Journal of Behavior Therapy and Experimental Psychiatry 59 (2018) 19–30

Contents lists available at ScienceDirect

Journal of Behavior Therapy and Experimental Psychiatry

journal homepage: www.elsevier.com/locate/jbtep

Attention and interpretation bias modification treatment for social anxiety disorder: A randomized clinical trial of efficacy and synergy

Reut Naim[a,*], Yogev Kivity[b], Yair Bar-Haim[a,c], Jonathan D. Huppert[b]

[a] School of Psychological Sciences, Tel Aviv University, Israel
[b] Department of Psychology, The Hebrew University of Jerusalem, Jerusalem, Israel
[c] The Sagol School of Neuroscience, Tel Aviv University, Israel

ARTICLE INFO

Keywords:
Social anxiety
Attention bias
Interpretation bias
Treatment
Cognitive bias modification

ABSTRACT

Background and objectives: Attention bias modification treatment (ABMT) and cognitive bias modification of interpretation (CBM-I) both have demonstrated efficacy in alleviating social anxiety, but how they compare with each other, their combination, and with a combined control condition has not been studied. We examined their relative and combined efficacy compared to control conditions in a randomized controlled trial (RCT).
Methods: Ninety-five adults diagnosed with social anxiety disorder (SAD), were randomly allocated to 4 groups: ABMT + CBM-I control (hereafter ABMT; n = 23), CBM-I + ABMT control (hereafter CBM-I; n = 24), combined ABMT + CBM-I (n = 23), and combined control (n = 25). Treatment included eight sessions over four weeks. Clinician-rated and self-reported measures of social anxiety symptoms, functional impairment, and threat-related attention and interpretive biases were evaluated at baseline, post-treatment, and 3-month follow-up.
Results: ABMT yielded greater symptom reduction as measured by both clinician-ratings (Cohen's ds = 0.57-0.70) and self-reports (ds = 0.70-0.85) compared with the CBM-I, the combined ABMT + CBM-I, and the combined control conditions. Neither of the other conditions demonstrated superior symptom change compared to the control condition. No group differences were found for functioning or cognitive biases measures.
Limitations: Limitations mainly include the mix of active and control treatments applied across the different groups. Therefore, the net effect of each of the treatments by itself could not be clearly tested.
Conclusions: Results suggest superiority of ABMT compared to CBM-I and their combination in terms of symptom reduction. Possible interpretations and methodological issues underlying the observed findings are discussed.

1. Introduction

Cognitive theories suggest that biased threat-related information-processing has a prominent role in the etiology and maintenance of social anxiety disorder (SAD; Clark & Wells, 1995; Mathews & MacLeod, 2002; Rapee & Heimberg, 1997). Socially anxious individuals preferentially attend to negative social cues (attention bias; see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Hofmann & Bitran, 2007) and interpret negative meanings in ambiguous social situations (interpretation bias; see Mobini, Reynolds, & Mackintosh, 2013). It has been suggested that such biases enhance anxiety and lead to ineffective social behavior (Amir, Foa, & Coles, 1998; Rapee & Heimberg, 1997; Wells et al., 1995). Inspired by these cognitive models and empirical data of biased cognition in anxiety, cognitive bias modification (CBM) interventions have emerged, targeting systematic modification of biases in processing of negative information (Bar-Haim, 2010; Beard, 2011; Hakamata et al., 2010; Hallion & Ruscio, 2011; Koster, Fox, & MacLeod, 2009; Mathews & MacLeod, 2005; Mogoase, David, & Koster, 2014).

RCTs of attention bias modification treatment (ABMT) suggest efficacy in reducing social anxiety symptoms. In the first published trial, Amir et al. (2009) reported that 50% of those who received ABMT no longer met diagnostic criteria of SAD relative to only14% of the participants in a control condition. These effects were maintained at a 4-month follow-up. Recent meta-analytic reviews of a number of studies reported small-to-medium significant effects of ABMT for SAD (Heeren, Mogoase, Philippot, & McNally, 2015b; Linetzky, Pergamin-Hight, Pine, & Bar-Haim, 2015). These small-to-medium effect sizes of ABMT also call for the development of more efficacious protocols. One such option is combining cognitive bias modification of interpretation (CBM-I) with ABMT.

CBM-I for SAD also shows promise. Socially anxious individuals trained to interpret ambiguous stimuli more benignly interpreted new situations less negatively and reported less social anxiety compared

* Corresponding author.
E-mail address: reutnaim@post.tau.ac.il (R. Naim).

https://doi.org/10.1016/j.jbtep.2017.10.006
Received 28 April 2017; Received in revised form 11 September 2017; Accepted 23 October 2017
Available online 24 October 2017
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with control conditions (Beard & Amir, 2008; Murphy, Hirsch, Mathews, Smith, & Clark, 2007). Amir and Taylor (2012) reported significant decreases in clinician-rated social anxiety symptoms relative to a control training following 12 sessions of CBM-I. Of those who received the active CBM-I, 65% no longer met criteria for SAD relative to only 13% of those in the control group. Change in negative interpretation bias significantly mediated treatment effects.

Cognitive biases are thought to influence one another and interact in maintaining social anxiety (Amir, Bomyea, & Beard, 2010; Hirsch & Clark, 2004; Hirsch, Clark, & Mathews, 2006; White, Suway, Pine, Bar-Haim, & Fox, 2011). Therefore, a combined training of different information-processing biases could potentially maximize symptom reduction. In an "open label" trial, Brosan, Hoppitt, Shelfer, Sillence, and Mackintosh (2011) reported that combined ABMT and CBM-I led to reductions in state and trait anxiety in individuals with SAD and generalized anxiety disorder, with 75% of patients showing reductions in anxiety and 50% showing clinically significant change. Beard, Weisberg, and Amir (2011) also found that a combined CBM-I and ABMT reduced self-reported social anxiety in socially anxious relative to non-anxious participants.

Thus, although a few studies examined CBM-I, ABMT, or their combination as potential treatments for SAD, no study has compared these interventions to each other with appropriate parallel control conditions, their combination, and to a comparison control group. In addition, only some studies utilized standardized clinician ratings of symptoms and conducted mediation analyses to determine the possible operative mechanisms of the interventions. We conducted a double-blind RCT with a three-month follow up (FU) testing the relative efficacy of multiple sessions of ABMT, CBM-I, combined ABMT + CBM-I, and a combined control condition on symptom change in SAD. Specifically we tested: 1) whether all three active groups would be superior to a control condition; 2) whether there would be additive efficacy of combined ABMT + CBM-I relative to ABMT or CBM-I. We did not have a strong hypothesis about the relative efficacy of ABMT vs. CBM-I; and c) we expected each intervention to differentially impact its targeted cognitive bias, which in turn would partially mediate symptom reduction.

2. Materials and methods

2.1. Participants

For participants' progress through the study see Fig. 1. Participants were recruited via internet and newspaper advertisements. 487 treatment-seeking individuals were screened using the Social Phobia Inventory (SPIN; Connor et al., 2000). 156 applicants with SPIN scores > 30 were invited for in-person clinical assessment between January 2012 and January 2014. Inclusion criterion was a primary DSM-IV diagnosis of SAD, with primacy determined as SAD being the main complaint and source of behavioral and emotional dysfunction ($n_{excluded}$ = 31). Exclusion criteria were: a) suicidal ideation/intent (n = 5); b) substance abuse/dependence (n = 1); c) schizophrenia, bipolar disorder, or obsessive-compulsive disorder (n = 3); d) concurrent psychotherapy or pharmacological treatments (n = 21); e) score ≤50 (Mennin et al., 2002; Taylor, Bomyea, & Amir, 2010) on the Liebowitz Social Anxiety Scale interview (LSAS; Liebowitz, 1987).

Ninety-five participants (M_{age} = 32.09, SD = 9.51; 58 males; M_{LSAS} = 76.7, SD =17.14) were randomized to one of four groups: ABMT (n = 23), CBM-I (n = 24), combined ABMT + CBM-I (n = 23), and combined control (n = 25). Sample size was determined by funding constrains that afforded in-person interviews of 150 patients, ending with similar group sizes as in previous ABM/CBM trials (e.g., Amir & Taylor, 2012; Amir et al., 2009; Beard et al., 2011; Bunnell, Beidel, & Mesa, 2013). All participants completed both ABMT and CBM-I tasks in each session, in a combination of active\\\\\\\\control variants according to their training condition. Thirteen participants discontinued participation (ABMT = 3, CBM-I = 3, ABMT + CBM-I = 2, combined control = 5) with no group differences in drop-out, $\chi^2_{(3)}$ = 1.36, p = 0.72. Completers did not differ from dropouts on age, gender, attention bias, interpretation bias, and symptoms at baseline; all $ps \geq 0.17$.

2.2. Measures

2.2.1. Primary outcome measure

The Liebowitz Social Anxiety Scale Interview (LSAS; Liebowitz, 1987) served as primary outcome. The LSAS is a clinician-administered scale assessing fear and avoidance associated with social anxiety (Fresco et al., 2001). Interviews were conducted by four graduate clinical psychology students trained to 85% reliability with an experienced clinical psychologist. All assessors were blind to group assignment. Cronbach's Alpha at baseline was 0.91.

2.2.2. Secondary outcome measures

The Social Phobia Inventory (SPIN; Connor et al., 2000), a self-report questionnaire that has sound psychometrics and assesses social anxiety symptoms, served as secondary outcome. Cronbach's Alpha at baseline was 0.80.

Sheehan Disability Scale (SDS; Sheehan, Harnett-Sheehan, & Raj, 1996) is a composite of three self-rated items measuring the extent to which three domains in participants lives are impaired by anxiety: 1) work; 2) social or leisure activities; and 3) home or family responsibilities. Each scale ranges between 0 ("not at all") to 10 ("very much"). The three items were averaged into a single dimensional measure of global functional impairment with scores ranging 0–10. The SDS typically shows high internal consistency, sensitivity, and specificity (Leon, Olfson, Portera, Farber, & Sheehan, 1997; Sheehan et al., 1996). In the current sample however, Cronbach's Alpha at baseline was.60.

The Mini International Neuropsychiatric Interview (M.I.N.I), a structured diagnostic interview, was used to confirm diagnosis of SAD and comorbid conditions (Sheehan et al., 1998). Interviewers were conducted by four graduate clinical psychology students trained to 85% reliability with an experienced clinical psychologist. Comorbidity distribution by group is presented in Appendix A.

3. Cognitive bias measures and training

3.1. Attention bias assessment and modification

To measure and modify threat-related attention bias away from threat we used a faces-based dot-probe task following the TAU-NIMH ABMT Initiative protocol (http://people.socsci.tau.ac.il/mu/anxietytrauma/research/). For a complete description see Appendix B.

3.2. Interpretation bias assessment and training

3.2.1. Sentence completion task (SCT)

Interpretation bias index was derived from the way participants resolve ambiguous social scenarios (see Huppert, Pasupuleti, Foa, & Mathews, 2007 for full description of the task). Ten sentences describing ambiguous social scenarios with the last word missing were presented (e.g., *"As you walk to the podium, you notice your heart racing, which means you are ___"*. Participants had to generate as many responses as came to mind for each sentence. Then, participants coded each of their sentence completions as positive, negative, or other, thus providing their own perspective. Interpretation bias scores were calculated by subtracting the number of positive responses from the number of negative responses, divided by the total number of responses provided by each participant. Positive scores reflect greater negative interpretation bias.

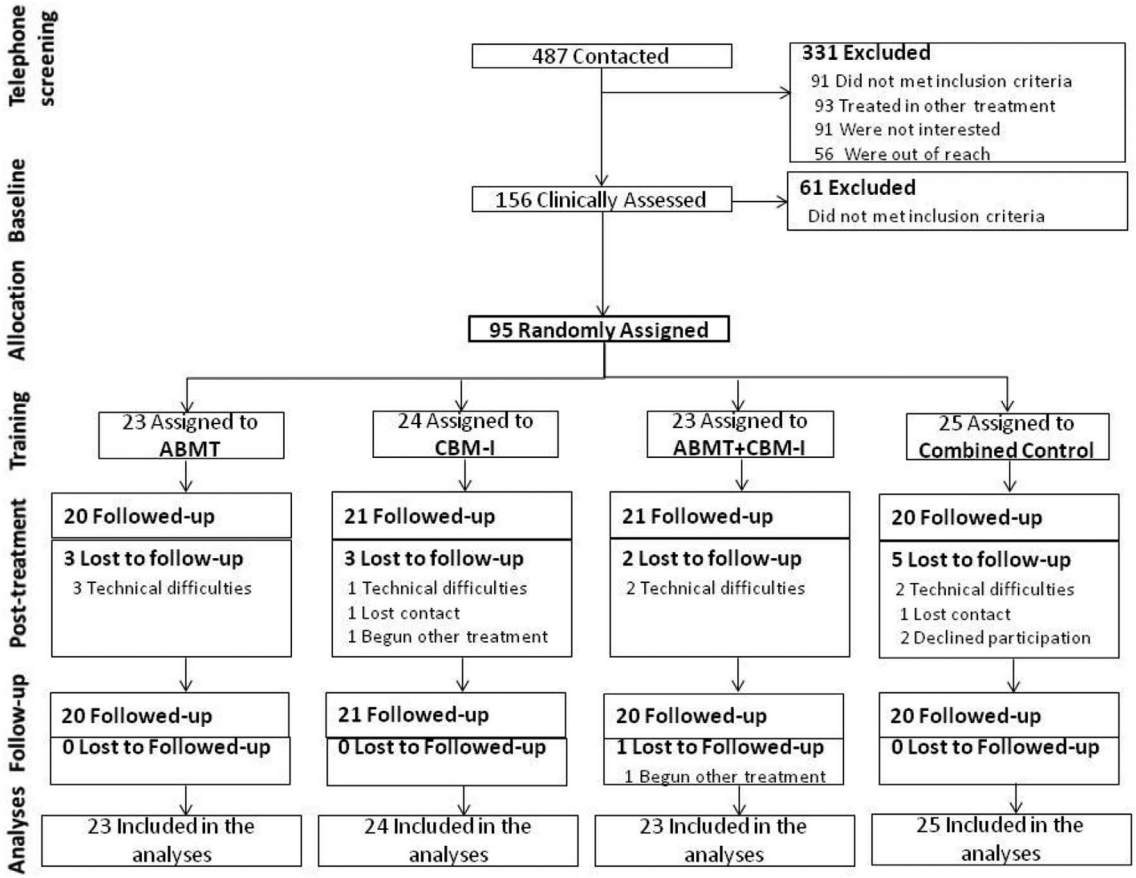


Fig. 1. CONSORT diagram illustrating participants flow throughout the study.

3.2.2. The grammar decision task (GDT)

The task used here is similar to the one used by Moser at al. (2008). 100 sentences with the last word left out were presented via headphones. Eighty scenarios described experiences within social situations (e.g., *"As you give a speech, you see a person in the crowd smiling, which means that your speech is …")* and were resolved by a negative (e.g., *"stupid")* or a positive (e.g., *"funny"*) terminal word. 20 scenarios were nonsocial (e.g., *"You've just started reading a new book that you bought and you find it to be …"*) and were also resolved by a negative (e.g., *"boring"*) or positive (e.g., *"interesting"*) terminal word. Half of the scenarios of each type were completed with a grammatical terminal word (boring/interesting), the other half was completed with a non-grammatical terminal word (bore/interest). Participants had to determine whether the word completes the sentence grammatically or not. Interpretation bias was calculated by subtracting mean reaction times to positive social words from mean reaction times of negative social words, within the social trials that terminated with a grammatical word. Positive scores reflect negative interpretation bias.

3.2.3. Interpretation bias modification

The CBM-I followed the regimen described by Mathews and Mackintosh (2000) and adapted by Murphy et al. (2007). 95 auditory descriptions of ambiguous social scenarios were presented via headphones. Scenario descriptions were identical across the active and control conditions, but the final sentence that resolved the ambiguity of the scenarios differed. Scenarios in the active training were designed to induce benign or positive interpretations. Descriptions in the control condition, not intended to modify interpretation bias, were resolved in a neutral outcome. Descriptions were followed by a yes\\\\\\\\no comprehension question. In the active training condition, the correct answers to the questions referred to the benign outcome in a way that encourages formation of positive images of the emotionally ambiguous scenarios (Holmes, Mathews, Dalgleish, & Mackintosh, 2006). In the control condition, the comprehension questions were neutral and did not contain information about emotional valence. Each trial ended with feedback *("Correct"* or *"Incorrect")* presented on the screen (for details see Appendix C).

4. Procedure

Patients were recruited via advertisement in social media and newspapers. Participants were informed that the study evaluates the efficacy of two novel treatments for social anxiety and that they would be randomly assigned to either one of the treatment groups or to a control group. Written informed consent was obtained. Study design was a 4 (Group: ABMT, CBM-I, ABMT + CBM-I, combined control) by 3 (Time: baseline, post-treatment, FU) mixed design. Participants were assessed at all three time points using semi-structured clinician-rated measures, self-report questionnaires, and information-processing measures. Clinical interviews were conducted by clinicians who were blind to treatment condition. Participants who met inclusion criteria were randomly assigned to one of the four groups following an automated randomization procedure.

Treatment included eight 45-min sessions, twice a week for four weeks. To control for the different durations of the ABMT (~10 min) and CBM-I (~35 min) tasks, all participants completed both tasks in each session, in a combination of active\\\\\\\\control variants according to their treatment condition. Participants in the ABMT group completed active ABMT and control CBM-I, and vice versa for the CBM-I group. In the ABMT + CBM-I group the active versions of ABMT and CBM-I were completed, and in the combined control group the control versions of the two tasks were completed. Task order within each group

was counter-balanced between participants. No order effects were found (all *ts* < 1.85; *ps* > 0.08). Post-treatment assessment was conducted one week after the last treatment session and FU 3-month later. Participants, independent evaluators, and research personnel were all unaware of participants' treatment condition. The study was approved by the local ethics committee. ClinicalTrials.gov registration identifier: NCT01503151. Full trial protocol can be accessed through ClinicalTrials.gov and is also available upon request from the first author.

5. Data analysis

Analysis of Variance (ANOVA) and Chi-square tests were used to compare between-groups descriptive characteristics at baseline. Mean changes in outcome measures were estimated using mixed-effect models with time, group, and time-by-group interaction as fixed effects (Raudenbush, 2002). Mixed effect models also accommodate missing data under the missing-at-random assumption and honors the intent-to-treat principle (Raudenbush, 2002). All available data were used, rendering this analytic strategy a full intent-to-treat analysis. Analyses were adjusted for repeated-measures with random intercepts and slopes included at the participant level with a full maximum likelihood estimation method, with first order autoregressive covariance structure.

We investigated the effects of treatment group on change in outcome and bias measures from baseline to post-treatment and from post-treatment to FU. The primary analyses examined the magnitude of change in the control group from baseline to post-treatment and from post-treatment to FU. These were followed by the investigation of whether symptoms change across the three intervention groups (ABMT, CBM-I, ABMT + CBM-I) was similar or significantly different from the change observed in the combined control group. Then, all contrasts examining possible differences among the three intervention groups were examined. Effect Sizes (ES) representing the magnitude of improvement that resulted from treatment type were calculated using Cohen's *d* (Morris, 2008; Morris and DeShon, 2002).

We also benchmarked the current effect sizes of baseline to post-treatment change in LSAS relative to those of prior studies (Morris, 2008). These analyses were conducted using Comprehensive Meta-Analysis software, version 2.002 (Biostat, Englewood, NJ). Q-tests were used to compare between effect sizes magnitudes.

6. Results

The groups did not differ in age, gender, cognitive biases, and social anxiety symptoms at baseline, all *ps* > 0.15 (Table 1).

6.1. Change in social anxiety symptoms following treatment

6.1.1. Clinician-rated change

Analyses of the primary clinical outcome (LSAS) revealed that all groups improved from baseline to post-treatment. LSAS scores reduced 13.89 points in the control group, $t_{(82)}$ = -3.80, $p < 0.01$, d = 0.76 [0.51, 1.01]; 25.41 points in the ABMT group, $t_{(82)}$ = -6.96, $p < 0.01$, d = 1.45 [1.15, 1.75]; 13.16 points in the CBM-I group, $t_{(82)}$ = -3.69, $p < 0.01$, d = 0.75 [0.51, 0.99]; and 15.52 in the ABMT + CBM-I group, $t_{(82)}$ = -4.35, $p < 0.01$, d = 0.91 [0.65, 1.17]. While the ABMT group had significantly larger reduction in clinician-rated LSAS from baseline to post-treatment relative to the combined control group, $t_{(82)}$ = -2.23, p = 0.03, d = 0.64 [0.33, 0.95], the CBM-I and the ABMT + CBM-I groups did not, *ts* < 0.32, *ps* > 0.75, *ds* < 0.09, Fig. 2a. Further analyses revealed that ABMT showed greater symptom reduction than CBM-I, $t_{(82)}$ = 2.40, p = 0.02, d = 0.70 [0.38, 1.02] while the difference between ABMT and the ABMT + CBM-I group was of moderate magnitude but not significant, $t_{(82)}$ = 1.94, p = 0.056, d = 0.57 [0.26, 0.88]. Finally, across all groups, treatment gains were maintained at FU, demonstrated by a lack of post-FU effects across the different groups, *ts* < 1.30, *ps* > 0.19, *ds* < 0.27.

6.1.2. Responder status

We examined the number of completers achieving reliable clinical significant change on the LSAS based on the approach described in Jacobson and Truax (1991). Besides being widely used in clinical studies, this approach has been specifically applied in ABMT trials for anxiety disorders (e.g., Amir & Taylor, 2012), and therefore allowed direct comparison of our findings to already existing reports in the literature. This method operationalizes recovery and remission status in a relatively objective and unbiased way, and provides reliable information on variability in outcome and on clinical significance. In the current study, cutoff scores were determined using published norms for the LSAS (Fresco et al., 2001; Taylor & Amir, 2012) and test-retest reliability data from Huppert et al. (2017).[1] To be considered "recovered" a participant's post-treatment LSAS score had to be lower than 36. To be considered "responder," with a significant clinical change, a participant's score had to decrease from baseline-to post-treatment by at least 34.08 points. In case of overlap, when participants met both criteria they were considered "recovered". Overall, the definitions were complementary and with each participant ending-up belonging to only one of the three categories. Using these criteria, 35% of the ABMT group had "recovered" status. 24% of the CBM-I group had improved (5% "responders" and 19% "recovered"), and within the ABMT + CBM-I group, 24% had improved (10% "responders" and 14% "recovered"). Finally, in the combined control group, 10% had improved (5% "responders" and 5% "recovered"). There was no difference in improvement ratio between groups either for "responders", $F_{(3)}$ = 0.57, p = 0.64, or for "recovered", $F_{(3)}$ = 2.19, p = 0.10. Response status did not differ among the groups, $\chi^2_{(6)}$ = 7.90, p = 0.25. Exploratory contrasts between each of the treatment groups vs. the control group revealed a significant difference in "recovered" ratio only between the ABMT and the combined control group, with fewer non-responders and more recovered in ABMT relative to combined control group, $\chi^2_{(2)}$ = 6.31, p = 0.04. No other significant differences were found on response or recovery status.

6.1.3. Self-rated change in social anxiety

For the secondary outcome (SPIN), all groups improved from baseline to post-treatment. SPIN mean score decreased in 8.24 points in the control group, $t_{(130)}$ = -3.46, p = 0.001, d = 0.69 [0.50, 0.88]; 17.19 points in ABMT, $t_{(130)}$ = -7.12, p = < 0.001, d = 1.48 [1.23, 1.73]; 9.22 in CBM-I, $t_{(130)}$ = -3.95, p < 0.001, d = 0.81 [0.61, 1.01]; and 7.54 in the ABMT + CBM-I group, $t_{(130)}$ = -3.23, p = 0.002, d = 0.67 [0.48, 0.86]. Again, a significantly greater decrease relative to combined control was found only in the ABMT group, $t_{(130)}$ = -2.65, p = 0.009; d = 0.77 [0.52, 1.02]. The CBM-I group showed similar symptom reduction as the combined control group, $t_{(130)}$ = -0.29, p = 0.77, d = 0.08 [-0.16, 0.32], and the same was for the ABMT + CBM-I group, $t_{(130)}$ = 0.21, p = 0.83, d = 0.06 [-0.18, 0.30], Fig. 2b. Contrasting ABMT with each of the other training groups revealed that ABMT induced greater decrease in symptoms from baseline to post-treatment relative to the CBM-I group, $t_{(130)}$ = 2.39, p = 0.02, d = 0.70 [0.45,.95]; and relative to the ABMT + CBM-I group, $t_{(130)}$ = -2.88, p = 0.005, d = 0.85 [0.60, 1.01].

Within the ABMT, ABMT + CBM-I, and combined control groups, post-treatment changes in SPIN were maintained at FU, *ts* < 1.92,

[1] We were unable to find any published test-retest reliability data on the LSAS interview. However, we used data collected in a separate randomized trial of CBT vs. ABMT for SAD (Huppert et al., 2017). An advantage of these data are that they use a similar population (civilians from the same country seeking treatment for social anxiety) and similar interviewers (graduate students trained to deliver the interview). Fifteen patients were interviewed with the LSAS before treatment during the intake and were re-interviewed by a second trained interviewer. The two measurements were taken 1 week apart. Results suggested strong test-retest reliability (r = 0.80).

Table 1
Demographics and estimated means and standard errors (in parentheses) of social anxiety symptoms, functioning levels, threat-related attention bias and interpretation biases as a function of treatment group and time.

	ABMT (n = 23)	CBM-I (n = 24)	ABMT + CBM-I (n = 23)	Combined Control (n = 25)	Statistics (p = value)
Demographics					
Age, Mean (SD)	31.96(8.48)	31.02.(11.43)	33.09(8.03)	32.34(10.09)	$F_{(3)}$ = 19.(90)
Gender (Male)	16	16	16	10	x^2 = 6.38(10)
Baseline					
LSAS,SE	77.70(5.01)	72.72(3.60)	79.87(3.68)	75.16(3.47)	$F_{(3)}$ = 76(52)
SPIN,SE	48.26(2.54)	43.58(2.51)	44.35(1.84)	43.48(1.76)	$F_{(3)}$ = 1.47(23)
SDS,SE	6.81(49)	7.22(54)	5.97(54)	7.04(37)	$F_{(3)}$ = 2.02(12)
AB(DT),SE	5.09(8.43)	-1.09(8.34)	-9.58(6.08)	5.27(5.84)	$F_{(3)}$ = 1.29(28)
IB(SCT),SE	31.88(10.33)	53.51(10.31)	55.35(14.7)	45.62(7.14)	$F_{(3)}$ = 2.04(12)
IB(GDT),SE	-39.33(53.60)	-21.11(53.02)	-70.26(38.80)	54.37(37.07)	$F_{(3)}$ = 1.30(28)
Post-treatment					
LSAS,SE	52.30(5.16)	59.45(3.96)	64.35(3.56)	61.26(3.65)	
SPIN,SE	31.07(3.37)	34.36(3.33)	36.80(2.33)	35.24(2.38)	
SDS,SE	5.17(97)	5.94(96)	4.33(69)	5.40(49)	
AB(DT),SE	2.80(10.47)	5.50(10.35)	-0.99(7.44)	-0.40(7.30)	
IB(SCT),SE	-16.91(12.5)	21.71(12.47)	14.34(8.72)	5.04(8.73)	
IB(GDT),SE	-116.50(61.30)	-58.92(60.51)	-76.48(43.35)	-106.66(42.75)	
Follow-up					
LSAS,SE	48.20(5.00)	54.93(4.90)	62.21(3.54)	59.81(3.54)	
SPIN,SE	28.22(3.34)	29.36(3.30)	32.28(2.36)	33.99(2.36)	
SDS,SE	5.28(81)	5.50(57)	4.50(57)	5.47(41)	
AB(DT),SE	-6.28(8.84)	-0.63(8.66)	0.43(6.00)	2.31(6.25)	
IB(SCT),SE	-14.80(9.56)	8.80(6.60)	18.56(6.80)	7.74(7.18)	
IB(GDT),SE	-64.74(52.71)	-114.40(51.17)	-74.17(72.36)	-23.31(37.26)	

Note: ABMT = Attention Bias Modification Treatment; CBM-I = Interpretation Bias Modification Treatment; LSAS = Liebowitz Social Anxiety Scale Interview; SPIN = Social Phobia Inventory; SDS = Sheehan Disability Scale; AB = Attention bias; DT = Dot probe; IB = Interpretation bias; SCT = Sentence Completion Task; GDT = Grammar Decision Task; SE = standard error.

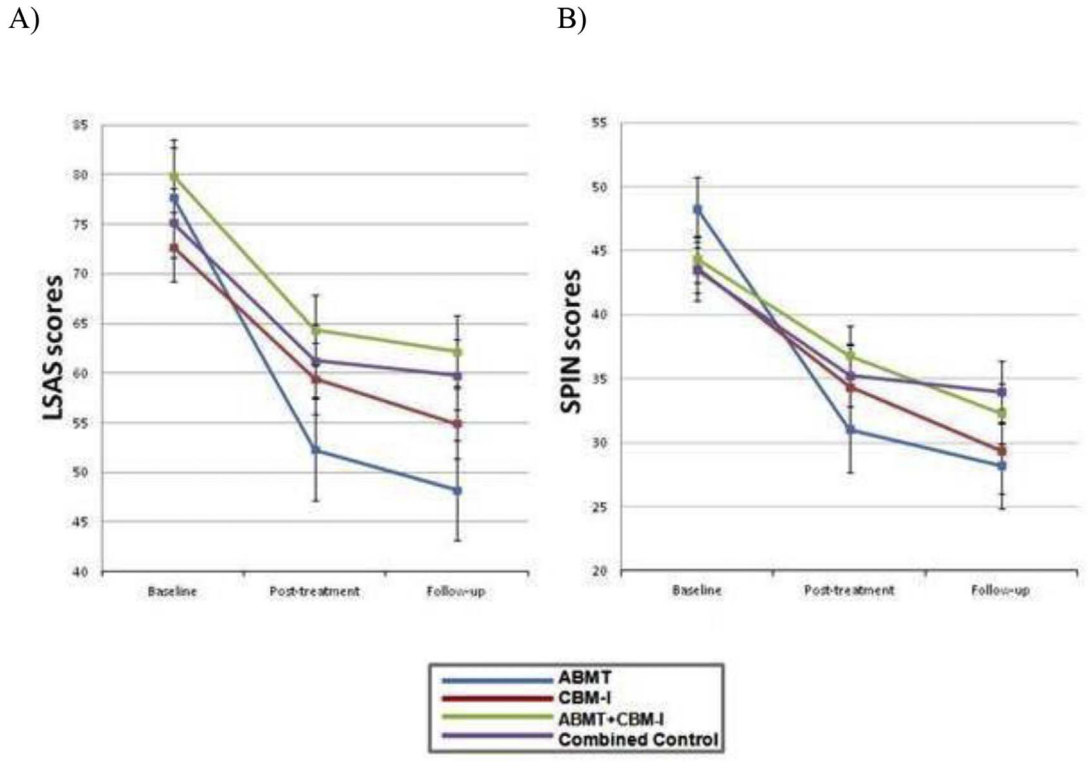


Fig. 2. Change in social anxiety symptoms across the different treatment groups at all three time points measured by clinician rated interview (Panel A) and self-report questionnaires (Panel B). Error bars represent standard errors.
Note: LSAS = Leibowitz Social Anxiety Scale; SPIN = Social Phobia Inventory; ABMT = Attention Bias Modification Treatment; CBM-I = Interpretation Bias Modification Treatment.

ps > 0.05, ds < 0.40. The CBM-I group yielded an additional decrease in symptoms from post-treatment to FU, which differed from zero, $t_{(85)}$ = 2.17, p = 0.03, d = 0.44 [0.22, 0.66]. Nevertheless, this decrease was not significantly different from the post-treatment to FU change in the combined control group, $t_{(85)}$ = 1.14, p = 0.26, d = 0.33 [0.03,.63], nor from the other groups, *ts* 0.65, *ps* > 0.52, *ds* < 0.19. To further investigate these patterns we conducted a post-hoc analysis comparing the direct effect of symptoms reduction measured by SPIN from baseline to FU between the ABMT group and the CBM-I group. This analysis revealed a non-significant effect, $t_{(82)}$ = 0.56, p = 0.58, d = 0.16 [-0.15, 0.47].

6.2. Self-rated change in functioning

There was a significant improvement in functioning as measured by the SDS from baseline to post-treatment across all groups with no difference between them. The combined control group demonstrated a reduction of 1.63 points from baseline to post-treatment, $t_{(171)}$ = -3.34, p = 0.001, d = 0.67 [0.50, 0.84]); ABMT reduced 1.64 points $t_{(166)}$ = -3.34, p < 0.001, d = 0.70 [0.53, 0.87]; CBM-I reduced 1.28 points, $t_{(165)}$ = -2.63, p = 0.009, d = 0.54 [0.38, 0.70]); and the ABMT + CBM-I group reduced 1.64 points, $t_{(163)}$ = -3.40, p = 0.001, d = 0.71 [0.54, 0.88]). All four groups did not differ from one another in baseline to post-treatment reduction, all *ts* < 0.53, *ps* > 0.60, *ds* < 0.16. These effects remained at FU, *ts* < 1.07, *ps* > 0.28, *ds* < 0.22.

Because SAD is defined by a particular dysfunction in the social domain, analyses were conducted also separately for the social item of the SDS. A significant change was observed across all groups. The combined control group showed a significant improvement in social functioning from an average score of 8.72 at baseline to an average score of 6.07 at post-treatment, $t_{(120)}$ = -5.03, p < 0.0001, d = 1.01 [0.79, 1.23]; the ABMT group improved by 2.65 points, $t_{(120)}$ = -5.02, p < 0.0001, d = 1.05 [0.83, 1.27]; the CBM-I group improved by 1.28 points, $t_{(120)}$ = -2.43, p = 0.02, d = 0.50 [0.31, 0.69]); and the ABMT + CBM-I group improved by 1.99 points, $t_{(120)}$ = -3.86, p < 0.0001, d = 0.81 [0.60, 1.02]. Improvements were across all groups with no differences between them, *ts* < 1.85, *ps* > 0.07, *ds* < 0.54, Fig. 3. These effects remained at FU, *ts* < 1.30, *ps* > 0.20, *ds* < 0.27, with no group differences in symptoms change, *ts* < 1.12, *ps* > 0.27, *ds* < 0.33.

6.3. Change in cognitive biases following treatment

None of the groups had threat-related attention bias at baseline, *ts* < 1.57, *ps* > 0.12, *ds* < 0.33. There were no significant changes in attention bias from baseline to post-treatment, *ts* < 1.37, *ps* > 0.17, *ds* < 0.40, and from post-treatment to FU, *ts* < 1.33, *ps* > 0.18, *ds* < 0.39, Fig. 4.

Analysis of interpretation bias as measured by the SCT indicated that all groups had a negative bias at baseline, *ts* > 4.06, *ps* < 0.01, *ds* > 0.85. We found a significant improvement in the SCT across all groups. The combined control group showed reduction in negative interpretation from baseline to post-treatment, b = −40.58, $t_{(140)}$ = -4.65, p < 0.001, d = 0.93 [0.73, 1.13]); ABMT, b = −48.80, $t_{(137)}$ = -5.45, p < 0.001, d = 1.14, [0.93, 1.35]); CBM-I, b = -32.03, $t_{(140)}$ = -3.60, p < 0.001, d = 0.74 [0.55, 0.93]); and the ABMT + CBM-I group, b = −41.00, $t_{(135)}$ = -4.70, p < 0.001, d = 0.98 [0.77, 1.19]). The three intervention groups showed similar reductions, not significantly different from the control group, *ps* > 0.49, *ts* < 0.68, *ds* < 0.20. The three intervention groups did not differ from each other, *ts* < 1.32, *ps* > 0.19; *ds* < 0.39. These effects remained at FU, *ts* < 1.84, *ps* > 0.07, *ds* < 0.38, Fig. 5a.

Analyses of interpretation bias measures by the GDT revealed mixed results. First, none of the groups had negative interpretation bias at baseline, *ts* < 1.81, *ps* > 0.07, ds < 0.38. Second, the combined control group presented a significant change in interpretation bias which became more positive from baseline to post-treatment, b = −161.03, $t_{(122)}$ = -3.77, p < 0.0001, d = 0.75 [0.55, 0.95]). Baseline to post-treatment change within the three intervention groups was non-significant: ABMT, $t_{(120)}$ = -1.73, p = 0.09, d = 0.36 [0.18, 0.54]; CBM-I, $t_{(117)}$ = -0.88, p = 0.38, d = 0.18 [0.00, 0.36]; ABMT + CBM-I, $t_{(115)}$ = -0.14, p = 0.88, d = 0.03 [-0.15, 0.21]). Third, while baseline to post-treatment change in interpretation bias in the ABMT group was similar in magnitude to the change induced by the combined control, $t_{(120)}$ = 1.38, p = 0.17, d = 0.40 [0.14, 0.66]), the CBM-I and the ABMT + CBM-I interventions induced a significantly smaller increase in positive interpretation from baseline to post-treatment relative to the control: CBM-I, $t_{(120)}$ = 2.04, p = 0.04, d = 0.58 [0.32, 0.84]; ABMT + CBM-I, $t_{(119)}$ = 2.54, p = 0.01, d = 0.73 [0.47, 0.99]). However, these patterns reversed from post-treatment to FU. Specifically, there was a significant decrease of positive interpretation in the combined control group from post-treatment to FU, b = 83.36, $t_{(80)}$ = 2.24, p = 0.03, d = 0.45 [0.22, 0.68]). Whereas the ABMT group and the ABMT + CBM-I group had a similar pattern of change in interpretation bias, not different from the combined control, *ts* < 1.58 *ps* > 0.12, *ds* < 0.46. CBM-I induced a significantly smaller decrease of positive interpretation from post-treatment to FU relative to the combined control, b = −138.85, $t_{(77)}$ = -2.71, p = 0.008, d = 0.77 [0.44, 1.10], Fig. 5b.

Since trends from baseline to post-treatment and from post-treatment to FU were found to be different and opposite, to examine a more general trend we investigated the direct effect of time from baseline to FU. This analysis yielded a non-significant effect of time across all groups, *ts* < 1.94, *ps* > 0.06, *ds* < 0.40.

6.4. Mediation and moderation analyses

Bootstrapping mediation analyses (Hayes & Preacher, 2014; model 4) were used to test for possible indirect effect of treatment group on social anxiety symptom reductions (LSAS and SPIN) from baseline to post-treatment through changes in attention (dot-probe) and interpretation (GDT and SCT) biases. All these analyses revealed non-significant effects, all *zs* < 0.32, *ps* > 0.70.

6.5. Benchmarking the effect sizes relative to published effects

We benchmarked the current effect sizes relative to published effects, using the calculation suggested by Morris (2008) of placebo-controlled effect size. Specifically, we compared the effect sizes of baseline to post-treatment change in LSAS, to those of prior ABMT and CBM-I studies in adults with SAD. Effect sizes of each study were generated based on pre-post change in the treatment group minus the mean pre-post change in the control group, divided by the pooled pretest standard deviation (Morris, 2008). We used *M, SD,* and *n* values reported in the papers.

Previous relevant studies for benchmarking were selected using the following inclusion criteria: (1) the study was a RCT; (2) the sample consisted of adults with SAD; (3) the study included a treatment group (ABMT away from threat or CBM-I treatment) and a control group; (4) LSAS was measured pre- and post-treatment; and (5) for ABMT studies training was conducted using the dot-probe task. These criteria yielded eight relevant studies: seven for ABMT (Amir et al., 2009; Boettcher, Berger, & Renneberg, 2012; Bunnell et al., 2013; Carlbring et al., 2012; Heeren, Peschard, & Philippot, 2012; Neubauer et al., 2013; Schmidt, Richey, Buckner, & Timpano, 2009), and one CBM-I study (Amir & Taylor, 2012).

A Combined within-between effect size was generated for all relevant prior ABMT studies (k = 7; d = 0.25), and was then contrasted with the current ABMT effect size (d = 0.32). This comparisons revealed no significant difference between previous and current ABMT studies (Q = 0.15, p = 0.70).

For CBM-I, contrasting the within-between effect size in Amir and

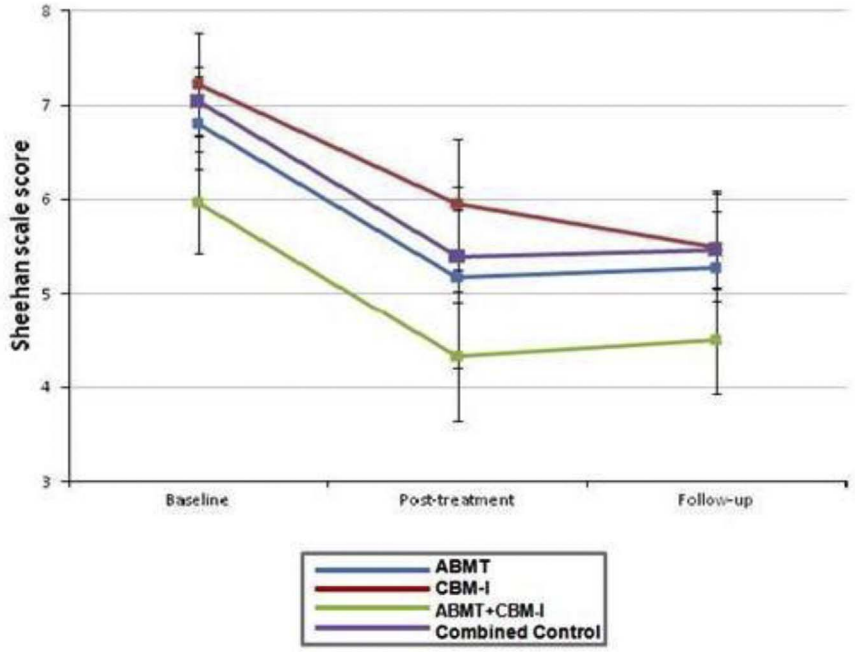


Fig. 3. Functioning impairment change scores across the different treatment groups at all three time points measured by the Sheehan Disability Scale. Error bars represent standard errors.
Note: ABMT = Attention Bias Modification Treatment; CBM-I = Interpretation Bias Modification Treatment.

Note: ABMT = Attention Bias Modification Treatment; CBM-I = Interpretation Bias Modification Treatment.

Taylor (2012; $d = 1.14$) with the effect size of the current study ($d = 0.10$) revealed a significant difference ($Q = 30.27$, $p < 0.01$).

7. Discussion

This RCT of ABMT, CBM-I, ABMT + CBM-I, and a combined control condition for SAD suggest that ABMT was superior to a combined control intervention in social anxiety symptom reduction, as measured by both clinician-rated and self-reported measures. Neither of the other active conditions demonstrated superior symptom change to the combined control condition. Overall, ABMT demonstrated superiority in symptom reduction in comparison to both CBM-I and the

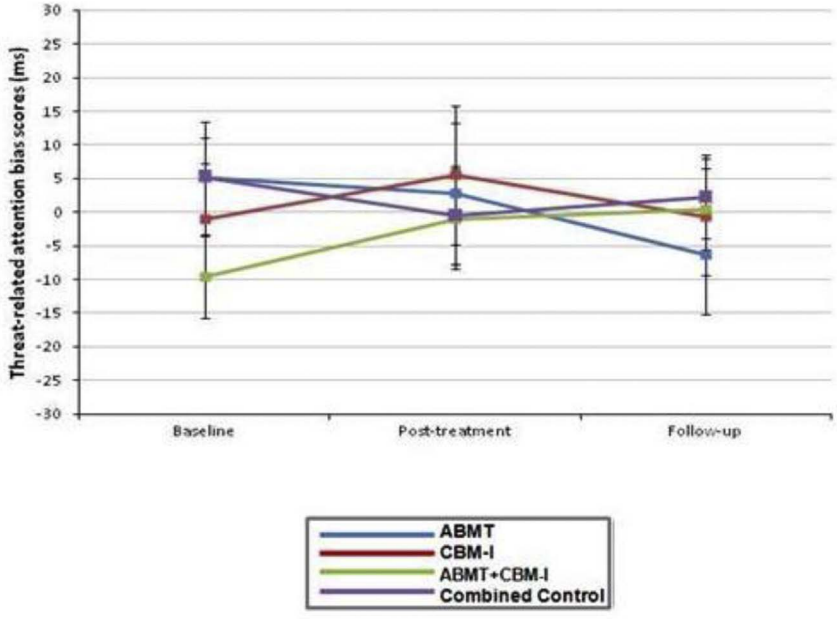
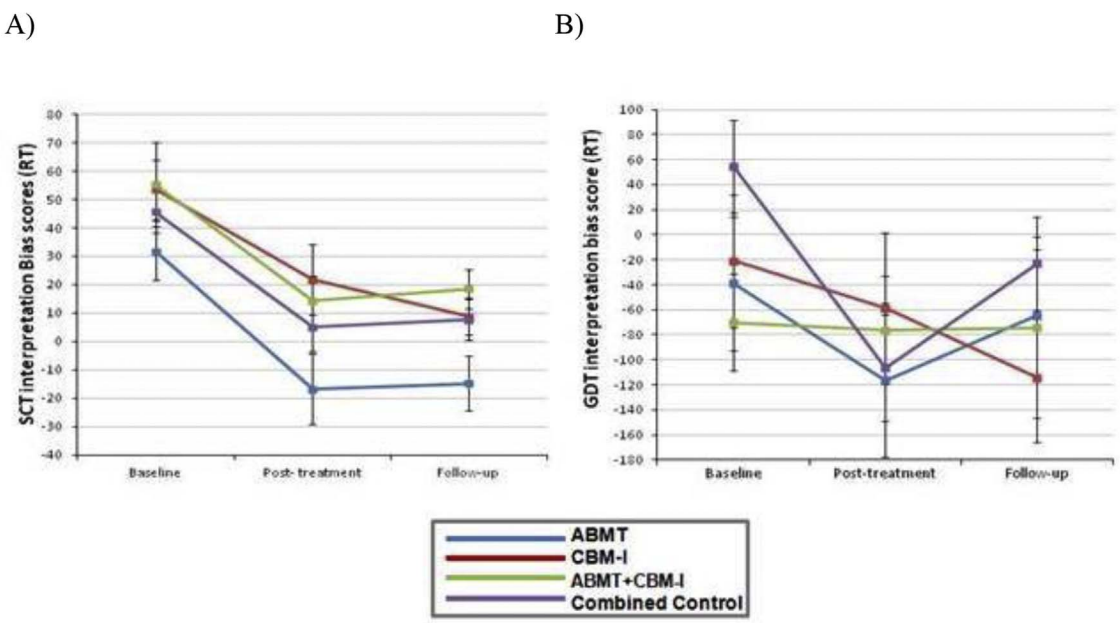


Fig. 4. Threat related attention bias change scores across the different treatment groups at all three time points measured by the dot-probe task. Error bars represent standard errors.
Note: ABMT = Attention Bias Modification Treatment; CBM-I = Interpretation Bias Modification Treatment.

Note: ABMT = Attention Bias Modification Treatment; CBM-I = Interpretation Bias Modification Treatment.



Note: SCT = Sentence Completion Task; GDT = Grammar Decision Task; ABMT = Attention Bias Modification Treatment; CBM-I = Interpretation Bias Modification Treatment.

Fig. 5. Interpretation bias change scores across the different treatment groups at all three time points measured by the Sentence Completion Task (Panel A) and the Grammar Decision Task (Panel B). Error bars represent standard errors.

ABMT + CBM-I condition. While ABMT demonstrated superior symptom reduction and greater recovery rates compared to the combined control group specifically, there was no greater improvement in other symptom or function status measures, or on any measure of cognitive bias. Overall, many of our hypotheses were not confirmed except that ABMT was more effective in symptom reduction than the other conditions.

We found a more modest response in ABMT than found by the two original studies that examined ABMT for adult SAD (Amir et al., 2009; Schmidt et al., 2009). This is consistent with meta-analyses that have suggested that these previous studies found larger effects than expected (e.g., Hallion & Ruscio, 2011; Heeren, Mogoase, McNally, Schmitz, & Philippot, 2015a; Mogoase et al., 2014). Still, ABMT had significant effects, larger than control and even other active conditions, suggesting that there was some superiority of ABMT over CBM-I, or the combination. The finding that superior effects emerged in both self-report and independent evaluator (IE) ratings differ from the meta-analytic findings of Linetzky et al. (2015), which found significant effects in IE measures only. This clinical improvement was found despite the fact that there was no indication that attentional bias actually changed in the ABMT group (MacLeod & Clarke, 2015). In addition, the current ABMT effect size of baseline to post-treatment change was not different in magnitude from the effect sizes found in previous SAD studies demonstrating efficacy of this treatment over a control condition (e.g., Amir et al., 2009; Boettcher et al., 2012; Heeren et al., 2012). Thus, overall, these data suggest that something is clinically working when individuals with SAD are treated with ABMT, though the mechanism it is not yet clear.

Counter to hypotheses, CBM-I was no more effective than the combined control condition and less effective than ABMT. There are a number of possible explanations for this. First, the CBM-I task used in this study differed from the version used in some prior studies that reported positive training effects (e.g., Amir & Taylor, 2012; Beard & Amir, 2008). Indeed, the placebo-controlled effect size in the current study was smaller than that in Amir and Taylor (2012). The fact that there were no specific improvements in interpretation bias following CBM-I suggests that the paradigm did not work sufficiently. Second, ABMT may simply be more effective for SAD than CBM-I in the context of a full clinical trial (cf. Hallion & Ruscio, 2011). This is one of the first attempts to administer CBM-I multiple times as a possible treatment for SAD. It may be that such repeated administration somehow dilutes potential effects. For instance, Sagi and Censor (2009) suggested the possibility of overlearning effects leading to perceptual deterioration. Third, it may be that provision of the control ABMT condition somehow neutralized the potential positive impact of CBM-I.

The combination of ABMT + CBM-I intervention was not more effective than ABMT or CBM-I plus control conditions. Previous studies have not examined this combination versus controlled interventions. The current finding that the ABMT + CBM-I combination was less effective than ABMT and equivalent to CBM-I raises many questions. Given that both groups received active ABMT, one interpretation is that active CBM-I decreased the efficacy of ABMT. Given that the CBM-I control condition included similar ambiguous content as the active training condition, it could mean that training in the resolution or interpretation of ambiguity somehow dampens the effects of ABMT. Unlike Beard et al. (2011) and Brosan et al. (2011), where participants completed the ABMT task first followed by CBM-I, here, task order was counterbalanced within each group. This difference might have contributed to the difference in results. Overall, the current findings suggest that more research is needed on the impact of both single forms of CBM and on their combinations. For example, could combining ABMT with cognitive therapy techniques or reappraisal impede the effects of ABMT? Results from Shechner at al. (2014) suggest that the answer to this question might be negative. This study examined the augmenting effects of threat-based ABMT on cognitive behavioral therapy (CBT) in clinically anxious youth. The results showed that both the active and control ABMT groups yielded greater reductions in clinician-rated anxiety symptoms compared to CBT alone. On the other hand, Rapee et al. (2013) found no additive influence of adding ABMT to CBT for adults.

The decreased effects of combined paradigms found in the current

study are in line with some previous data. For instance, Browning, Holmes, Murphy, Goodwin, and Harmer (2010) revealed that combining ABMT with SSRIs serves to erode ABMT's impact. This study suggests that the results found in the current study are not necessarily unique to CBM combinations.

As in some previous studies, we did not find change in attention bias in those who received ABMT (MacLeod & Clarke, 2015). First, as we reported, despite meeting criteria for SAD and the fact that all individuals who enrolled were seeking treatment, there was no indication that on average these individuals evidenced biased attention at baseline. Some published studies had failed to show attention bias in socially anxious individuals at baseline (e.g., Boettcher et al., 2013; Julian, Beard, Schmidt, Powers, & Smits, 2012; McNally, Enock, Tsai, & Tousian, 2013). Other studies suggest that anxious individuals do not consistently show attention bias toward threat and sometimes show threat-avoidance or no bias (e.g., Cisler & Koster, 2010; Salum et al., 2013; Waters, Bradley, & Mogg, 2014). These previous findings as well as the current report speak to variability in results but do not coincide with clear meta-analytic findings indicating a significant association between social anxiety and baseline threat bias (Bar-Haim et al., 2007; Van Bockstaele et al., 2014). Additionally, as in some previous ABMT studies, despite the inability to detect threat bias at baseline or bias change from pre-to post-treatment, a clinical improvement was still observed in the current study. Overall, the current data suggest that something is clinically working when individuals with SAD are treated with ABMT, though the exact mechanism is not yet clear. In light of the limited psychometric properties of the bias scores derived from the dot-probe task (Rodebaugh et al., 2016), it is possible that ABMT is more effective in modifying biases than dot-probe tasks are in detecting such biases.

Overall, change in interpretation biases occurred in all conditions, regardless of the type of training administered. Were these changes to be correlated with changes in symptoms, then one could argue that this non-specific effect was related to a basic cognitive factor associated with social anxiety. However, no specific effects were found. This suggests that there was no specific impact of CBM-I in the current study. One potential explanation to this non-specific effect may relate to the possibility that the specific tasks applied in measuring interpretation bias in our study were not sensitive enough to capture mild between-group differences in change patterns. Alternatively, this finding could points to the potency of the CBM-I control condition to also reduce negative interpretation bias, for example, through providing an exposure to threatening scenarios. Along with the lack of established data on sensitivity to change and other psychometric properties of the tasks measuring interpretation bias, our data suggest that more work is needed to understand the mechanisms underlying interpretation bias modification procedures as well as the relations among interpretation biases, attentional biases, their training, and their relation to symptom reduction.

Inconsistency and mixed findings appear to reflect the state of research in the field of cognitive bias modification (CBM) for SAD. A number of potential factors could drive this variability in results. Relevant factors are the clinical status of the study sample; the specific procedural detail of the interventions (i.e., task characteristics, feedback, training setting, number of training session), the severity of SAD symptoms at baseline, baseline cognitive biases, and participants' characteristics such as age and gender (Menne-Lothmann et al., 2014). More research is needed on the key factors influencing CBM treatment outcome.

Previous research has demonstrated some interrelations between attentional and interpretation biases and their modification such that training in interpretation bias can lead to decreases in attentional bias (Amir et al., 2010), although see Hoppitt et al. (2014) for negative findings. Similarly, White et al. (2011) demonstrated specific change in interpretation biases after attentional training toward threat. This finding was specific to first interpretations, and no effect was found for total interpretations. In our data, first interpretations yielded the same patterns of baseline bias and non-specific treatment effect as found for total interpretations measure.[2] However, it is also possible that instilling negative attentional biases is different from attempting to reduce them in patients.

The results of the current study should be viewed in light of some limitations. First, we applied a mix of active and control treatments across the different groups. This allowed us to control for session duration and stimuli exposure across conditions, but also prevented us from estimating the net effect of each of the treatments by itself. Second, there is some evidence suggesting that the balanced dot-probe control condition used here might also have clinical benefits (Badura-Brack et al., 2015; Shechner et al., 2014), potentially accounting for why all groups improved from baseline to post-treatment. Future studies could contrast ABMT and CBM-I as single treatments, shedding light on their relative efficacy when delivered in their original format. Other potential explanations for why all groups clinically improved from baseline to post-treatment could be spontaneous improvement over time or anxiolytic effects of positive-outcome expectancies, which were not controlled for in our study. With regard to LSAS however, despite the significant anxiety reduction in the control condition, our findings show that the active conditions, and specifically the ABMT condition, showed significantly larger anxiety reductions.

Third, the reliability score for the SDS measuring functioning level was low in the current study, suggesting that the results regarding this measure should be interpreted cautiously. Forth, although sample size was large enough to detect significant symptoms change from baseline to post-treatment in the ABMT group, a larger sample size might have led to more consistent effects. Future RCTs may benefit from larger samples.

8. Conclusions

To summarize, ABMT was more effective in reducing SAD symptoms than a combined control condition, CBM-I, or the combination of ABMT and CBM-I. Effects were moderate, and we could not explain our findings based on changes in specific cognitive biases. While the current trial addressed most methodological issues aside from modest sample size (Heeren et al., 2015a), results are still inconclusive, and more research is needed to determine the effects of computerized cognitive interventions for SAD.

Contributors

All authors made substantial contribution to the conception and design of the current study, as well as to the acquisition of the data or to the process of analyzing and interpretation of the data.

All authors were involved in drafting and revising this manuscript. All authors gave final approval of the submitted version. All persons who contributed to this manuscript are included as authors.

This manuscript is the authors' original work. It has not been submitted for publication elsewhere and is not under consideration for publication in another journal, website or textbook.

Role of funding

This work was partially support by the United States - Israel Binational Science Foundation (BSF) for YBH - 2013349.

There are not any commercial or similar relationships of the authors or members of their families to products or companies mentioned in or related to the subject matter of the article being submitted. There are

[2] In our data, first interpretations yielded the same patterns of baseline bias, ts $>$ 2.20, ps $<$ 0.03, and non-specific treatment effect, ts $>$ 3.26, p $<$ 0.01 as found for the total interpretations measure.

not any corporate appointments of the authors or members of their families relating to or in connection with products or companies mentioned in the article or otherwise bearing on the subject matter of the article being submitted. There are not any other pertinent financial relationships of the authors or members of their families, such as consultancies, stock ownership or other equity interests or patent-licensing arrangements to products mentioned in the article being submitted.

Acknowledgments

This work was partially support by the United States - Israel Binational Science Foundation (BSF) for YBH - 2013349.

Appendix A. Comorbidity distribution (percent) of participants diagnosed with other disorders according to DSM-VI beside SAD by group:

Psychiatric Diagnosis	Percent (%)
ABMT:	
No comorbid disorders	47%
Major Depressive Disorder	48%
Generalized Anxiety Disorder	21%
Panic disorder	17%
Agoraphobia	8%
CBM-I:	
No comorbid disorders	50%
Major Depressive Disorder	45%
Generalized Anxiety Disorder	29%
Panic disorder	13%
Agoraphobia	8%
ABMT + CBM-I:	
No comorbid disorders	54%
Major Depressive Disorder	39%
Generalized Anxiety Disorder	26%
Panic disorder	17%
Agoraphobia	13%
Combined Control:	
No comorbid disorders	48%
Major Depressive Disorder	40%
Generalized Anxiety Disorder	28%
Panic disorder	20%
Agoraphobia	12%

*There were no differences between the groups with regards to the presence of comorbid disorders

Appendix B. The dot-probe task

We used a faces-based variant of the dot-probe task (MacLeod, Mathews, & Tata, 1986) following the TAU-NIMH ABMT Initiative protocol (http://people.socsci.tau.ac.il/mu/anxietytrauma/research/). The bias measurement task included 120 trials: 80 threat-neutral and 40 neutral-neutral. The face stimuli were photographs of 20 different individuals (10 male, 10 female) taken from the NimStim stimulus set (Tottenham et al., 2009). Each photograph subtended 45 mm in width and 34 mm in height. In each trial, a fixation cross appeared for 500 ms (ms), followed by a pair of faces appearing for 500 ms. The top photograph was positioned 20 mm from the top edge of the screen with a distance of 14 mm between them. Replacing the faces display a probe (“ < ” or “ > ”) appeared in the location of either the neutral or threatening face.

Participants were instructed to indicate the orientation of the probe by clicking the left or right mouse button. The probe remained on screen until response and then the next trial began. Threatening face location, probe location, and probe type were fully counterbalanced in presentation. Reaction time differences of mean threat-incongruent RT minus mean threat-congruent RT provided a measure of threat-related attention bias, such that positive values indicated bias toward threat. Inaccurate responses, trials with response latencies < 150 ms or > 1200 ms, and trials with response latencies $\pm$ 2.5 SDs from the participant's mean were excluded ($< 2\%$ of all trials, with no group differences).

The ABMT protocol consists of 160 trials (120 threat-neutral and 40 neutral-neutral presentations) with a different set of faces from those used in the assessment task. In the control condition, threat-face location, probe location, and actor were fully counterbalanced in presentation. In the ABMT condition, the target appeared at the neutral-face location in 100% of threat-neutral trials.

Appendix C. Interpretation bias modification training task

Sentence Completion Task (SCT). This task produced an interpretation bias index based on the way participants resolve ambiguous social situations (see Huppert et al., 2007 for full description of the task). Ten sentences related to ambiguous social scenarios with last word missing were presented to the participants on a computer (e.g., *“As you walk to the podium, you notice your heart racing, which means you are ___”*. Participants were asked to generate and type as many responses as came to mind for each sentence. The participant's responses were listed on the computer screen and then they were asked to endorse the response that best completes the sentence. Then, participants coded each of their sentence completions as either positive, negative, or other. Interpretation bias scores were calculated by subtracting the number of positive responses from the number of negative responses, divided by the total number of responses provided by each participant. Positive scores reflect greater negative interpretation bias.

Grammar Decision Task (GDT). The GDT used here is similar to the one used by Moser at al. (2008). Briefly, one hundred sentences with the

last word left out were presented via headphones. Eighty scenarios described experiences within social situations (e.g., *"As you give a speech, you see a person in the crowd smiling, which means that your speech is …")* and were resolved by either a negative (e.g., *"stupid")* or a positive (e.g., *"funny"*) terminal word. The task also included 20 described experiences with nonsocial contexts (e.g., *"You've just started reading a new book that you bought and you find it to be …"*) and were also resolved by either a negative (e.g., *"boring"*) or positive (e.g., *"interesting"*) terminal word. Half of the scenarios of each type were completed with a grammatical terminal word (boring/interesting), while the other half was completed with a non-grammatical terminal word (bore/interest). Participants were asked to determine whether the word completes the sentence grammatically or not via a button press. Interpretation bias was calculated by subtracting mean reaction times to positive social words from mean reaction times of negative social words, within the social trials that terminated with a grammatical word. Positive scores reflect negative interpretation bias and negative score reflects the opposite pattern. **Interpretation bias modification training task.** The CBM-I was administered using a translated variant of the regimen described by Mathews and Mackintosh (2000) and adapted by Murphy et al. (2007). The task included 95 auditory descriptions presented via headphones of ambiguous social scenarios (e.g., *"You've been working for the same company for a number of years. Your boss asks you to give a speech at an upcoming conference and you agree to do it. On the day, you walk up to the podium and you ___"*). To facilitate self-referential processing and help participants imagine themselves immersed in the scenario, the second person 'you' was used throughout the descriptions. Scenario descriptions were identical across the active training and control conditions, but the final sentence that resolved the ambiguity of the scenarios differed. Scenarios in the active training were designed to induce benign or positive interpretations, concluding with information that resolved the scenarios in a positive *("are very steady")* or non-negative *("aren't shaking")* manner. Descriptions in the control condition, not intended to modify interpretation bias, were resolved in a neutral outcome *("he tells you that a couple of other colleagues will also be speaking")*. Descriptions were followed by a yes\\\\\\\\no comprehension question both in the active condition *("were you trembling as you walked to the podium?")* and control condition *("were you the only one from your company giving a speech?")*. These were presented on the computer screen and participants were required to respond using the keyboard. In the active training condition, the correct answers to the questions referred to the benign outcome in a way that encourages formation of positive images of the emotionally ambiguous scenarios (Holmes et al., 2006). In the control condition, the comprehension questions were always neutral and did not contain information about emotional valence. Each trial ended with feedback (*"Correct"* or *"Incorrect"*) presented visually on the computer screen. The task was delivered using Presentation experimental software (http://www.neurobs.com).

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