Published in final edited form as:

Cognit Ther Res. 2016 October ; 40(5): 661–671. doi:10.1007/s10608-016-9781-1.

A Pilot Study of an Adaptive, Idiographic, and Multi-Component Attention Bias Modification Program for Social Anxiety Disorder

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Abstract

An attentional bias toward threat may be one mechanism underlying clinical anxiety. Attention bias modification (ABM) aims to reduce symptoms of anxiety disorders by directly modifying this deficit. However, existing ABM training programs have not consistently modified attentional bias and may not reflect optimal learning needs of participants (i.e., lack of explicit instruction, training goal unclear to participants, lack of feedback, non-adaptive, inability to differentiate or target different components of attentional bias). In the current study, we introduce a new adaptive ABM program (AABM) and test its feasibility in individuals with social anxiety disorder. We report task characteristics and preliminary evidence that this task consistently modifies attentional bias and that changes in attentional bias (but not number of trials) correlate with the level of symptom reduction. These results suggest that AABM may be a targeted method for the next generation of studies examining the utility of attention training.

Keywords

Social Anxiety; Cognitive Bias Modification; Attentional Bias; Attention Bias Modification

Attention bias modification (ABM) has recently emerged as a mechanism-driven treatment for anxiety disorders (for reviews see MacLeod & Clarke, 2015; Kuckertz & Amir, 2015). Indeed, a recent PsycINFO search of “attention bias modification/attention training/attention modification” yielded 183 peer-reviewed studies within the past five years alone. Five meta-analyses suggest that ABM results in significant reductions in anxiety symptoms (Beard, Sawyer, & Hofmann, 2012; Hakamata et al., 2010; Hallion & Ruscio, 2011; Linetzky, Pergamin-Hight, Pine, & Bar-Haim, 2015; Mogoa e, David, & Koster, 2014). However, there have also been a number of failures to replicate both a reduction in attentional bias, and in turn, a reduction in symptoms (for a review see Clarke, Notebaert, & MacLeod, 2014).

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Conflict of Interest: The first author is part owner of a company that market anxiety relief products. The second and third authors declare that they have no conflicts of interest.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent: Informed consent was obtained from all individual participants included in the study.

Indeed, as recent reviews have pointed out, a more consistent pattern of findings is that studies that have successfully manipulated attentional bias have resulted in subsequent symptom reduction, whereas studies that have not successfully manipulated attentional bias have also not resulted in symptom change (Clarke et al., 2014; Kuckertz & Amir, 2015; MacLeod & Clarke, 2015). As ABM is predicated on the hypothesis that change in attentional bias is a necessary condition for its efficacy, these results are fully consistent with the theoretical framework of ABM.

Thus, the most fundamental question facing the field now is: How do we ensure that the next generation of ABM programs consistently change attentional bias? Several factors may be related to the consistency and effective manipulation of attentional bias in ABM (Kuckertz & Amir, 2015). First, it may be beneficial to give participants explicit instructions regarding the contingencies in the task (i.e., informing participants that the probe will always appear in the opposite screen location as the threat word or in the same screen location as the positive word). Indeed, several studies have examined the effect of explicit instructions on ABM (Krebs, Hirsch, & Mathew, 2010; Nishiguchi, Takano, & Tanno, 2015). These studies suggest that explicit instructions can lead to more effective manipulation of attentional bias. However, these studies provided instructions only at the beginning of the experiment. It is not clear whether a one-time instruction provides the maximal effects of instructions as ABM procedures comprise hundreds of trials and it is likely that the participants soon forget the instructions. We therefore implement instructions at every trial (e.g., providing a color cue that informs the participant about the location of the probe in relationship to the location of the preceding emotional stimuli and pop up windows through the task) to enhance the effect of instruction on ABM consistency.

Indeed, research examining the relationship between conscious performance goals and task performance may shed light on methods of improving ABM (Locke, 1996). For example, explicit goals lead to more regulated performance (Locke & Latham, 2006), and goal setting is most effective when there is feedback showing progress in relation to the goal. Similarly, research suggests that performance feedback boosts motivation in brain-training games (e.g., Burgers, Eden, van Engelenburg, & Buningh, 2015). To our knowledge, previous studies have neither informed participants about the specific goal of ABM (i.e., modify attentional bias) at each trial, nor have they provided feedback showing change of attentional bias (e.g., moving up in levels, i.e. changes in attentional bias).

Second, most ABM studies have used tasks (e.g., probe detection task: MacLeod, Mathews, & Tata, 1986) that do not differentiate between training attention away from negative information and training attention toward benign (i.e., neutral or positive) information. For example, in the typical dot probe task, the two sources of information (i.e., negative and neutral words) are presented on the screen at the same time. Thus, it is not possible to differentiate speeded attention toward benign information from slowing of attention disengagement, limiting the theoretical specificity of the task. Other ABM tasks, e.g. spatial cueing tasks, present only one type of information (e.g., negative, or neutral), which may allow for the precise identification and manipulation of ABM mechanisms (e.g., Baert, De Raedt, Schacht, & Koster, 2010).

Third, changes in general attentional control, rather than changes in valence-specific attentional bias, may also be responsible for the effects of ABM (Heeren, Mogoa e, McNally, Schmitz, & Phillipot, 2015). However, changes in attentional control and in attentional bias are often confounded by overlapping measurement issues. Although these constructs are related, attentional control refers to the ability to control one's attention in general (i.e., regardless of the emotional valence of stimuli) whereas attentional bias refers to attentional engagement with emotionally relevant information. Paradigms such as the modified spatial cueing task have been successfully employed in ABM research (Baert et al., 2010; Bar-Haim, Morag, & Glickman, 2011) and may offer more mechanistic specificity, as their design allows calculation of an attentional control index score uninfluenced by positive or negative valence of stimuli.

Finally, extant programs have not tailored the training task to each individual's differential rate of learning. For example, participants differ in their accuracy and overall speed. However, the typical ABM task presents the same number of trials in the same format to all participants. This monotonous task may limit learning rate (i.e., change in biases or attentional control) in those who master the task quickly and prove frustrating for those who have difficulty with initial learning of the task. An adaptive task that changes its characteristics and becomes more demanding on attentional resources as the training continues may prove more effective in producing consistent manipulation of attentional bias than traditional ABM tasks. For example, the classic probe detection task (i.e., identify a letter as either an E or an F) is relatively low on attentional demands. However, as Eriksen and Eriksen (1974) showed, by flanking the centrally located target probe (e.g., E) with letters that either match the identity of the probe (i.e., congruent trial, e.g., EEEEE) or that are different than the identity of the probe (i.e., incongruent trial, e.g., FFEFF) one can increase the attentional demands of the probe detection task. This increase in attentional resources can then be indexed by lower accuracy and slower response latency on these more attentionally demanding conditions.

Similarly, classic probe detection tasks use the same fixation cue throughout the training. However, other cognitive paradigms, e.g., the anti-saccade task (Hallett, 1978; O'Driscoll, Alpert, Matthyse, Levy, Rauch, & Holzmann, 1995), use the fixation cue to provide information about the location of the upcoming probe. For example, green cues may indicate that the probe will be the same location as the cue, whereas red cues may indicate that the probe will be in the opposite location as the cue. Research suggests that this type of trial level instruction can affect performance with color cues providing faster reaction times when compared to unicolored trials where all the fixation cues are white (Hutton, & Ettinger, 2006). Given that ABM tasks aim to speed response latency for threat disengagement (i.e., when probe replaces location opposite of threat stimulus) and/or for benign engagement (i.e., when probe replaces same location as benign stimulus), it is possible that informative fixation cues may facilitate bias change.

In summary, existing research suggests that ABM procedures can successfully modify attentional bias that in turn results in symptom reduction. Moreover, procedures that do not succeed in modifying attentional bias do not produce symptom decreases. As such, recent reviews have called for novel ABM procedures that consistently and effectively maximize

change in attentional bias (Clarke et al., 2014; Kuckertz & Amir, 2015; MacLeod & Clarke, 2015). Our intent in the current pilot study was to design a program that would maximize the likelihood that participants experienced a change in attentional bias. Thus, we introduce a set of adaptations from traditional ABM programs with the aim of demonstrating that it is possible to consistently modify attentional bias. Thus, adaptive AABM (AABM) differs from previous ABM programs in that it: 1) provides participants explicit instructions using trial level color cues and valence cues during training; 2) informs participants of the goal of the training (i.e., to change attentional bias) and gives continuous feedback in reaching this goal in the form of levels reached; 3) differentiates and targets multiple components of attentional bias, including negative attentional bias, positive attentional bias, and attentional control; 4) increases in attentional demands on the perceptual system by incorporating flanker and speed accuracy tradeoffs once participants reach a certain level; and 5) includes adaptive features that adjust the difficulty of the program to each individual's initial accuracy, response latency, and attentional bias.

Because of the novel AABM training program being tested in the current study, our primary goal was to test the hypotheses that (a) AABM would consistently modify both negative as well as positive attentional bias and (b) that both negative as well as positive attentional bias change would correlate with symptom change. We elected to examine our research questions in a single-group design in order to first demonstrate that our intervention was consistently successful in producing mechanistic change (i.e., change in attentional bias) prior to directly comparing AABM to traditional ABM programs.

Method

Participants

Participants comprised 18 individuals (50.0% female; age $M = 43.28$, $SD = 16.30$; years of education $M = 15.89$, $SD = 2.70$) meeting the primary diagnosis of social phobia as determined by a Structured Clinical Interview for DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 2002) who initiated treatment (i.e., completed pre-assessments and initiated bias training phase of program, i.e., reaching level > 30 , see below *Bias training phase*). Participants were also within the clinical range on a dimensional scale of social anxiety severity (Liebowitz Social Anxiety Scale; $M = 85.28$, $SD = 16.30$). We asked participants to complete 4 ($n = 15$) to 6 weeks ($n = 3$) of an adaptive attention bias modification (AABM) program. Fifteen participants completed all four or six weeks of training as scheduled and provided post-treatment data for primary outcome (Liebowitz Social Anxiety Scale). Three participants stopped using the program prior to the study end date due to life changes (i.e., job, relocation, medication change).

Symptom Outcome Measure

Liebowitz Social Anxiety Scale (LSAS, Clinician-Rated: CR and Self-Report: SR)—The LSAS is a 24-item scale that provides separate scores for fear and avoidance of social interaction and performance situations (Liebowitz, 1987). This scale was originally designed as a clinician-rated measure (LSAS-CR) and has demonstrated strong internal consistency and convergent validity with other measures of social anxiety used in clinical

populations (Heimberg et al., 1999). The LSAS-Self Report (LSAS-SR) version shows strong psychometric properties (Baker, Heinrichs, Kim, & Hofmann, 2002; Fresco et al., 2001). Furthermore, the LSAS has been shown to be highly correlated between self-report and clinician-administered versions ($r = .85$) (Fresco et al., 2001). Reliability in the current sample was good for the LSAS-CR ($\alpha = .89$) as well as LSAS-SR ($\alpha = .90$), and these measures were strongly correlated at pretreatment ($r = .76$). Scores of 30 or higher are generally indicative of a diagnosis of non-generalized social anxiety disorder, whereas scores of 60 or higher are generally indicative of a diagnosis of generalized social anxiety disorder (Mennin et al., 2002).

Adaptive Attention Bias Modification (AABM) Program

Here we briefly describe the phases and features of training, but encourage readers to view an expanded description of task characteristics in the Supplemental Material. We implemented all software development in Embarcadero Studio X2 (<http://www.embarcadero.com>).

The program was a modified spatial cueing task (Amir, Elias, Klumpp, & Przeworski, 2003; Koster, De Raedt, Goeleven, Franck, & Crombez, 2005; Posner, 1980) and had two phases, practice phase and training phase. The practice phase was designed to familiarize participants with the program while gradually introducing more attentionally demanding elements (e.g., flanking letters); the training phase directly targeted an increase in positive attentional bias and a decrease in negative attentional bias. We provided participants with information regarding the purpose of the task and explicit instructions both prior to the task and during the task (via popup windows).

Each session of the program comprised 360 trials. During each trial a fixation cue appeared in the center of the screen (500ms) alerting the participants to the beginning of a trial. The fixation cue then disappeared and a single word appeared either above or below the fixation cue directing attention to that location. The word then disappeared and a probe appeared (either the letter 'E' or the letter 'F'). Participants pressed a corresponding mouse button indicating whether the letter was an E or an F. Each word was one of 15 (5 negative, 5 positive, and 5 neutral) ideographically selected words. The negative words always served as invalid cues (i.e., the probe always appeared in the location opposite the location of the negative word), and the positive words always served as valid cues (i.e., the probe always appeared in the same location as the positive word). The neutral words could serve as either a valid cue or an invalid cues with equal frequency (i.e., the location of the neutral word was not informative about the location of the probe).

Practice phase—During the practice phase (levels 0–29), participants increased in levels by consistently performing accurately during the task. The practice phase was designed to familiarize participants to the procedure of the AABM and prepare them for the training phase. We gradually increased the difficulty of the program during the practice phase through: 1) using color of fixation cue to predict probe location at beginning, and gradually fading the color of the cue for emotional (i.e., positive and negative) words, and 2) flanking the probe beginning with level 20 in order to increase attentional demand.

Bias training phase—At the beginning of the formal attentional bias training phase (levels 30 and higher), a popup window informed participants that they would now move through the levels of the program through (a) increasing their positive attentional bias, and/or through (b) decreasing their negative attentional bias. Specifically, either a decrease in negative bias (1 ms) or an increase in positive bias (1 ms) would increase their level in the game.

We defined and created a positive bias score by subtracting average response latency for positive valid trials (probes replaced valid positive words) from average response latency for neutral valid trials (probes replaced valid neutral words). Thus, higher positive bias indicated faster engagement towards positive cues compared to neutral cues.

Similarly, we defined negative bias by subtracting the average response latency for neutral invalid trials (probes following neutral words in the opposite location as the word) from the average response latency for negative invalid trials (probes following negative words in the opposite location). A lower negative bias indicated faster disengagement from negative cues compared to neutral cues.

Finally, we calculated an attentional control score by subtracting average response latency for probes following neutral invalid words from average response latency for probes following neutral valid words. Thus, higher attentional control scores indicated faster engagement to the cues in the same location as the probe when compared to probes in the opposite location as the word.

At the end of each session, a popup window showed participants the level they had reached. In addition, participants had the option to view their positive bias, negative bias, attentional control, and current level in a small window on the computer screen throughout the course of the program as a real-time feedback.

Recalibration—As the program was adaptive and depended on the participants' performance to move to higher levels, it was possible for the program to become frustrating if the intended change in bias did not occur (i.e., neither positive bias would increase nor would negative bias decrease) over many trials. To ensure that participants remained engaged in the task and increase the chance that bias would improve, we included a recalibration feature in the program. If the participants chose to recalibrate (optional after 100 trials without an increase in level), we reset their best bias levels for both positive and negative scores to their current level. This lowered the difficulty of the program if progress did not occur after 100 trials.

Cumulative training—At the end of each AABM session, the program automatically saved the participant's data as a game file with information about the participant's negative bias, positive bias, attention control, and last level reached. Thus, if a participant ended a session at level 53, then they would simply re-load their existing game at the next session and start at level 53, progressing in level based on improvement upon last saved positive or negative attentional bias scores. Thus, participants only completed the practice phase of the task during their first session.

Procedure

Participants first completed a diagnostic clinical interview (SCID; First et al., 1994) as well as clinician-rated LSAS. All clinical interviews were administered by either Ph.D. level psychologists or by an advanced clinical psychology doctoral student. While enrolled in the study, participants completed two consecutive sessions of AABM once a week for four weeks in the laboratory (360 trials each session, for a total of 720 trials per laboratory visit) and at home as often as they wished. Although cumulative, sessions within and across participants were identical in the sense that the goal was to increase positive bias and/or decrease negative bias within each session, thus moving up in levels through either or both type of bias change (after Practice Phase). Each session lasted approximately 20 minutes. The number of trials completed ranged from 720 to 9025 ($M = 3590$, $SD = 2127$). At post-treatment, participants again completed a clinical interview and clinician-rated LSAS. Participants completed the LSAS-SR weekly throughout the duration of the study.

Analysis

All analyses were completed on an intent-to-treat basis ($N = 18$). For the three participants who did not provide post-treatment data, data from their last LSAS-SR (collected weekly during the study) was imputed to calculate an LSAS change score. To remain consistent in comparing measurements across time points, for participants who did not provide LSAS-CR data at post-treatment, change scores were calculated as $LSAS-SR_{pre} - LSAS-SR_{post}$. For the remaining 15 participants who provided LSAS-CR data at post-treatment, change scores were calculated as $LSAS-CR_{pre} - LSAS-CR_{post}$.

Results

Consistency in training attention during AABM

On average, participants reached level 90 of the program, with a standard deviation of 39.11 (range: 46 to 188). These data demonstrate that every participant succeeded in modifying their bias in the expected direction, as it was impossible to progress past level 30 without the expected bias change. Thus, on average the participants were able to change their attentional bias (away from threat and/or towards positive) by about 60 ms across the cumulative training sessions (levels 30 to 90 = 60 point bias change).

Consistency in symptom reduction

On average, participants experienced a LSAS decrease of 21.44 points over the duration of treatment ($SD = 16.37$, range: -13 to 62). Seventeen participants experienced a reduction in symptoms. One participant reported a 13-point increase in symptoms within the first week of treatment and withdrew from the study after completing two sessions.

Relationship between mechanistic dose (i.e., level) and symptom reduction

Next, we examined the relationship between the dose of AABM and symptom reduction. Classic ABM studies define dose as the length of treatment (e.g., 4 weeks) or the number of trials (Beard et al., 2012; Hakamata et al., 2010). However, these definitions of dose do not reflect the treatment mechanism (change in attentional bias). A more mechanism-driven

definition of dose would be the amount of the change in attentional bias. As described above, the proposed mechanism of AABM is the reduction of negative bias and increase in positive bias. Therefore, we used level as our indicator of mechanistically defined dose, which directly corresponded with changes in positive and negative bias. To examine the relationship between classic measures of dose (i.e., number of trials) as well as bias measure of dose (i.e., level) and symptom reduction (i.e., LSAS change scores), we correlated these measures. These data are depicted in Table 3. The number of trials completed did not correlate with change in symptoms ($r = .18$, $p = .484$). However, the level reached in the program was strongly and significantly correlated with change in symptoms ($r = .57$, $p = .015$).

Contribution of individual target mechanisms to symptom reduction

To examine the contribution of each target of AABM (negative bias, positive bias, and attentional control) to symptom reduction, we next examined the relationship between change of each attentional bias component and change in LSAS (see *Bias Training Phase* above for calculation). Consistent with our rationale of introducing new elements of the program at 10-level increments to allow for optimal learning and practice, we defined initial levels of biases at level 40 for the purpose of analyses, thus allowing participants 10 levels (levels 30–39) to acclimate to the process of monitoring bias scores and moving up in levels as a function of changing bias. We calculated bias for the initial levels of the bias training phase (level 40 in the program), the last level in the program, and the difference between initial and last bias. These data are summarized in Table 2.

Examination of the correlations between these bias scores and change in LSAS suggested that both change in negative bias ($r = .56$, $p = .017$) and change in positive bias ($r = -.54$, $p = .020$) were strongly and significantly correlated with change in LSAS with reduction in negative bias and increase in positive bias correlating with decrease in LSAS. On the other hand, change in attention control did not correlate with change in LSAS ($r = -.13$, $p = .60$).

Discussion

In the current study we present pilot data from an idiographic and multi-component, adaptive ABM program designed to train both negative and positive components of attentional bias. AABM was successful in this goal as revealed by an average bias change of approximately 67ms across trainings. We were also able to show that this targeted intervention was strongly associated with change in social anxiety severity. Finally, we demonstrated that our definition of dose (i.e., level as representative of change in attentional bias) outperformed the commonly used definition (i.e., number of trials) when examining the relationship with treatment response.

This research was partly inspired by a recent realization that traditional methods of both assessing and training attentional bias may not be optimum in operationally defining these constructs (MacLeod & Clarke, 2015; Price et al., 2015). As such, some researchers have attempted to define other metrics of attentional bias, finding that variability (i.e., extent to which attention bias fluctuated within session) rather than attentional bias per se was correlated with post-traumatic stress symptoms (Iacoviello et al., 2014; for similar work see

also Zvielli, Bernstein, & Koster, 2015). Researchers have also used different methodologies to modify attentional bias including the “faces in the crowd” paradigm (e.g., Dandeneau & Baldwin, 2004; Dandeneau et al., 2007) and variations of the probe detection task (e.g., Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006; MacLeod et al., 2002). Although each of these methodologies have unique advantages and disadvantages, the ultimate utility of each manipulation rests on its ability to measure and modify attentional bias and to influence anxiety symptoms. In this preliminary study we attempted to demonstrate that a variation of the exogenous cueing task, with adaptive features, can meet these requirements.

Based on a number of recent failures to replicate positive ABM effects on symptoms (see Emmelkamp, 2012), we (Kuckertz & Amir, 2015; Kuckertz et al., 2014) and others (Clarke et al., 2014; MacLeod & Clarke, 2015) have urged a return to theory-driven, mechanistic considerations of ABM successes and failures to replicate. However, the overwhelming majority of ABM reviews have focused on descriptive features of ABM (e.g., vertical versus horizontal presentation of stimuli; word versus pictorial stimuli) or somewhat distant proxies for mechanism (e.g., number of trials). From a theory-driven perspective, it is unlikely that investigators would *a priori* theorize that such factors as direction of presentation of stimuli would affect the results. Such speculations may arise from the fact that researchers have abandoned simple theory based explanations (i.e., differences in target engagement across studies) for unlikely but easily measured factors (e.g., vertical vs. horizontal presentation of stimuli). To illustrate this point consider an example from medicine. Many illnesses are more likely to affect humans when individuals are young with relatively underdeveloped immune systems. However, it is difficult to assess immune system functionality. Instead, one can readily assess height as a proxy concluding “most diseases affect short members of the species”. Height is easier to measure, but it is not theoretically related to the construct of interest, immune system development. Similarly, proposing that the direction in which the stimuli are presented on the screen matters is readily assessed. However, it is not likely to advance our knowledge of the role information processing biases in anxiety.

Our approach is consistent with the recent National Institute of Mental Health (NIMH) call to examine individual variability in response to interventions and establish consistent modulation of proposed mechanisms prior to conducting group comparison studies of clinical efficacy (<http://grants.nih.gov/grants/guide/rfa-files/RFA-MH-16-425.html>). Indeed, NIMH recently proposed a two-stage funding mechanism through which investigators must first demonstrate the ability of their intervention to consistently modulate the targeted mechanism. Only after demonstration of the link between intervention and mechanism does the grant allow continued research examining the link between degree “target engagement” (i.e., manipulation of mechanism) and symptom reduction (<http://grants.nih.gov/grants/guide/rfa-files/RFA-MH-15-300.html>). Thus, the current study is in line with the first stage of this process, in which we demonstrate that the AABM consistently (i.e., in every participant) modulates attentional bias.

Consistent with NIMH’s approach, we did not feel that AABM warranted a head-to-head trial with traditional ABM prior to demonstration of the link between the intervention and target engagement. While we are not able to make definitive statements about the clinical

efficacy of AABM due to the lack of a control group, we do note that our correlational data is suggestive that mechanistic changes are strongly associated with symptom reduction. Given (a) the consistency with which AABM succeeded in modifying attentional bias, and (b) the strong association between bias and symptom changes demonstrated in the current pilot study, it is possible that by training individual variability in positive and negative attentional bias, AABM may have potential to produce more robust training effects than traditional ABM methods.

This AABM paradigm advances the mechanistic science of training and assessment of attentional bias through three novel features. *First*, AABM is idiographic allowing it to be applied to different anxious populations but also to individuals with other primary concerns (e.g., alcohol: McGeary, Meadows, Amir, & Gibb, 2014; eating disorders: Boutelle, Kuckertz, Carlson, & Amir, 2014). *Second*, AABM has a multi-component structure, simultaneously training different components of attentional bias (three domains described by NIMH Research Domain Criteria, RDoC: negative valence system, positive valence system, and cognitive attention system: <http://www.nimh.nih.gov/research-priorities/rdoc/rdoc-constructs.shtml>). Indeed, RDoC summaries suggest that it is likely that multiple domains are involved in various forms of psychopathology and exclusive reliance in training one component has limited utility. *Finally*, AABM is adaptive. The program tailors its performance to the needs of each individual. That is, the program only advances in levels once the particular goal (i.e., change in bias) is achieved. Such a learning procedure is more likely to result in sustained and universal learning than generic methods of training attention.

Many medical interventions have a clearly defined, measurable mechanism of action (e.g., measuring blood sugar levels in order to administer the appropriate dose of intravenous insulin for diabetes individualized to each patient). ABM, compared to other psychosocial treatments, has the clear advantage of mechanistic specificity (i.e., change in attention bias) which makes it particularly well-suited to examine questions of mechanism and optimal dose. Thus, it may be useful to define this mechanism for patients and ask them to monitor their level of the purported mechanism. It may also be useful to rely on basic learning principles in designing an ABM program. Indeed, Skinner (1954) defined learning as requiring a “carefully designed program of gradually changing contingencies and the skillful use of schedules to maintain the behavior in strength.” This suggests that learning is incremental in nature, and that multiple contingencies play a part in the act of learning. As such, an incremental ABM program that allows patients to build on previous learning and reinforces them by allowing them to reach new levels could increase learning and thereby change their attentional bias.

Our study has limitations. For example, our exclusive reliance on clinician-report of anxiety does not allow us to link our findings to biological components that may be involved in attention and anxiety. For example, a wealth of research has examined the error-related negativity (ERN), an event-related potential that arises approximately 50ms after the commission of an error (Cavanagh & Shackman, 2015). Indeed, two recent meta-analyses suggest that anxious individuals are characterized by an increased neural response to errors (i.e., larger ERN) (Cavanagh & Shackman, 2015; Moser, Moran, Schroder, Donnellan, & Yeung, 2013). Therefore, examining the effect of AABM components on ERN and other

event-related potentials may be beneficial in the context of treatment. Indeed, preliminary evidence in a non-clinical sample suggests that a single session of ABM may modify ERN (Nelson, Jackson, Amir, & Hajcak, 2015).

In addition, AABM has adopted multiple new approaches (e.g., colored fixation cue, flankers, levels, and etc.) to enhance its effect. Although results in manipulation of attentional bias and symptom reduction is promising, it is unclear how each enhanced approach contributed to the effectiveness of AABM. Given growing frustration as reflected in recent reviews (Cristea, Kok, & Cuijpers, 2015; Cristea, Mogoș, David, & Cuijpers, 2015; Emmelkamp, 2012) over the utility of ABM in modifying attentional bias and/or producing symptom change, our primary goal in this pilot study was simply to demonstrate that it is possible to consistently modify attentional bias given optimal training parameters. Our data, while preliminary and demonstrated in a small sample, support not only the notion that AABM consistently modifies bias, but also the relationship between dose and symptom reductions in clinically anxious individuals.

Finally, we note that our pilot findings are correlational and thus do not provide direct support for ABM's theory that changes in attentional bias predict subsequent symptom changes. That is, we cannot rule out the possibility that changes in symptoms preceded changes in attentional biases because these constructs were measured at the same timepoints. However, as AABM provides a continuous measure of attentional bias, this program may be particularly well-suited for longitudinal analyses provided the inclusion of multiple (e.g., weekly) symptom assessments during the intervention phase.

Consistent with these limitations, we suggest three primary steps for future AABM research. First, larger samples of clinically anxious participants are needed in order to replicate the efficacy and mechanisms of this program. The current study represents a small, pilot sample of socially anxious individuals and was intended to introduce the AABM program and provide preliminary support for continued research in this area. We emphasize that the efficacy of AABM in modulating both mechanisms and symptoms should be considered tentative until further replicated. Second, research is needed that directly compares the utility of AABM versus traditional ABM programs in modifying mechanisms (i.e., attentional bias) and symptoms. This step is secondary to prior demonstration that the intervention consistently modulates the proposed mechanism in adequately-powered samples. Finally, we emphasize the importance of dismantling the features of the AABM program in order to determine to what extent each feature contributes to the program's ability to manipulate the target mechanism.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

Funding: This study was supported by National Institutes of Health Grant R01 MH087623 awarded to the first author.

We would like to thank Cathy Chen and Kerry Kinney for their help with data collection.

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Figure 1.
Negative bias change by level.

Figure 2.
Positive bias change by level.

Figure 3.
Attentional control change by level.

Table 1

Task Characteristics

Trial Type	Flanker Type		
	Non Flanker	Congruent Flanker	Incongruent Flanker
Overall RT	641 (133)	625 (102)	683 (101)
Invalid negative	650 (131)	643 (104)	701 (108)
Valid positive	636 (125)	593 (98)	653 (91)
Valid neutral	624 (141)	608 (94)	672 (96)
Invalid neutral	655 (144)	657 (118)	706 (117)

Note. All response latencies reported in milliseconds. Standard deviations presented in parentheses.

Table 2

Clinical and Bias Variables

Variable	<i>Intent-to-Treat N = 18</i>	
	<i>M (SD)</i>	<i>Range</i>
LSAS before training	85.28 (16.30)	48 – 118
LSAS after training	63.83 (20.76)	31 – 108
Change in LSAS	21.44 (16.37)	–13 – 62
Number of trials	3590 (2127)	722 – 9025
Level reached	90.17 (39.11)	46 – 188
Negative bias level 40	–1.27 (24.57)	–76 – 31
Positive bias level 40	–4.51 (29.24)	–66 – 65
Neutral bias level 40	37.03 (34.90)	–13 – 117
Negative bias last level	–11.62 (26.83)	–66 – 28
Positive bias last level	14.10 (25.93)	–32 – 69
Neutral bias last level	40.24 (30.10)	–7 – 98
Negative bias change 40-last	10.35 (19.59)	–15 – 70
Positive bias change 40-last	–18.60 (23.72)	–79 – 5
Neutral bias change 40-last	–3.21 (15.03)	–28 – 31

Note. LSAS: Liebowitz Social Anxiety Scale. LSAS change score calculated as pre – post. Bias change scores calculated as bias at level 40 – bias at last level reached. Bias scores reported in milliseconds.

Table 3

Correlation Between Change in LSAS and ABM Measures

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 LSAS before training													
2 LSAS after training	0.63**												
3 Change in LSAS	0.19	-0.64**											
4 Level reached	-0.01	-0.45	0.57*										
5 Number of trials completed	-0.48	-0.52*	0.18	0.45									
6 Negative bias at level 40	0.06	0.01	0.05	-0.07	-0.08								
7 Negative bias at last level	-0.06	0.24	-0.36	-0.67**	-0.17	0.71***							
8 Negative bias change 40-last	0.16	-0.31	0.56*	0.84***	0.14	0.28	-0.48*						
9 Positive bias at level 40	-0.06	-0.09	0.06	-0.20	0.26	-0.47*	-0.19	-0.34					
10 Positive bias at last level	0.04	-0.41	0.57*	0.56*	0.40	-0.47	0.69**	0.36	0.64**				
11 Positive bias change 40-last	-0.11	0.34	-0.54*	-0.87***	-0.11	-0.07	0.52*	-0.81***	0.54*	-0.31			
12 Neutral bias at level 40	0.08	-0.02	0.10	0.51*	-0.14	-0.59*	-0.77***	0.31	-0.17	0.30	-0.54*		
13 Neutral bias at last level	0.13	-0.05	0.19	0.57*	0.05	-0.56*	-0.78***	0.37	0.03	0.44	-0.44	0.90***	
14 Neutral bias change 40-last	-0.06	0.06	-0.13	0.04	-0.43	-0.24	-0.22	-0.01	-0.45	-0.19	-0.36	0.51*	0.10

Note. LSAS change score calculated as pre – post. Bias change scores calculated as bias at level 40 – bias at last level reached.

* $p < .05$

** $p < .01$

*** $p < .001$.