R., Kivity, Y., Bar-Haim, Y., & Huppert, J. D. (2018). Attention and interpretation bias modification treatment for social anxiety disorder: A randomized clinical trial of efficacy and synergy. *Journal of Behavior Therapy and Experimental Psychiatry, 59*, 19–30. https://doi.org/10.1016/j.jbtep.2017.10.006.

Peters, L. (2000). Discriminant validity of the Social Phobia and Anxiety Inventory (SPAI), the Social Phobia Scale (SPS) and the Social Interaction Anxiety Scale (SIAS). *Behaviour Research and Therapy, 38*(9), 943–950.

Pishyar, R., Harris, L. M., & Menzies, R. G. (2004). Attentional bias for words and faces in social anxiety. *Anxiety, Stress & Coping, 17*(1), 23–36. https://doi.org/10.1080/10615800310001601458.

Rapee, R. M., & Heimberg, R. G. (1997). A cognitive-behavioral model of anxiety in social phobia. *Behaviour Research and Therapy, 35*(8), 741–756.

Rapee, R. M., & Lim, L. (1992). Discrepancy between self- and observer ratings of performance in social phobics. *Journal of Abnormal Psychology, 101*(4), 728–731.

Reese, H. E., McNally, R. J., Najmi, S., & Amir, N. (2010). Attention training for reducing spider fear in spider-fearful individuals. *Journal of Anxiety Disorders, 24*(7), 657–662. https://doi.org/10.1016/j.janxdis.2010.04.006.

Sharpe, L., Ianiello, M., Dear, B. F., Perry, N., Refshauge, K., K., & Nicholas, M. K. (2012). Is there a potential role for attention bias modification in pain patients? Results of 2 randomised, controlled trials. *Pain, 153*(3), 722–731. https://doi.org/10.1016/j.pain.2011.12.014.

Sharpe, L., Johnson, A., & Dear, B. F. (2015). Attention bias modification and its impact on experimental pain outcomes: Comparison of training with words versus faces in pain. *European Journal of Pain (London, England), 19*(9), 1248–1257. https://doi.org/10.1002/ejp.648.

Sportel, B. E., de Hullu, E., de Jong, P. J., & Nauta, M. H. (2013). Cognitive bias modification versus CBT in reducing adolescent social anxiety: A randomized controlled trial. *PloS One, 8*(5), 1–11. https://doi.org/10.1371/journal.pone.0064355.

Standage, H., Ashwin, C., & Fox, E. (2009). Comparing visual and auditory presentation for the modification of interpretation bias. *Journal of Behavior Therapy and Experimental Psychiatry, 40*(4), 558–570. https://doi.org/10.1016/j.jbtep.2009.07.006.

Vasey, M. W., Daleiden, E. L., Williams, L. L., & Brown, L. M. (1995). Biased attention in childhood anxiety disorders: A preliminary study. *Journal of Abnormal Child Psychology, 23*(2), 267279.

Vasey, M. W., El-Hag, N., & Daleiden, E. L. (1996). Anxiety and the processing of emotionally threatening stimuli: Distinctive patterns of selective attention among high- and low-test-anxious children. *Child Development, 67*(3), 1173–1185.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology, 54*(6), 1063–1070.

Zou, J. B., & Abbott, M. J. (2012). Self-perception and rumination in social anxiety. *Behaviour Research and Therapy, 50*(4), 250–257. https://doi.org/10.1016/j.brat.2012.01.007.