# Attention Bias Modification Treatment: A Meta-Analysis Toward the Establishment of Novel Treatment for Anxiety

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**Background:** Attention Bias Modification Treatment (ABMT) is a newly emerging, promising treatment for anxiety disorders. Although recent randomized control trials (RCTs) suggest that ABMT reduces anxiety, therapeutic effects have not been summarized quantitatively.

**Methods:** Standard meta-analytic procedures were used to summarize the effect of ABMT on anxiety. With MEDLINE, January 1995 to February 2010, we identified RCTs comparing the effects on anxiety of ABMT and quantified effect sizes with Hedge's *d*.

**Results:** Twelve studies met inclusion criteria, including 467 participants from 10 publications. Attention Bias Modification Treatment produced significantly greater reductions in anxiety than control training, with a medium effect ($d = .61$, $p < .001$). Age and gender did not moderate the effect of ABMT on anxiety, whereas several characteristics of the ABMT training did.

**Conclusions:** Attention Bias Modification Treatment shows promise as a novel treatment for anxiety. Additional RCTs are needed to fully evaluate the degree to which these findings replicate and apply to patients. Future work should consider the precise role for ABMT in the broader anxiety-disorder therapeutic armamentarium.

**Key Words:** Anxiety disorders, attention bias modification treatment, cognitive bias, meta-analysis, novel treatment, psychotherapy

Anxiety disorders affect between 10% and 30% of individuals (1–3), creating significant clinical burden (4). Nevertheless, many affected individuals do not receive treatment (5), and among those who do, many continue to suffer (6,7). Hence, novel treatments are needed.

Selective serotonin reuptake inhibitors (SSRIs) are an established medication treatment. Nevertheless, some patients are reluctant to take SSRIs because of known side-effects or because much remains unknown about their mechanism of action. Particular concerns arise in children (8). Cognitive behavioral therapy (CBT) is an established psychotherapeutic treatment (9). Nevertheless, as with SSRIs, problems arise with this treatment. Many patients do not have access, and the treatment is demanding for some of those who do (10). This is because some aspects of CBT require patients to understand complex concepts and build relationships with a therapist. Finally, not all patients achieve remission with CBT. Thus, data on SSRIs and CBT suggest the need for novel therapies.

Recent work has generated interest in one such treatment: Attention Bias Modification Treatment (ABMT). Attention Bias Modification Treatment arises from the notion that cognitive biases cause pathological anxiety, which also underlies models of CBT. Cognitive behavioral therapy targets a range of biases, on the basis of this idea. It engages patients in explicit integrative processes by way of verbalization, coupled with exposure to feared situations, so that they can interpret or learn that feared objects/situations are safe. Attention Bias Modification Treatment differs from CBT in that its therapeutic action targets a specific bias in attention, extending work implicating threat-related attention bias in anxiety (11).

The focus of ABMT on attention resonates with findings in translational neuroscience. Research in animal models suggests that anxiety-related attention bias emerges from parallel-distributed neural pathways, some of which place relatively limited demands on cortically based networks and associated top-down interpretive processes (8). Human brain imaging research implicates such parallel neural pathways in threat-related attention bias and interindividual differences in anxiety (8,12–14), suggesting that attention bias in anxiety disorders involves both cortical and subcortical perturbations. Forms of CBT targeting top-down interpretive processes might fail to fully target this subcortical component. Compared with the explicit training techniques of CBT, attention perturbation might be more easily shaped by ABMT, with its use of repetitive, computer-based training methods targeting implicit, subcortical processes (8). As such, ABMT might represent a novel treatment that directly targets perturbed neural circuitry function.

In 1995, MacLeod (15) first suggested that ABMT might augment available anxiety-disorder treatments. Training used the now classic dot-probe task, as illustrated in Figure 1. The task requires subjects to identify a nonemotional probe, such as a letter or symbol (e.g., a colon in Figure 1), which can appear in one of two spatial locations, as also shown in Figure 1. Immediately before the probe presentation, a threatening and a nonthreatening stimulus appear simultaneously in two separate locations. Differences in response time to probes appearing behind threatening and nonthreatening stimuli indexes attention bias. For example, in Figure 1A, the probe appears behind the threat-related word, and responses on these trials are expected to be slower for individuals whose attention is captured by threat or has difficulty disengaging from threat to identify the probe's spatial location.

MacLeod *et al.* (16) were the first to show that healthy individuals could be trained to exhibit an attention bias toward threat, with an associated increase in stress reactivity. Since then, other investigators attempted to use and extend this effect to reduce stress reactivity by the way of reducing an attention bias toward threat, for

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Received Apr 29, 2010; revised Jun 22, 2010; accepted Jul 9, 2010.

0006-3223/$36.00
doi:10.1016/j.biopsych.2010.07.021

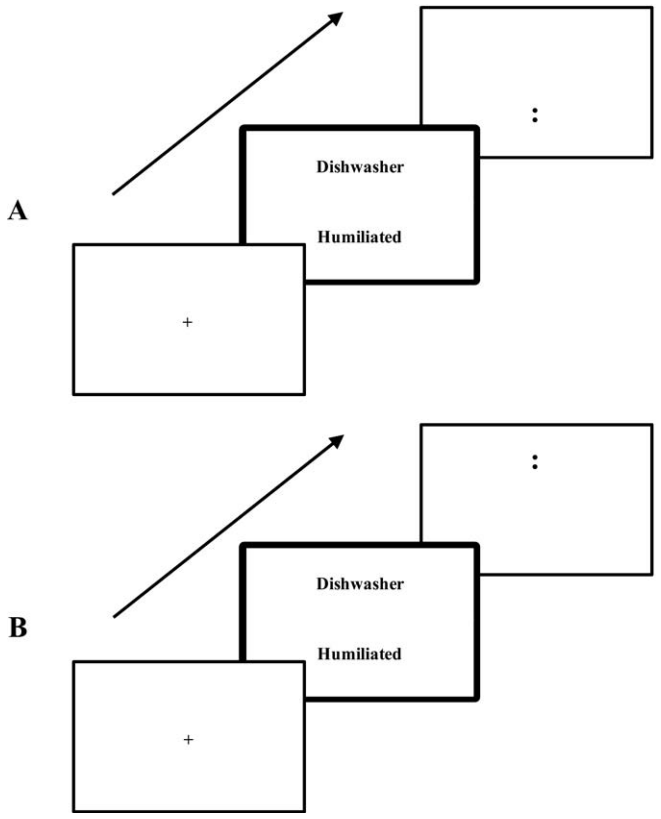


**Figure 1.** Two stimuli differing in emotional valence (threat or nonthreat) are presented at the same time usually for 500 msec and then followed by a probe (i.e., colon). In the classic dot probe task to measure an attention bias, a probe appears shortly after either of the locations that the two stimuli were presented, with the same frequencies (i.e., 50%, trials A and B are equally mixed). By contrast, in the modified dot probe task (i.e., Attention Bias Modification Treatment), a probe always appears in the location of neutral stimulus (i.e., 100%, only B trials).

example with such a modified task composed of trials only from Figure 1B (17–34). Although the number of studies is small, enough data have accumulated to generate questions on the utility of ABMT. The current report provides a quantitative meta-analysis to estimate effects of ABMT on anxiety.

## Methods and Materials

### Literature Search and Selection Criteria

Studies were selected through a computer search of English reports in MEDLINE from January 1995 to February 2010 with the following key words: "attentional training and anxiety;" "attentional retraining and anxiety;" or "attention modification and anxiety." This search was supplemented through a review of reference lists and correspondence with researchers. Studies were selected with five criteria: 1) the study investigated the impact of ABMT on anxiety symptoms in a randomized controlled trial (RCT); 2) use of the dot-probe task; 3) use of a control group; 4) intention of reducing anxiety; and 5) inclusion of at least two anxiety assessment points. These criteria initially were applied by the first author (YH) and then independently reviewed by another (DSP); with disagreements adjudicated by all authors.

The search produced 817 articles, which were reduced to 19 published reports on ABMT treatment. Application of the aforementioned criteria led to the exclusion of nine reports. The first reported study, by MacLeod *et al.* (16), was removed because the experimental manipulation was not designed to reduce anxiety; the assessment points for Experiment 1 were embedded in training trials (i.e., no pre-ABMT assessment); and the control group in Experiment 2 involved training subjects to attend toward negative stimuli, which could enhance rather than reduce anxiety. The lack of an appropriate control group and the use of a design intended to increase anxiety led to exclusion of three other studies: Eldar *et al.* (22), Krebs *et al.* (25), and Browning *et al.* (35). MacLeod *et al.* (33) (Study 2) and Wadlinger and Isaacowitz (30) were excluded, because they did not include an anxiety outcome measure. A final set of two studies was excluded, because neither used a modified dot-probe task (36,37).[1] After these exclusions, 12 sample datasets from 10 published reports served as the target data. Three studies examined the effect of ABMT on anxiety after stress exposure (19,24,29), and one included a 4-month follow-up (32). Otherwise, designs for eight other studies were similar: parallel-group RCT and brief follow-up. Corresponding authors were contacted to facilitate effect size calculations. Study characteristics appear in Table 1.

To investigate sources of heterogeneity, we considered six modifiers: 1) subject characteristics (patients or healthy individuals, anxious or nonanxious); 2) training-target stimulus (faces or words); 3) stimulus location (right or left, top or bottom); 4) stressor exposure (presence or absence of stressor exposure after training); 5) outcome measures (self-reported or clinician assessed); and 6) extent of training (number of trials and sessions).

### Computing Effect Sizes for Primary and Secondary Analyses

We first generated within-group effect sizes for ABMT and control groups. We then generated one effect size/experiment to index the differential effect on anxiety between the two experimental groups. Although some studies collected data on a range of symptoms, our primary goal was to estimate effects on anxiety. As a result, the principal analysis used only anxiety measures. For studies using more than one anxiety scale, effect sizes were computed per scale and averaged. Additional analyses examined effects for specific scales. Cohen's *q* (38) (pp. 109–143) indexed effect sizes.

Standard software (Meta-Analysis Programs, version 5.3 [39] and DSTAT [40]) was used. The *q* statistic is not a simple function of the difference between two effect sizes (*d*), because the same difference between effect sizes can result in different outcomes, depending on where along the *d* scale this difference occurs. To address this potential problem, the effect size *d* can be converted to an *r* statistic. Then, the *r* statistic can be transformed with Fisher's *z* ($z = 1/2 \log_e + [1r/1 - r]$) to generate the *q* statistic, which is the difference between Fisher *z* scores across the experimental and control groups. Cohen applies Fisher's *z* because intervals along the scale remain equal. As such, differences of the same magnitude can be detected, regardless of the sizes of the *z* statistic in the experimental and control groups. According to Cohen (38) (pp. 109–143), *q* reflects an effect size index comparable to the "*d* family" of effects, and it can be converted to *d* by transforming *q* to *r* and then back to *d*. Given the frequent reliance on other meta-analyses on this "d-family" of effect sizes, the unbiased estimator *d* (Hedge's *d*) was used to index the between-group effect size of ABMT versus control on anxiety and other symptoms. This *d* index was selected because it corrects for the bias in estimation of population effect size (41). Positive *d* values indicate greater improvement of outcome mea-

[1] Dandeneau *et al.* (36,37) trained biased attention in healthy individuals using a visual search task. This procedure has also produced a promising effect in reducing anxiety. However, this procedure is quite distinct from a modified dot-probe task and thus we decided not to include these results in the meta-analyses.

sures in ABMT compared with control. To estimate the overall effect size across studies, the weighted grand mean score was used for the ABMT and control groups.

To evaluate the file-drawer problem, we calculated a fail-safe *N* for all effect-size subsets, thereby estimating the number of unpublished studies with effect sizes of zero needed to reduce the aggregated effect below significance (42). A fail-safe *N* was not computed for effect-size aggregations producing nonsignificant results.

The overall effect size of changes in attention bias between pre- and post-ABMT was estimated in the same way as changes in anxiety-related scales. Attention bias toward negative stimuli is usually given as the subtraction of mean response latencies to targets in the location of neutral stimuli from that of negative stimuli. Of 12 studies, 2 did not measure change in attention bias (24,32). From the remaining 10, we obtained data from 7 studies, either through published results or correspondence with authors. We also computed Spearman's correlations to examine association between changes in attention bias and changes in anxiety pre- to post-ABMT.

Our secondary goal was to test for effects of moderators on anxiety score changes as well as attention bias changes. These effects were estimated with two procedures. First, for categorical measures including the subject characteristics, training-target stimulus, stimulus location, stressor exposure, and outcome measures, weighted mean effect sizes were generated from different levels of a moderator and then compared with Qb tests (40). The Qb statistic is a between-group homogeneity test derived from Hedges and Olkin (41) that is analogous to a two-category pair-wise comparison. Second, moderation by continuous measures including the extent of training, age, and gender was tested with weighted least-squares analysis (effects weighted by sample size). For such analysis, the adjustment to the standard error recommended by Hedges (43) was applied, and 95% confidence intervals (CIs) for the standardized regression coefficients were constructed. All tests are two-tailed with $\alpha$ set at .05.

## Results

Thirty-nine effect sizes were computed with the 12 datasets from the 10 published reports. Study characteristics and 39 effect sizes/scale or assessment point are provided in Table 1. We generated one averaged effect size for each study, on the basis of these effect sizes, and then estimated the overall effect size across studies as well as potential effects of categorical moderator variables. As a result, each of the 12 studies only contributed one effect size to these main analyses. These results appear in Table 2.

The primary analysis revealed a significant benefit of ABMT on anxiety measures, with a medium effect size ($d = .61$, $p < .001$, 95% CI = .42–.81). This result was also supported by a relatively large fail-safe $n = 54$. Figure 2 shows standard differences in means and CIs/study. This figure suggests the presence of three possible outliers with particularly large effects (28,32). When the three studies are removed, the overall effect size is reduced but remains medium, $d = .36$ ($k = 9$, $n = 372$, $p < .001$, 95% CI = .15–.57; Qw = 12.52, $p = .13$) with a fail-safe $n = 7$.

Secondary analyses examined potential moderators (Table 2). When participants were divided into patients and healthy subjects, *d* was .78 ($p < .001$, 95% CI = .38–1.20) in patients, a medium-to-large effect size, and .48 in nonpatients ($p < .001$; 95% CI = .27–.70). Nevertheless, $Q_b$ is nonsignificant. In the three studies employing stress exposure after ABMT, *d* was .77 ($p < .001$, 95% CI = .47–1.07), indicating a buffering effect of ABMT against stressor exposure. The *d* on trait-anxiety scales was significantly higher than that on state-anxiety scales ($d = 1.06$, $p < .001$, 95% CI = .75–1.37 vs. d = .41, $p < .001$, 95% CI = .17–.65; $Q_b = 13.35$, $p < .001$).

In categorical models, ABMT training procedures emerged as moderators. Here, studies using verbal target stimuli (words) generated a larger effect than those using face stimuli ($d = 1.29$, $p < .001$, 95% CI = .92–1.67 vs. $d = .37$, $p < .005$, 95% CI = .14–.60; $Q_b = 18.19$, $p < .001$). Similarly, studies using target stimuli presented in a top-bottom formation yielded a significant effect size, although those presented in a side-by-side formation did not ($d = .79$, $p < .001$, 95% CI = .56–1.03 vs. $d = .21$, $p = .12$, 95% CI = −.14–.57; $Q_b = 8.06$, $p < .01$). For continuous models, regression analysis considered age, gender, and extent of training; no moderators predicted ABMT effect on anxiety.

As with analyses treating anxiety symptoms as an outcome, analyses estimating the effect of ABMT on attention bias also yielded a significant effect, in this instance with a large overall effect size ($d = 1.16$, $p < .001$, 95% CI = .82–1.50). Table 3 presents results from categorical moderator analyses. Similar to the result for anxiety symptoms, studies using words generated a significant effect, although those using face stimuli did not ($d = 2.68$, $p < .001$, 95% CI = 2.13–3.23 vs. $d = .30$, $p = .08$; $Q_b = 46.32$, $p < .001$). Also, studies using target stimuli presented in a top-bottom formation yielded a larger effect than those presented in a side-by-side formation ($d = 2.22$, $p < .001$, 95% CI = 1.65–2.80 vs. $d = .62$, $p < .01$, 95% CI = .20–1.04; $Q_b = 19.37$, $p < .001$). Finally, for continuous moderators, number of sessions significantly predicted effect of ABMT on attention bias ($\beta = 1.18$, $t = 37.33$, $p < .05$, 95% CI = .54–1.10). Moreover, the correlation between magnitude of attention bias change and anxiety change across studies was large although of trend level significance (Figure 3).

## Discussion

This review of 12 RCTs in 467 participants finds a statistically significant medium effect of ABMT on anxiety with a relatively large fail-safe calculation. Thus, a significant beneficial effect still would be present even if 54 unpublished studies had produced null results. Given the early stage of research on ABMT, no head-to-head trials compare ABMT with established interventions. Indeed, the effect of ABMT on anxiety seems smaller than for SSRIs and CBT, which typically produce large effects (6–10).

In one sense, a difference in effect-size magnitude between ABMT and SSRIs or CBT might seem unsurprising. Attention Bias Modification Treatment is a limited, focused intervention, in terms of clinician involvement. As a result, contributions to efficacy from staff contact, other nonspecific factors, and expectancy are likely to be small in ABMT. In addition, SSRIs or CBT trials exclusively focused on clinical populations, whereas the ABMT RCTs analyzed in the present report are mostly of nonclinical or subclinical populations. Upon isolation of the ABMT RCTs conducted in clinical settings and with clinical samples (20,21,32), the effect sizes are comparable to those observed for CBT and SSRIs. Moreover, CBT often has been compared with conditions, such as wait-list control, that are poorly matched to the active treatment, in terms of nonspecific treatment factors and expectancy (9,10). The studies of ABMT typically involve tight experimental control in which all participants are exposed to the exact same cue stimuli, number of training/placebo trials, number of treatment sessions, and overall procedures. As a result, although the current data suggest that ABMT is probably inferior to SSRIs and CBT, they also suggest a possible applicability of ABMT to the overall management of anxiety.

The current analysis also showed a large effect size of ABMT in reducing threat-related attention bias, indicating that, overall, the attention training protocols are effective. The correlation between effect sizes on attention bias change scores and on anxiety change

**Table 1.** Study Characteristics and Mean Effect Sizes (Hedge's *d*)

| Study[a] | Population | No. of Subjects | | Mean Age of Subjects | Female % of Subjects | Blind (Double/ Semi) | ABMT Condition | |
|---|---|---|---|---|---|---|---|---|
| | | ABMT Group | Control Group[b] | | | | Pair of Target Stimuli (Probe Apperance % After Neutral/Happy Stimulus Location) | Stimulus Duration (msec) |
| Amir *et al.* (21) | Patients with GSP | 22 | 26 | 29.35 | 59 | Double | Neutral-Disgust Faces (100%) | 500 |
| Eldar & Bar-Haim (23) | Low anxious students | 15 | 15 | 22.64 | 73 | Semi | Neutral-Angry Faces (100%) | 500 |
| | High anxious students | 15 | 15 | 22.72 | 87 | Semi | Neutral-Angry Faces (100%) | 500 |
| Klumpp & Amir (24) | High anxious students | 31 | 22 | 19.55 | 40 | Double | Neutral-Disgust Faces (100%) | 500 |
| Schmidt *et al.* (32) | Patients with GAD | 18 | 18 | 23 | 44 | Double | Neutral-Disgust Faces (100%) | 500 |
| See *et al.* (29) | Nonselected students | 22 | 18 | 21.55 | 60 | Semi | Neutral-Negative Words (100%) | 500 |
| Hazen *et al.* (18) | High anxious students | 12 | 12 | 19.3 | 65 | Double | Neutral-Threat Words (100%) | 500 |
| Amir *et al.* (20) | Patients with GAD | 14 | 15 | 25.5 | 48 | Double | Neutral-Threat Words (100%) | 500 |
| Amir *et al.* (19) | High anxious adults | 47 | 47 | 19 | 51 | Double | Neutral-Disgust Faces (100%) | 500 |
| Li *et al.* (26) | High anxious adults | 12 | 12 | 20.54 | 42 | Semi | Positive-Negative Faces (100%) | 500 |
| Mathews & MacLeod (28) Exp7 | High anxious adults | 15 | 14 | N/P | 55 | Semi | Neutral-Negative Words (100%) | 16 (as a mask, 50%) + 500 (50%) |
| Mathews & MacLeod (28) Exp8 | High anxious adults | 16 | 14 | N/P | 57 | Semi | Neutral-Negative Words (100%) | 16 (as a mask, 50%) + 500 (50%) |

GSP, generalized social phobia; STAI-T, state-trait anxiety inventory-trait; LSAS, Liebowitz social anxiety scale (clinician-administered); SPAI, social phobia and anxiety scale; BDI-II, Beck depression inventory-II; HAM-D, Hamilton rating scale of depression (clinician-administered); SDS, Sheelan disability scale; STAI-S, state-trait anxiety inventory-state; GAD, generalized anxiety disorder; BSPS, brief social phobia scale (clinician-administered); PSWQ, Penn state worry questionnaire; WDQ, worry domains questionnaire; HRSA, Hamilton rating scale of anxiety (clinician-administered); SIAS, social interaction anxiety scale; SPS, social phobia scale; FNES, fear of negative evaluation scale; N/P, not provided.

[a]Definition of categories for *d*: no effect (0−.2), low effect (.2−.5), medium effect (.5−.8), and high effect (>.8).

[b]Control groups got through a normal dot-probe task (i.e., probe appears in either location of two different stimuli with equal frequency).

[c]Significant at $p < .001$.

[d]Significant at $p < .01$.

[e]Significant at $p < .05$.

scores was also large, suggesting that ABMT reduces anxiety via effects on attention bias. However, more studies are needed to reveal the mechanism underlying the effects of ABMT on anxiety.

Benefits of ABMT seem to emerge under various experimental conditions, in diverse samples, assessed with a variety of clinical response measures. This conclusion is supported by the analyses of heterogeneity in response (Table 2). Attention Bias Modification Treatment produced a greater effect on trait than state anxiety measures. This suggests that ABMT might target the more enduring aspects of anxiety. Similarly, procedural factors also predicted response: the nature of stimuli and their location moderated outcome. Specifically, studies that used a Top-Bottom stimulus presentation achieved better effects than those using a Side-by-Side presentation, as did studies that used words relative to pictures. Interestingly, extent of training moderated effects on attention bias but not anxiety symptoms. More work is needed to characterize the nature and robustness of these influences. In particular, given the relatively small number of studies, negative findings should be viewed particularly cautiously. However, research on ABMT as an evidence-based therapy remains immature, and well-controlled clinical RCTs are costly. As a result, future research might be shaped by results from these moderator analyses.

These data might shape therapeutics. If future RCTs yield positive results, ABMT and similar computer-based training regimens

**Table 1.** Continued

| ABMT Condition | | | | | Hedge's *d* | | |
|---|---|---|---|---|---|---|---|
| Stimulus Location (Left-Right/ Top-Bottom) | No. of Training Trials | No. of Sessions (Days) | Type of Stressor | Outcome Measures | Post-Training | Post-Stressor | Follow-Up (4 Months) |
| Top-Bottom | 160 | 8 | None | STAI-T | −.10 | — | — |
| | | | | LSAS | .43 | — | — |
| | | | | SPAI | −.33 | — | — |
| | | | | BDI-II | 1.12[c] | — | — |
| | | | | HAM-D | .58 | — | — |
| | | | | SDS | .89[d] | — | — |
| Left-Right | 480 | 1 | None | STAI-S | .01 | — | — |
| Left-Right | 480 | 1 | None | STAI-S | −.34 | — | — |
| Top-Bottom | 160 | 1 | Speech Task | STAI-S | −.06 | .36 | — |
| Top-Bottom | 160 | 8 | None | BSPS | 1.22[d] | — | 1.91[c] |
| | | | | LSAS | 1.84[c] | — | 2.68[c] |
| | | | | SPAI | 1.46[c] | — | 1.98[c] |
| | | | | STAI-T | 3.98[c] | — | 8.68[c] |
| | | | | BDI-II | 1.12[d] | — | 1.77[c] |
| Left-Right | 192 | 15 | Moving to a foreign country | STAI-S | — | .60 | — |
| | | | | STAI-T | — | .79[e] | — |
| Top-Bottom | 1080 | 5 | None | PSWQ | 1.10 | — | — |
| | | | | STAI-T | .79 | — | — |
| | | | | BDI | 1.00 | — | — |
| Top-Bottom | 280 | 8 | None | STAI-T | 1.06[d] | — | — |
| | | | | STAI-S | 1.63[c] | — | — |
| | | | | BDI-II | .09 | — | — |
| | | | | WDQ | .72 | — | — |
| | | | | PSWQ | .44 | — | — |
| | | | | HRSA | .99[e] | — | — |
| | | | | HAM-D | .43 | — | — |
| Top-Bottom | 128 | 1 | Public speaking | STAI-S | .11 | 1.07[c] | — |
| Left-Right | 480 | 7 | None | SIAS | .94[e] | — | — |
| | | | | SPS | −.18 | — | — |
| | | | | FNES | .48 | — | — |
| Top-Bottom | 750 | 10 | Exam | STAI-T | 5.76[c] | — | — |
| Top-Bottom | 750 | 8 | None | STAI-T | 2.60[c] | — | — |

might be viable stand-alone treatments in patients who do not have access to CBT or SSRI treatment or who are either unwilling or incapable of undergoing such treatment. Attention Bias Modification Treatment might also serve as a viable alternative for treatment of children with anxiety disorders. However, only three of the reviewed studies of ABMT were conducted in anxiety-disorder patients, and none examined children. Although biased allocation of attention represents an important correlate of anxiety, it is only one of many cognitive biases (44); differences in attention bias between healthy and anxious subjects are only moderate in size (11); and a significant group of anxiety-disorder patients exhibit no biasing of attention. Future ABMT studies might consider the magnitude and nature of the biases of patients, adopting a personalized medicine approach, before prescribing training protocols (see also Bar-Haim) (34).

Future studies could also test the utility of ABMT as an adjunct to SSRIs or CBT, both of which show strong effects but fail to produce remission in many patients. Although SSRIs or CBT target a broad array of biases, ABMT provides a more focused, targeted approach that might augment the impact of the other treatments on attention bias. Similarly, the finding in the current meta-analysis that verbal stimuli seem more powerful than pictures when attempting to alter anxiety might implicate personalized information as a target for training. This, in turn, might provide targets for other computerized approaches, focused on various other biases to be altered by novel treatments in anxiety. Taken together, such views resonate with those emerging from neuroscience, emphasizing delineation of the unique substrates that underlie distinct forms of learning (45). In fact, beyond the clinical relevance of the findings reported in the current meta-analysis, the findings reported here also might usefully shape theoretical views on anxiety disorder pathophysiology and treatment.

In anxious patients, therapeutic goal-based learning might be achieved through deliberative teaching, verbal instruction, and guided experiences with threats. Each of these learning tasks is targeted by CBT. Attention Bias Modification Treatment, by contrast, represents a focused attempt to teach patients one specific skill, attention control. Available neuroscience literature suggests that attention control abilities reflect competencies in specific, dedicated neural architecture. Thus, brain imaging studies on individual differences in anxiety implicate perturbed subcortical engagement to threats presented relatively rapidly or outside the focus of

**Table 2.** Tests of Categorical Models of Study Characteristics in Anxiety Score Changes

| Categorical Variables and Relevant Contrasts | *k* | *n* | *d*+[a] | (95% CI) | Fail-Safe *n* | $Q_w$ | $Q_b$ |
|---|---|---|---|---|---|---|---|
| All Within Study Effect Sizes Averaged | 12 | 467 | .61[b] | (.42–.81) | 53.99 | 91.28[b] | |
| Type of Participants | | | | | | | |
| 1. Patient | 3 | 113 | .78[b] | (.38–1.20) | 15.04 | 25.58[b] | |
| 2. Healthy subjects | 9 | 384 | .48[b] | (.27–.70) | 39.32 | 70.57[b] | |
| a. High anxious | 7 | 284 | .62[b] | (.36–.87) | 38.92 | 61.95[b] | |
| b. Non-High anxious | 2 | 70 | .36[ns] | (−.29–1.02) | 1.64 | 1.87[ns] | |
| Contrast 1 (1 vs. 2) | | | | | | | .94[ns] |
| Contrast 2 (2a vs. 2b) | | | | | | | .93[ns] |
| Contrast 3 (1 vs. 2a) | | | | | | | .49[ns] |
| Contrast 4 (1 vs. 2b) | | | | | | | 1.86[ns] |
| Contrast 5 (1+2a vs. 2b) | | | | | | | 1.38[ns] |
| Type of Outcome Measures | | | | | | | |
| 1 Self-reported anxiety (state)[c] | 10 | 408 | .41[b] | (.21–.61) | 12.27 | 28.06[b] | |
| 2 Spielberger State Anxiety | 6 | 276 | .41[b] | (.17–.65) | 6.37 | 14.72[d] | |
| 3 Self-reported anxiety (trait) = Spielberger Trait Anxiety | 7 | 236 | 1.06[b] | (.75–1.37) | 73.49 | 97.20[b] | — |
| 4 Social anxiety[e] | 4 | 219 | .33[f] | (.06–.60) | 2.55 | 3.21[ns] | |
| 5 Generalized anxiety[g] | 2 | 53 | .93[b] | (.36–1.50) | 7.28 | .93[ns] | |
| 6 Self-reported anxiety[h] | 12 | 467 | .59[b] | (.39–.77) | 58.79 | 107.33[b] | |
| 7 Self-reported depression[i] | 4 | 137 | .90[b] | (.55–1.26) | 13.89 | 7.11[ns] | |
| 8 Self-reported measures[j] | 12 | 467 | .63[b] | (.44–.83) | 55.95 | 91.75[b] | |
| 9 Clinician-assessed anxiety[k] | 3 | 113 | .92[b] | (.53–1.32) | 12.73 | 8.54[d] | |
| 10 Clinician-assessed depression[l] | 2 | 77 | .51[d] | (.06–.97) | 3.12 | .10[ns] | |
| 11 Clinician-assessed measures[m] | 3 | 113 | .95[b] | (.55–1.35) | 12.48 | 6.98[d] | |
| 12 All anxiety measures | 12 | 467 | .61[b] | (.42–.81) | 53.99 | 91.28[b] | |
| 13 All depression measures | 4 | 137 | .85[b] | (.50–1.21) | 13.15 | 4.92[ns] | |
| Contrast (2 vs. 3)[n] | | | | | | | 13.35[b] |
| Contrast (4 vs. 5) | | | | | | | 3.51[ns] |
| Contrast (12 vs. 13)[o] | | | | | | | 1.83[ns] |
| Type of Training Target Stimulus | | | | | | | |
| 1. Face | 7 | 315 | .37[f] | (.14–.60) | 9.79 | 34.37[b] | |
| 2. Word | 5 | 152 | 1.29[b] | (.92–1.67) | 45.79 | 38.71[b] | |
| Contrast 1 (1 vs. 2) | | | | | | | 18.19[b] |
| Type of Stimulus Location | | | | | | | |
| 1. Top-Bottom | 8 | 343 | .79[b] | (.56–1.03) | 55.50 | 78.48[b] | |
| 2. Left-Right | 4 | 124 | .21[ns] | (−.14–.57) | .04 | 4.74[ns] | |
| Contrast 1 (1 vs. 2) | | | | | | | 8.06[f] |
| Assessment Followed by Stressor Exposure After Attention Bias Modification Treatment | 3 | 187 | .77[b] | (.47–1.07) | 8.05 | 4.01[ns] | |

*k*, number of effect sizes; *d*+, effect sizes weighted by the reciprocal of their variances; CI, confidence interval; fail-safe *n*, the number studies with an effect size of ".00" needed to attenuate the average effect size below significance; $Q_w$, test of within-category homogeneity; $Q_b$, test of between-category homogeneity analogous to a pairwise comparison; other abbreviations as in Table 1.

[a]Hedge's *d*. Definition of categories for *d*: no effect (0–.2), low effect (.2–.5), medium effect (.5–.8), and high effect (> .8).

[b]Significant at $p < .001$.

[c]Self-reported anxiety (state): STAI-S, BSPS, LSAS, SPAI, FNES, PSWQ, WDQ, HRSA, SPS, SIAS, SPQ.

[d]Significant at $p < .05$.

[e]Social anxiety includes Amir *et al.* (21): GSP, Klumpp and Amir (24): mild level social anxiety by LSAS, Amir *et al.* (19): high level social anxiety by LSAS, and Li *et al.* (26): social interaction anxiety by SIAS.

[f]Significant at $p < .01$.

[g]Generalized anxiety includes Amir *et al.* (20): GAD and Hazen *et al.* (18): pathological worry by PSWQ.

[h]Self-reported anxiety combines the self-reported anxiety (state) and the self-reported anxiety (trait).

[i]Self-reported depression: BDI or BDI-II.

[j]Self-reported measures includes all self-reported measures whether they are for assessing anxiety or depression.

[k]Clinician-assessed anxiety includes: BSPS, LSAS, HRSA.

[l]Clinician-assessed depression: HAM-D.

[m]Clinician-assessed measures: BSPS, LSAS, HRSA, HAM-D.

[n]In the $Q_b$ comparison between STAI-S and STAI-T, two sets of data from Amir *et al.* (20) and See *et al.* (29), which have effect sizes on both measures, were excluded because $Q_b$ analysis does not allow an overlap of data from the same sample across groups.

[o]In the $Q_b$ comparison between All anxiety measures and All depression measures, four studies that have effect sizes on both (Amir *et al.* [20]; Schmidt *et al.* [32]; Hazen *et al.* [18]; Amir *et al.* [21]) were excluded because of the reason that $Q_b$ analysis does not allow an overlap of data from the same sample across groups.

attention (12–14). Prior work on other forms of learning, such as motor skill development, suggest that abilities moderated by subcortical pathways, such as habitual responses, might be most efficiently shaped through repeated exposures to specific, focused tasks, as occurs in ABMT, even without verbal instruction or deliberative teaching (8,46). By contrast, attention control also is likely to

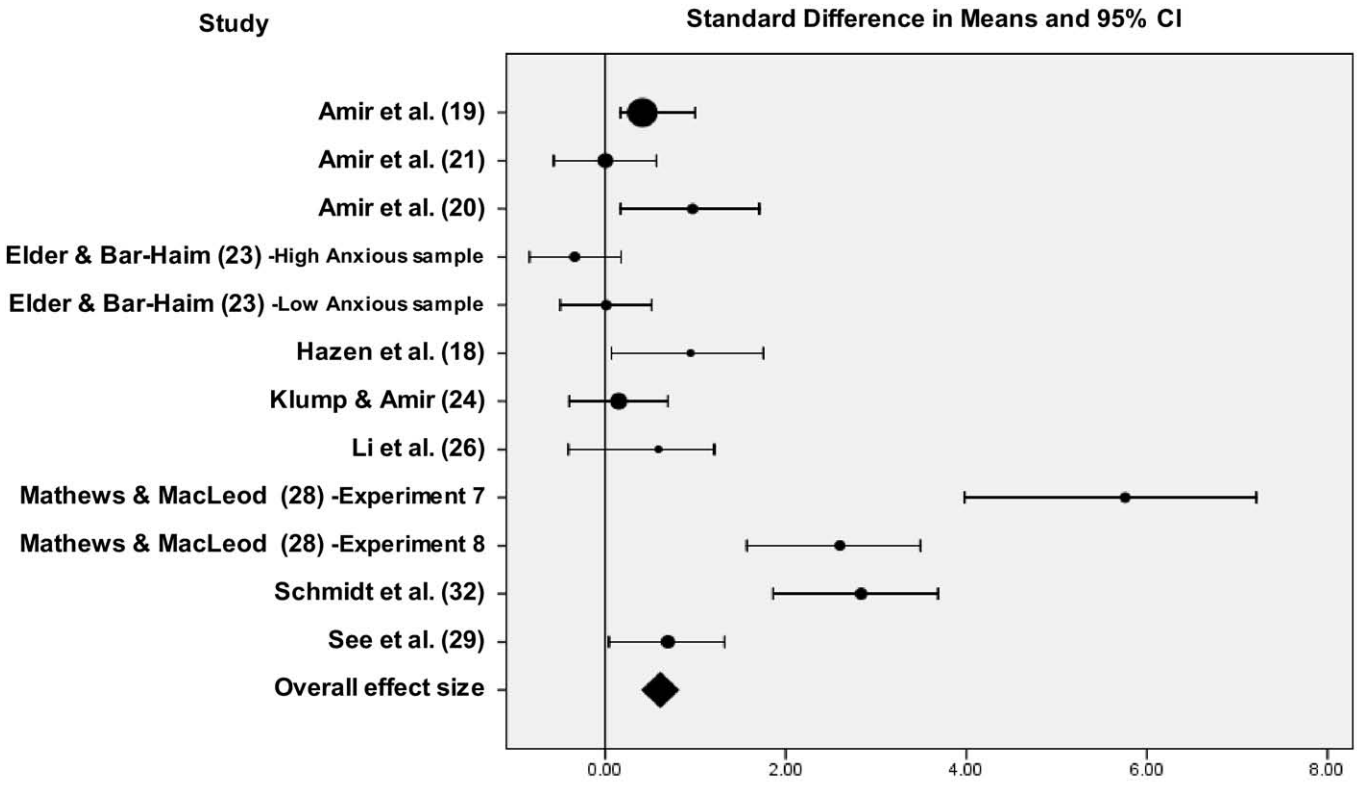


**Figure 2.** Size of round circle reflects sample size. CI, confidence interval.

be shaped by multiple, convergent neural pathways—much like in motor learning (46). In the case of ABMT, available research implicates lateral expanses of prefrontal cortex in the control of attention (8). The only imaging study to examine the effect of ABMT found that, consistent with these observational data, training altered lateral frontal regions in healthy individuals in tandem with attention biases (35). This suggests that both frontal-cortical and subcortical circuitry might be targeted by ABMT.

For various reasons, the review generates only tentative conclusions. Perhaps most importantly, the review is based in a relatively small number of studies, containing relatively few patients with anxiety disorders, performed by a limited number of research groups. Moreover, the available data, as illustrated by an asymmetrical funnel plot and variable effect sizes across the 12 experiments, suggest heterogeneity in treatment response and possibly some degree of outliers, although findings remained significant albeit weakened when the three findings with the strongest results were removed. Such patterns are not unusual in early research on prom-

**Table 3.** Tests of Categorical Models of Study Characteristics in Attention Bias Changes

| Categorical Variables and Relevant Contrasts | *k* | *n* | *d*+[a] | (95% CI) | Fail-safe *n* | $Q_w$ | $Q_b$ |
|---|---|---|---|---|---|---|---|
| All Within Study Effect Sizes Averaged | 7 | 207 | 1.16[b] | (.82–1.50) | 78.11 | 98.95[b] | |
| Type of Participants | | | | | | | |
| 1. Patient | 0 | — | — | — | — | — | — |
| 2. Healthy subjects | 7 | 207 | 1.16[b] | (.82–1.50) | 78.11 | 98.95[b] | |
| a. High anxious | 5 | 137 | 1.27[b] | (.88–1.67) | 36.48 | 29.81[b] | |
| b. Non-High anxious | 2 | 70 | .84[b] | (.16–1.51) | 43.16 | 65.40[b] | |
| Contrast 1 (2a vs. 2b) | | | | | | | .87[ns] |
| Type of Training Target Stimulus | | | | | | | |
| 1. Face | 3 | 84 | .30[ns] | (−.13–.74) | 1.57 | 1.70[ns] | |
| 2. Word | 4 | 123 | 2.68[b] | (2.13–3.23) | 77.53 | 50.94[b] | |
| Contrast 1 (1 vs. 2) | | | | | | | 46.32[b] |
| Type of Stimulus Location | | | | | | | |
| 1. Top-Bottom | 3 | 83 | 2.22[b] | (1.65–2.80) | 34.03 | 12.48[c] | |
| 2. Left-Right | 4 | 124 | .62[c] | (.20–1.04) | 44.99 | 67.10[b] | |
| Contrast 1 (1 vs. 2) | | | | | | | 19.37[b] |

Abbreviations as in Tables 1 and 2.
[a]Hedge's *d*. Definition of categories for *d*: no effect (0–.2), low effect (.2–.5), medium effect (.5–.8), and high effect (> .8).
[b]Significant at $p < .001$.
[c]Significant at $p < .01$.

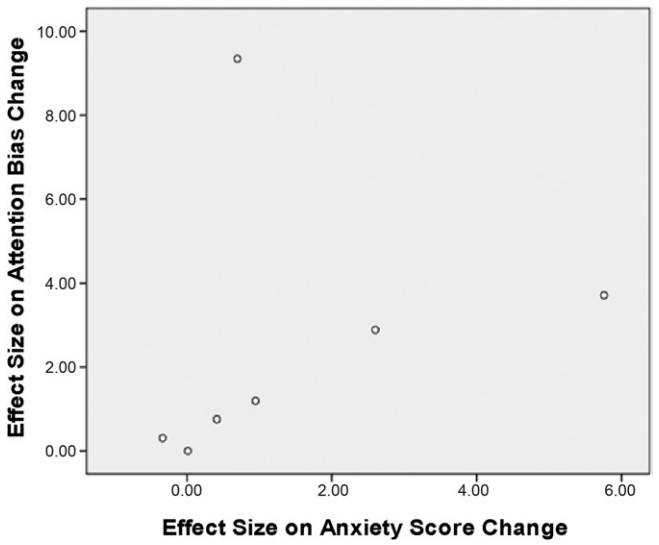


**Figure 3.** Scatterplot for effect sizes of anxiety score changes and attention bias changes per study ($k = 7$). Spearman's $r = .75$, $p = .052$.

ising novel treatments. Given the promising nature of these early results, the next few years might herald a growing series of RCTs evaluating ABMT as a treatment for anxiety disorders.

In closing, this meta-analysis indicates that ABMT shows promise as a novel treatment for anxiety disorders. These results emerge from an initial, small series of RCTs demonstrating greater benefits on anxiety from ABMT, relative to control-training regimens. Reflecting a translational approach, the ideas for ABMT emerge from a melding of cognitive and neuroscience theory over the past 20 years. These ideas generate novel procedures that might enhance currently available treatments focused on perturbed cognition. Given the role for perturbed cognition in many common, impairing psychiatric disorders, such an approach in the anxiety disorders might serve as a guide for developing other novel learning-based therapies in a range of conditions.

*Yuko Hakamata was a visiting fellow in the National Institute of Mental Health from 2009 to 2010. The stipend was supported by the Japan Society for the Promotion of Science. Sincere appreciation is extended to Dr. Yoshiharu Kim, Dr. Tetsuya Suhara, Dr. Haruhiko Shimoyama, Dr. Toshiya Inada, Dr. Yutaka Matsuoka, Dr. Masatoshi Inagaki, Dr. Kiyoto Kasai, Dr. Robert B. Innis, and Dr. Danny Pine for their help and support in this matter.*

*All authors report no biomedical financial interests or potential conflicts of interest.*

*Supplementary material cited in this article is available online.*

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