Research Review: attention bias modification (ABM): a novel treatment for anxiety disorders

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Attention bias modification (ABM) is a newly emerging therapy for anxiety disorders that is rooted in current cognitive models of anxiety and in established experimental data on threat-related attentional biases in anxiety. This review describes the evidence indicating that ABM has the potential to become an enhancing tool for current psychological and pharmacological treatments for anxiety or even a novel standalone treatment. The review also outlines the gaps in need of bridging before ABM techniques could be routinely applied and incorporated into standard treatment protocols.

In our field of research and practice few things generate more excitement than a new treatment for a major psychopathology such as the anxiety disorders, for which the considerable treatment data collected thus far leaves much room for improvement in treatment efficacy (Insel, 2009; Pine, 2009). Anxiety disorders occur in anywhere from 5–20% of children (Bernstein, Borchardt, & Perwein, 1996) and about 18% of adults (Kessler, Chiu, Demler, & Walters, 2005), inflicting considerable suffering and dysfunction. With remission rates in first line treatments (cognitive-behavior therapy, pharmacotherapy) standing at only about 50% (Ballenger, 2004; Barlow, Gorman, Shear, & Woods, 2000; Cartwright-Hatton, Roberts, Chitsabesan, Fothergill, & Harrington, 2004), it is imperative to continue refining existing treatments and actively pursuing more efficacious ones. This is particularly relevant for pediatric anxiety disorders for which barriers to treatment (reviewed later in this paper) are higher than those for adults. Given that chronic patterns of clinically significant anxiety and depression typically emerge during childhood (Pine, Cohen, Gurley, Brook, & Ma, 1998), and given the potential of early intervention for disrupting such long-term cycles of maladaptation, it is particularly important to develop and test novel treatments for highly anxious children.

Against this backdrop, a novel attention bias modification (ABM) treatment for anxiety has started to emerge. This new theory-driven treatment stems from established experimental data on threat-related attentional biases in anxiety (for a review see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007), and utilizes computer-based attention training protocols to implicitly modify biased attentional patterns in anxious patients. This review first localizes ABM treatments in the broader context of cognitive therapies for anxiety. It then describes the accumulating evidence highlighting the potential of ABM for alleviating anxiety. Finally, the review outlines the gaps in need of bridging before ABM techniques could be routinely applied and incorporated into standard treatment protocols.

Cognitive theories of anxiety and attention bias modification

Cognitive accounts of anxiety suggest that information-processing biases play a central role in the etiology and maintenance of anxiety disorders (Beck & Clark, 1997; Eysenck, 1992, 1997; Rapee & Heimberg, 1997; Williams, Watts, MacLeod, & Mathews, 1997). Along with application of conditioning principles derived from behavior learning theories (e.g., Rachman, 1991; Wolpe, 1973, 1978), such cognitive models laid fertile grounds for the development and refinement of cognitive-behavioral therapies (CBT), now considered established evidence-based treatments for anxiety disorders in both adults and children (A. C. Butler, Chapman, Forman, & Beck, 2006; G. Butler, Fennell, Robson, & Gelder, 1991; Chambless & Gillis, 1993; Kendall, 1994; Kendall et al., 1997; Kendall, Hudson, Gosch, Flannery-Schroeder, & Suveg, 2008; Kendall & SouthamGerow, 1996). According to such models, processing is guided by schemas (cognitive frameworks or concepts) that largely determine how information is attended to, interpreted, and remembered. In anxious individuals, schemas are thought to be biased toward threat. The translation of such models into applicable CBT protocols focused primarily on training in relaxation techniques, systematic and graded exposure to threat as a vehicle promoting fear extinction, and direct, explicit, and conscious challenging of negative interpretive and memory biases. Although current cognitive models of anxiety readily acknowledge the involvement of early, automatic, and preconscious attentional biases in the etiology and maintenance of anxiety disorders, and evidence from

both animal and human research indicates that a major component of emotion in general and anxiety in particular reflects functional aspects of sub-cortical neural circuits that are not available to conscious thought (e.g., Delgado, Nearing, LeDoux, & Phelps, 2008; LeDoux, 2000; Pine, 2007), lack of means to directly manipulate such biases and patterns of neural activation within the context of standard psychotherapy leaves the treatment of these biased cognitive processes out of the CBT tool box.

Recently, however, ABM treatment studies have started to emerge. At the heart of this novel and promising approach lies the idea that the classic cognitive tasks, which provided ample evidence for specific attentional biases in both anxious children and adults (Bar-Haim et al., 2007; Mogg & Bradley, 1998), can be modified to implicitly manipulate attention biases and reduce anxiety. Such translations of insights from cognitive neuroscience have started to generate novel approaches to treatment for a variety of psychopathologies. Relevant examples emerge in dyslexia, for which behavioral remediation focused on auditory processing and oral language training was found to improve reading performance in children (Gabrieli, 2009; Temple et al., 2003). In the same vein, schizophrenic patients who received implicit computerized auditory training showed significant gains in global cognition, verbal working memory, and verbal learning and memory (Fisher, Holland, Merzenich, & Vinogradov, 2009). Finally, children with attention deficit hyperactive disorder (ADHD) who received computerized working memory training showed improved response inhibition, reasoning, and working memory, as well as reduction in parent-reported inattentive symptoms of ADHD relative to a control group receiving a sham training program (Klingberg et al., 2005).

A specific example of how such techniques are currently applied in treatment for anxiety disorders is provided in the next section. Note, however, that an important distinction should be made between the teaching of anxious patients to employ top-down effortful attention control strategies to divert attention away from anxiety-provoking thoughts as is sometimes applied in standard CBT or other cognitive therapies (e.g., Wells, White, & Carter, 1997), and the direct but implicit targeting of early, auto-matic, and sometimes unconscious attentional biases by ABM therapy. ABM techniques may prove valuable to anxiety patients who do not respond to currently available treatments and in particular for anxious children for whom compliance with elaborate CBT protocols often proves problematic (Kendall & Sugarman, 1997), and for whom parents are often reluctant to consider pharmacological treatment. As will be discussed later in this review, it remains to be seen whether these novel ABM tools will be integrated into standard CBT protocols or will end up serving as standalone therapies.

The design of ABM protocols for anxiety

Most ABM studies utilized variants of the dot-probe task (MacLeod, Mathews, & Tata, 1986) to measure and manipulate threat-related attention biases. Figure 1 describes a typical dot-probe trial. In this task, two stimuli, one threat-related and one neutral (typically words or pictures of faces with distinct expressions of emotion), are shown briefly on each trial, and their removal is followed by a small target probe in the location just occupied by one of the stimuli. Participants are required to discriminate as fast as possible between two variants of the probe (e.g., the letters *F* and *E* or the shapes '..' and ':') without compromising accuracy. In the classic format of this task, designed to measure attention biases, targets appear with equal probability at the location of threat and neutral stimuli. Thus, response latencies provide a 'snapshot' of the distribution of participants' attention, with faster responses to probes evident in the attended location relative to the unattended location. Attention bias towards threat is revealed when participants are faster to respond to probes that replace threat-related stimuli rather than neutral stimuli. The opposite pattern indicates avoidance of threat.

In attention-training variants of the dot-probe task, target location is systematically manipulated to increase the proportion of targets appearing at the location of the intended training bias. For example, in a training protocol intended to induce attentional bias away from threat and toward neutral stimuli, targets would appear more frequently at the location
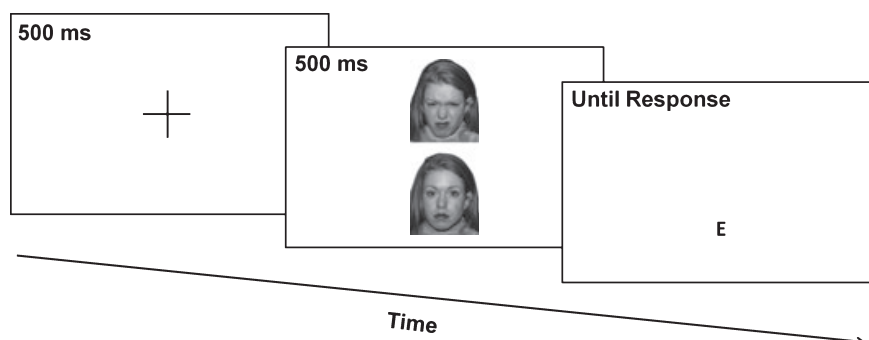

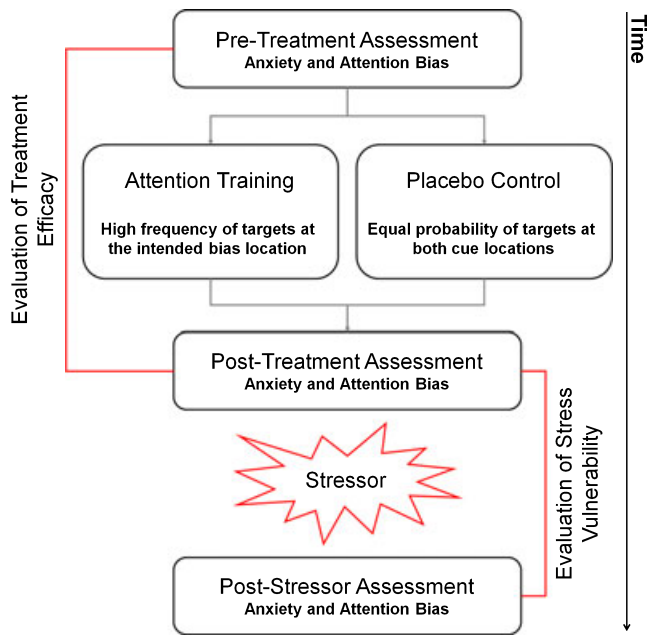**Figure 1** Sequence of events in a dot-probe trial

Figure 2 Schematic of Attention Bias Modification (ABM) study designed to evaluate treatment efficacy and stress vulnerability

of the neutral stimulus than at the location of threat. It is assumed that because attending to such contingencies can assist in task performance, an implicitly learned bias away from threat is gradually induced with a systematic repetition of tens or hundreds of trials. Effects of the training procedure on anxiety symptoms can be measured immediately upon completion of the training protocol, whereas effects of attention training on vulnerability to stress can be measured if participants are exposed to a stressor following the attention training protocol (Figure 2).

Because only one published study on attention training for anxiety used a paradigm different than the dot-probe task (Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007), the rest of this review will focus on dot-probe-based attention-training studies. This by no means implies that the dot-probe task is the most effective or most relevant paradigm. In fact, the anxiolytic effects demonstrated by Dandeneau et al. (2007), who used a visual search task to repeatedly train participants to locate a single smiling face in a matrix of frowning faces, are quite impressive and equal those obtained with the dot-probe task.

ABM attenuates clinical symptoms of anxiety

Basic research on threat-related attentional biases has been primarily motivated by the hope that it would lead to new and more efficient psychotherapeutic interventions for emotional disorders (MacLeod, Koster, & Fox, 2009; Mobini & Grant, 2007; Pine, Helfinstein, Bar-Haim, Nelson, & Fox, 2009). Of particular interest for ABM therapy are early attentional processes that have been typically considered not

readily amenable to explicit/conscious cognitive intervention and which are supported by fast-responding neural circuitries (Eldar & Bar-Haim, 2010; Monk et al., 2008; Pine, 2007 for a review).

The precursors of ABM approach were provided in two studies (reviewed in Mathews & MacLeod, 2002) in which high trait-anxious students received a number of dot-probe attention training sessions (6000–7500 trials) designed to direct their attention away from threat cues. These students reported significant reductions in trait anxiety scores from pre- to post-training. Over the past two years ABM studies have taken an important step forward by showing quite dramatic effects of attention training on anxiety symptoms in anxious patients and in sub-clinical populations (see Table 1 for a summary of the extant ABM studies). These studies have focused on generalized anxiety disorder (GAD) and social phobia (SP) employing dot-probe training protocols. A readily spotted lacuna in this research is the lack of ABM studies in pediatric anxiety patients, to which I will refer later in this review.[1]

ABM for GAD

Amir, Beard, Burns, and Bomyea (2009a) randomly allocated patients with GAD to either an attentional training condition designed to induce avoidance of threat words or to an attentional control condition. This dot-probe training entailed 160 trials of threat-neutral word pairs per session, administered in eight sessions across a four-week period. Following training 58% of the patients in the attentional training condition no longer met DSM-IV diagnostic criteria for GAD compared to only 17% of the patients in the control condition. The clinical efficacy of the attentional training procedure was further supported by improvements on a range of clinician-delivered and self-report measures of anxiety. Similar findings were recorded in a study of undergraduate students (Hazen, Vasey, & Schmidt, 2009) who reported stable and severe levels of worry (most of which met DSM-IV diagnostic criteria for GAD). In this study, participants were randomly assigned to receive five sessions of either attentional training to avoid threat words or a control placebo-training. Compared to participants in the control condition, the participants who received the active training program produced significant reductions in both threat bias and anxiety-depression symptoms.

ABM for social anxiety

Three dot-probe studies using neutral and disgust faces as cue stimuli applied attentional training protocols to reduce social anxiety. Schmidt, Richey, Buckner, and Timpano (2009) randomly assigned

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[1] The author is aware of three attention training studies in anxious children being currently conducted.

Table 1 A list of the extant attention bias modification (ABM) studies

Study	Population	Paradigm	Stimuli	Threat Content	Attention Redirection	# of Sessions	Total # of critical Trials
Amir et al. (2008)	Socially Anxious Students	Dot-Probe	Faces	Disgust	Neutral	1	128
Amir et al. (2009a)	GAD Patients	Dot-Probe	Words	Negative	Neutral	8	1024
Amir et al. (2009b)	SP Patients	Dot-Probe	Faces	Disgust	Neutral	8	1024
Dandeneau et al. (2007)	Nonselected Students	Visual Search	Faces	Rejecting	Happy	1/5	112/560
Eldar et al. (2008)	Nonanxious Children	Dot-Probe	Faces	Angry	Neutral and Threat	2	672
Eldar & Bar-Haim (2010)	High Trait- Anxious Students	Dot-Probe	Faces	Angry	Neutral	1	480
Harris & Menzies (1998)	Nonselected Students	Dot-Probe	Words	Spider	Neutral and Threat	1	40
Hazen et al. (2009)	Sever Worry Students	Dot-Probe	Words	Negative	Neutral	5	640
Klumpp & Amir (2010)	Socially Anxious Students	Dot-Probe	Faces	Disgust	Neutral and Threat	1	128
Li et al. (2008)	Socially Anxious Students	Dot-Probe	Faces	Angry	Happy	7	3360
MacLeod et al. (2002)	Nonanxious Adults	Dot-Probe	Words	Negative	Neutral and Threat	1	576
MacLeod et al. (2007)	Nonselected Adults	Dot-Probe	Words	Negative	Neutral and Threat	1	288
Mathews & MacLeod (2002)	High Trait- Anxious Students	Dot-Probe	Words	Negative	Neutral	8/10	6000/7500
Schmidt et al. (2009)	SP Patients	Dot-Probe	Faces	Disgust	Neutral	8	1024
See et al. (2009)	Nonselected Students	Dot-Probe	Words	Negative	Neutral	15	2880

patients with generalized SP to either a training condition designed to reduce vigilance for threat (disgust facial expressions) or to a control condition. In this study patients received eight sessions across four weeks, each incorporating 160 trials (128 critical trials). After the intervention, 72% of the patients in the attentional training condition no longer met diagnostic criteria for SP, compared to 11% of the patients in the control condition. At a follow-up assessment four months later, 64% of the participants in the attentional training condition were classified as remitted versus only 25% of those in the control condition. Using the same procedure in a randomized, double-blind placebo-controlled trial in a group of patients diagnosed with generalized SP, Amir et al. (2009b) found that attention training away from disgust faces facilitated attention disengagement from threat and reduced clinician- and self-reported symptoms of social anxiety relative to a placebo training condition. The percentage of participants no longer meeting DSM-IV criteria for generalized SP post treatment was 50% in the active training group and 14% in the placebo control group. Symptom reduction in the active training group was maintained at four-month follow-up assessment. Finally, using a similar design, Amir, Weber, Beard, Bomyea, and Taylor (2008) exposed socially anxious undergraduate students to a single dot-probe session (128 critical trials) of either attention training away from facial expressions of disgust or a control condition. Relative to participants who received control placebo training, participants who were trained to attend away from disgust faces showed significantly less attention bias after training as well as lower levels of anxiety in response to a public-speaking challenge.

Furthermore, blind raters judged the speeches of those in the attention training condition as better than those in the control condition.

ABM in nonanxious populations

One of the most important theoretical and practical questions concerning ABM is whether attention bias toward threat is causally related to anxiety symptoms. Proving causality is important because it constitutes the logical foundation for the mechanisms by which ABM therapies work. Scientifically, this question can only be answered by experimentally inducing a temporary bias toward threat and measuring its impact on anxiety levels. Although temporary threat bias-induction may be ethically justified for nonanxious participants, it might be more difficult to defend for clinically anxious patients (but see Klumpp & Amir, 2010).

To my knowledge there are only two studies, one in adults and one in children, that directly tested for causality in a controlled experimental ABM design. In a seminal report, MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) demonstrated that it is possible to modify patterns of attention to threat in nonanxious participants and that such changes alter affective responses to subsequent stress. In this study, a variant of the dot-probe task was used to train nonanxious participants either to adopt a biased attentional response toward threat words (i.e., probes always appeared in the loci of threat) or to adopt an attentional bias away from threat (i.e., probes always appeared in the loci of neutral words). MacLeod et al. (2002) found that these two groups of participants developed differentially biased attention responses

that were in accord with the assigned threat-target contingency. This differential attention bias did not result in an immediate change in anxiety following training, perhaps due to the nonanxious nature of the participants who were specifically selected for this trait. However, attention modulation did lead to a group difference in anxiety vulnerability to a subsequently induced stress. Whereas both groups of participants responded to the stress manipulation with elevation in state anxiety, the magnitude of this elevation was significantly greater in those participants who had been exposed to the attendance to threat condition. Eldar, Ricon, and Bar-Haim (2008) replicated this finding in nonanxious 7–12-year-old children using a dot-probe variant with naturalistic pictures of angry and neutral facial expressions. In addition to group differences in self-reported anxiety following stress induction, this study showed that relative to children who were trained to attend away from threat, children trained to attend toward threat showed a higher frequency of anxious behavior as coded from video tapes recorded during the stress episode. By demonstrating that children as young as 7 years of age are able to comply with repeated attention training sessions and that training is effective in modulating both threat bias and anxiety, this study sets the stage for evaluating the clinical relevance of ABM for anxious children.

ABM techniques may also be used as a prevention measure reducing anxiety and stress vulnerability in individuals who are bound to face stressful naturalistic circumstances, which could range from mild (e.g., upcoming midterm exams) to severe (e.g., military deployment to combat). This potential application was demonstrated by See, MacLeod, and Bridle (2009) who followed Singaporean students while preparing to immigrate to Australia for tertiary education – an event considered highly stressful by these students. Applying a dot-probe attention training schedule before migration, half of the participants were randomly biased away from emotionally negative word stimuli, and half received a placebo control training not intended to change attention patterns. Training reduced anxiety responses to the upcoming naturalistic stressor of migration and reduced state anxiety scores collected upon arrival at the host country.

These findings from normative samples provide crucial evidence in support of the hypothesis that threat bias is a causal factor in anxiety by confirming two pivotal assumptions of ABM research: a) attention patterns can be altered through training procedures using classic cognitive tasks; and b) biased attentional responses to threat can exert a specific influence on the tendency to experience anxiety when encountering stressors. This latter finding could be highly relevant for the use of ABM as a preventive measure for upcoming and unavoidable stressors as well as in the context of relapse prevention and sustainment of therapeutic gains.

Summary

The evidence of clinically relevant effects of attention training in GAD and SP patients directly links the research on therapeutics and the research on attention bias. At the theoretical level, the extant attention training studies provide strong support for the hypothesis that modifying attentional biases toward threat causally reduces anxiety symptoms. At the practical level, these findings indicate that it may be possible to utilize attention training procedures clinically, either independently or as augmentation of already established treatments for anxiety. Despite its high prevalence, many individuals with anxiety disorders do not receive treatment. Additionally, many individuals who present for treatment respond poorly to it, do not respond at all, or drop out of treatment (Kendall & Sugarman, 1997). Specifically for children and adolescents, computer-based training of attention may be more acceptable than traditional in-person therapy formats, and it may offer advantages by delivering systematic exposure to threat during which attention can be guided and controlled (Pine et al., 2009). Such computer-based attention retraining may act directly to reduce anxiety symptoms and could augment the core-CBT feature of systematic exposure to threats. With CBT, patients attempt to use cognitive control strategies to willfully alter their attentional focus (see also Wells et al., 1997). With computerized ABM, patients can implicitly learn to control attention in the absence of explicit instructions. Thus, combining CBT with ABM may simultaneously target explicit and implicit processes contributing to biased cognitive processes in anxiety.

Finally, the computer-based nature of ABM bears the potential to enhance dissemination of treatment both in the clinic and remotely, over the internet or via installation of simple software packages (Chu et al., 2004; MacLeod, Soong, Rutherford, & Campbell, 2007).

Technical and theoretical considerations

The extant preliminary data suggest impressive efficacy of ABM protocols for reducing anxiety symptoms. The data also raise some important theoretical considerations and a pressing need to identify the most efficient parameters for intervention protocols. Specifically, it remains undecided whether anxiety-reducing effects are specific to threat-related attentional training or reflect a more general attentional control process; whether there are contraindications for ABM treatment; whether threat content, when used in training, should be congruent with the typical fears of the specific anxiety disorder being treated or represent a more general category; to what classes of stimuli should attention be redirected to in training? What subcomponents of attention should be targeted by ABM? What is the optimal frequency

of ABM treatment and how many training trials would yield the highest therapeutic gains? And, should the contingencies being trained remain implicit or should these be explicitly spelled out for patients? Scientific evidence concerning these issues will play a central role in determining the faith of ABM protocols as acceptable treatments for anxiety, and each of these issues will be discussed below.

Are anxiety-reducing effects of attention training specific to enhanced threat avoidance?

Attention training protocols for anxious individuals rely theoretically on the premise that anxiety is associated with a faster engagement of attention to threat stimuli and with a greater difficulty to disengage attention from threat after it has been captured (Bar-Haim et al., 2007; Fox, Russo, Bowles, & Dutton, 2001; Mogg & Bradley, 1998). Thus, attention training away from threat in anxious individuals is expected to reduce both the enhanced attention capture by threat and the delayed attentional disengagement from threat. Specifically, if the anxiety-reducing effects of attention training are consistent with these premises, it must be attention training *away from threat* that decreases anxiety symptoms and anxious reactivity to stressors and not placebo or attention training conditions that are not specific to threat avoidance.

In contrast, recent theory and research may be taken to suggest that cognitive biases in anxiety reflect a more general cognitive deficit that may not be specific to attentional threat processing (e.g., Bishop, 2009; Derakshan & Eysenck, 2009; Derryberry & Reed, 2002; Eysenck, Derakshan, Santos, & Calvo, 2007; Wells et al., 1997). According to such views, the anxiety-reducing effects of attention training may be due to increase in general attentional control regardless of its valence-related directionality. For instance, attention training may increase attentional control via enhancement of top-down cognitive capacities that may in turn inhibit threat processing (e.g., Pessoa, 2009; Pessoa, McKenna, Gutierrez, & Ungerleider, 2002).

The extant attention training studies did not include systematic testing of the general attentional control hypothesis. However, Klumpp and Amir (2010) studied a group of moderately socially anxious undergraduate students, and, in addition to the standard training away from threat and placebo training conditions, included a third training condition in which participants were trained to attend toward threat. While implicitly training anxious individuals to attend toward threat seems somewhat counterintuitive given the vast data showing that anxious individuals typically possess such threat bias to begin with, this condition provides a preliminary test of the hypothesis that perhaps enhanced attentional control rather than more efficient attentional disengagement from threat is

achieved through the training protocol, and is in turn responsible for the noted reductions in anxiety. Although the behavioral response time data in this study were largely inconclusive with regard to attention training effects, consistent with an attentional control hypothesis, both participants who were trained to attend toward threat and participants who were trained to attend away from threat faces exhibited a relative decrease in anxiety during a speech challenge compared to participants in a placebo control condition. No difference in anxiety scores between the two attention training conditions was found in this moderately anxious sample.

Despite these preliminary data (Klumpp & Amir, 2010), the general attentional control hypothesis must wait for a more programmatic experimental testing in clinical and sub-clinical populations. Perhaps the first step in this direction should be testing the anxiety-reducing effects of an attention training protocol that utilizes non-affective cue stimuli (e.g., geometric shapes). If simple attention control enhancement is the anxiolytic component of this intervention then anxiety-reducing effect should be expected with attention training to non-affective stimuli.

Who should be treated with ABM protocols?

A meta-analysis found equivalent combined effect sizes of threat-related bias in clinical and nonclinical high trait anxious populations (Bar-Haim et al., 2007). This finding suggests that an official clinical cutoff is of little significance with regard to biased attentional processes in anxious individuals, and that milder forms of anxiety are sufficient for triggering the full potential of the bias. In addition, despite the fact that threat-related attention bias is reliably observed in anxious patients and participants and not in nonanxious participants (Bar-Haim et al., 2007), this effect has only been established as a group-means difference and is not reported at the level of the individual subject. Careful inspection of several samples of clinically anxious children and adults indicate that not all anxious individuals show an attention bias toward threat. In fact, despite showing higher threat bias scores, the distribution of threat bias in anxious patients is rather normal, with large numbers of individuals not showing the bias. Taking this unofficial (but not disputed) statistic into consideration, an important question arises: namely, *should anxious patients who show no evidence of an attention bias toward threat be treated with attention training protocols?*

A few issues may be of interest to consider in this respect. First, if ABM produces a general improvement in attentional control rather than specific threat-related effects, and this improvement serves as the anxiolytic agent of ABM, then training attention away from threat should have a therapeutic effect on patients whether they show threat bias or

not. Second, attention training procedures may serve to regulate and normalize attentional biases in both directions (i.e., toward and away from threat). This may be particularly relevant to social anxiety, for which it has been shown that patients demonstrate both faster initial engagement with threat but also enhanced later avoidance of threat (e.g., Amir, Foa, & Coles, 1998). Finally, initial measurement of threat bias may not represent the true tendency of anxious individuals to be highly vigilant toward threat. Specifically, several studies have shown that threat bias is suppressed and even reverses in anxious individuals under conditions of threat (e.g., Amir et al., 1996; Constans, McCloskey, Vasterling, Brailey, & Mathews, 2004; Helfinstein, White, Bar-Haim, & Fox, 2008; Mathews & Sebastian, 1993; Mogg, Kentish, & Bradley, 1993). Thus, if a priori bias is to become a consideration in prescribing ABM treatment, some standard measurement of bias, preferably not taken during the stress of the first session of psychotherapy, should be delineated and tested. Furthermore, the stability and retest reliability of threat-bias measurement will have to be carefully established.

Considerations related to stimuli selection

Even if accumulating data will eventually indicate that training attention away from threat is a key factor in anxiety-reducing effects, it will remain important to decide: a) what are the most effective and relevant threat stimuli that can be used in attention training protocols; and b) what are the most effective and relevant stimuli to veer attention to.

Specificity of threat stimuli. To date, attention training studies appear to have selected threat stimuli that are conceptually relevant to the specific anxiety disorder being treated. In one case, stimuli were idiosyncratically selected to represent the specific worries of individual patients (Amir et al., 2009). That is, before training, each patient was asked to rate the emotional valence of each word from a large list and the specific words that were rated as most negative by a particular participant were used as the threat stimuli in his or her dot-probe training task. Such a strategy may be particularly relevant to GAD in which there is a large variability in the nature of concerns for each patient. Attention training studies for SP (Amir et al., 2008; Schmidt et al., 2009) also applied a disorder-specific approach in selecting threat stimuli utilizing disgusted faces as threat. Indeed, the primary concerns of patients with SP are in the realm of social evaluation and social rejection (see Yoon & Zinbarg, 2007) and arguably disgust conveys a message of aversion or rejection (Rozin, Lowery, & Ebert, 1994).

In addition to relevance of specific contents for specific disorders, the selection of disorder-specific threat stimuli may also relate to more basic features of the stimuli such as words versus pictures. Word stimuli may be particularly useful in the case of attention training protocols for disorders in which anxiety is related to abstract threat themes (e.g., GAD, PTSD) – such abstraction could be represented more efficiently with written words. In contrast, for specific phobias (e.g., spider phobia, social phobia), in which anxiety is more focused and refined, the use of images may be more effective.

Utilization of threat stimuli that are specifically tailored for a particular disorder or the anxious concerns of a particular patient indicates a good deal of common sense and rhymes well with clinical tradition. However, personalized protocols introduce a serious toll on ease of delivery, dissemination, and costs of treatment. If attention training protocols serve to balance perturbations in basic and relatively hard-wired mechanisms (Bar-Haim et al., 2007; Pine et al., 2009), then it might be possible to achieve significant therapeutic effects with attention training protocols applying a standard set of stimuli.

Where should attention be directed? Once threat stimuli are selected, researchers and therapists must decide on the class of stimuli to which attention be directed when training for disengagement from threat. The vast majority of attention training studies to date manipulated attention bias by veering it away from threat and onto a neutral stimuli (words or pictures). Enhanced attention to neutral over threat material may represent a realistic therapeutic goal in which perturbed interplay between attention and emotion in anxious individuals reaches a more neutral balance. Although this approach proved efficient in various clinical trials (e.g., Amir et al., 2009a; Amir et al., 2009b; Schmidt et al., 2009), it is not clear whether this training approach is indeed the most potent approach available. For example, there is evidence that anxious individuals also show biases and deficits in the processing of positive stimuli (e.g., Bradley, Hogg, White, Groom, & de Bono, 1999; Frenkel, Lamy, Algom, & Bar-Haim, 2008; Mansell, Clark, Ehlers, & Chen, 1999), thus, conceptually, attention could be trained away from threat and toward positive stimuli or even simply away from neutral and toward positive stimuli.

Indeed, Wadlinger and Isaacowitz (2008) used a dot-probe task to train a nonselected group of undergraduate students to attend either toward positive or toward neutral words (happy–neutral displays). Eye-tracking revealed that participants trained to attend to positive information looked significantly less at stressful negative images presented to them upon completion of the attentional training than their counterparts who were trained to attend to neutral stimuli. This finding suggests that positive attention bias may be used to regulate attention patterns and thereby emotional response while under stress. Li, Tan, Qian, and Liu (2008) took a different training approach and used threat–happy

face pairs in a dot-probe protocol designed to train socially anxious students to attend away from threat and toward positive faces. Their task comprised a total of 480 critical trials per session, delivered on seven successive days. However, group differences in threat bias were unstable during the seven days of training and training effects did not last from one session to the next. Furthermore, no significant changes in social anxiety scores as a function of attention training condition were found. These results may be taken to suggest that attention training toward positive stimuli is less efficient in reducing anxiety than attention training away from threat and toward neutral stimuli. However, there are numerous factors that can explain the failure of this particular study to alter attention and anxiety patterns. Perhaps the most obvious reason is that each daily training session in this study ended with 120 trials presenting the target probes with equal probability at the locations of threat and happy faces. This was done to obtain a measure of threat bias change for each session, but might have undone the intended training effect at the end of each session. This is an excellent example of a common conflict in this line of research between the desire to closely monitor the impact of training on attention (manipulation check) and maximizing the potential impact of training on anxiety symptoms. Another reason for the unstable results in the Li et al. (2008) study might have to do with the simultaneous presentation of two emotional faces (happy and threat). This presentation mode can influence the affective tone and arousal levels of the training procedure as a whole, and introduce an emotion-related competition for attentional resources that might flatten the expected threat bias reduction effect.

To summarize this section, there is a rich variety of stimuli that could be used in attention training protocols for anxious populations. Selecting the right combination of stimuli for specific patient populations can immensely impact the magnitude of treatment effects and presents as a major area of much needed systematic exploration.

What is being trained with attention training protocols?

There is an overwhelming dominance for use of the dot-probe task in attention training studies. One of the criticisms of the dot probe task is that training-related changes in performance could be the result of either modulation in attentional engagement with threat, or of modulation of the ability to disengage from it. Thus, it is not entirely clear what the attention components being trained with dot-probe protocols are. A recent dot-probe attention training study measuring event-related brain potentials revealed that attention training away from threat modulated anxious participants' top-down processes of attention control rather than processes of early

attention orienting (Eldar & Bar-Haim, 2010). Indeed, there is some indication that the threat-related bias in clinical anxiety might be dependent to a greater extent on more elaborate processing of the threat than on automatic pre-attentive processes (Bar-Haim et al., 2007; see also McNally, 1995). These findings may have practical implications for interventions aiming at a systematic reduction of threat bias in anxious patients. For instance, ABM protocols targeting the disengage component of attention (e.g., using variants of the Posner's spatial cueing task) may prove highly efficient. It is important, though, to make a distinction between the attention training procedures discussed here and attention training therapy (Wells, 2009). Wells and colleagues' approach deals primarily with diverting attention away from self-focused negative thoughts. In contrast, ABM is focused on diverting attention from minor threats in the environment, which may be effective in many daily circumstances entailing minimal objective threat. There is also a difference in its focus on targeting early attention processes vs. the more elaborate attention control processes targeted by Wells' procedures.

The optimal structure of attention training protocols

There is considerable variability in the number of sessions and the number of trials per session that have been implemented in ABM protocols. This variability ranges from 7500 trials delivered over 10 sessions (Mathews & MacLeod, 2002) to a single session of 160 trials (Amir et al., 2008) that lasts approximately 8 minutes. There is not enough systematic data yet to determine the optimal delivery of attention training protocols in terms of number of trials and sessions. Our own experience suggests that most clinically anxious children who are at least 8 years of age are able to comply with five 50-minute weekly dot-probe training sessions of 480 trials each. Clearly, however, shorter and fewer sessions could increase compliance and cost-effectiveness, particularly in pediatric populations. To delineate the parameters of the most efficacious protocol, future studies will have to closely inspect both group and individual learning curves within and across sessions.

Additionally, the lasting effects of training on both attention bias and anxiety should be measured in follow-up assessments. The most impressive evidence to date suggest that for adults with SP, eight sessions across four weeks, each incorporating 160 trials, produce strong therapeutic effects and considerable retention at four-month follow-up (Amir et al., 2009b; Schmidt et al., 2009). It remains to be seen whether attention training protocols could be shortened without ceding efficacy. Furthermore, as discussed by MacLeod, Koster et al. (2009), the possibility that treatment results and outcome per-

sistence might be enhanced by spreading rather than crowding therapy sessions should be seriously considered. The use of booster sessions, to periodically reinstate the target patterns of attention training, may also prove effective in sustaining the impact of treatment.

Explicit vs. implicit training

All ABM studies so far have relied on participants' implicit (as opposed to explicit) learning of the intended contingencies between threat cues and target location. Some studies have even added a certain amount of non-contingent trials in order to ascertain that the intended cue-target contingencies do not become obvious (e.g., Amir et al., 2009). There are reasons to believe that implicit learning might be more efficient in modifying threat bias, as it overcomes potential resistance and conscious avoidance by gently but consistently challenging preexisting biases. Indeed, a vast majority of participants who received active training report that they believe they had been assigned to the placebo control group (MacLeod, Mackintosh, & Vujic, 2009). However, one may argue that explicit instruction to attend to a certain contingency may produce steeper learning curves and more prominent reductions in anxiety. A recent study delivering the same dot-probe ABM task either with explicit instruction and explanation of the task's contingencies, or with no such instructions, indicates that this is probably not the case, and that anxiety-related effects are stronger in the implicit learning condition (MacLeod, Mackintosh et al., 2009). However, a more detailed examination of the effects of explicit vs. implicit learning on attention bias modulation and anxiety symptoms is required.

Attention training for anxious children

As mentioned above, except for Eldar et al.'s (2008) study, which applied an ABM protocol with non-anxious children, no other pediatric data has been published. There are at least three clinical trials currently running with children but it will take a while before these data will be ready for presentation. However, accumulating experience and prior studies on attentional threat bias in children and adolescents (Dalgleish et al., 1997; Monk et al., 2008; Pine, 2007) indicate that there are several unique considerations in applying attention training to this population. First, due to large variability in children's reading proficiency, it is recommended that attention training protocols designed for children use pictorial cues (e.g., faces) rather than words. Second, children younger than 7 years of age find the dot-probe task very difficult, which results in large number of errors and unreliable procedures. For older children (8–12 years), shorter training periods, fewer trials, and frequent breaks between training blocks may be necessary (Perez-Edgar & Bar-Haim, in press) and this might have a negative impact on anxiolytic

effects. Even older children and adolescents commit significantly more errors than do adults on tasks similar to those used in ABM protocols, and anxious children are prone to even lower accuracy, particularly during the first sessions of training when stress is still high. Therefore, close monitoring of accuracy rates as training progresses is required. That being said, our experience also indicates that with a reasonable number of slow self-paced training (∼40 trials), accuracy levels can be enhanced considerably. Such preparation can sometimes make the difference between successful application of ABM and dropout. Finally, attention training research and practice relies on relatively simple and, in many respects, visually dated and dull graphics. Current technology could clearly provide new packaging of the computer tasks in a fashion that is more appealing for children. This could considerably enhance compliance and clinical efficacy.

Summary

While for the time being most of the above delineated dilemmas remain unresolved, they highlight the complexity and myriad parameters that could influence the efficacy and cost-effectiveness of attention training protocols, and the need for systematic manipulation of these attention training parameters. In a sense, attention training research and practice is like a newly discovered oil field. Preliminary surveys clearly indicate that a valuable resource has been identified, and it is now time to move on and systematically delineate the most efficient ways to extract it.

Conclusion

Taken together, the extant evidence portrays a promising future for ABM treatments in anxiety. The findings suggest that attention training is associated with dramatic symptom reductions, including remission of diagnoses and maintained positive treatment effects four months after completing the training. ABM may have several advantages over traditional psychosocial treatments because of ease of delivery. Some of the specific advantages that make this treatment particularly appealing for children and adolescents include little need for therapist contact and that, relative to standard CBT or psychosocial protocols, it requires little effort or motivation from patients. Furthermore, the computer-based interface of attention training (with some graphic and packaging upgrades) could bring therapy into the intuitive lifestyle of many children and adolescents, improve compliance with treatment, and open up the possibility of reaching potential patients who do not have access to CBT or medication, through web-based protocols and software installations (see also Kaltenthaler et al., 2008). Finally, as pointed out by MacLeod, Koster, and Fox (2009), because it can be delivered remotely

and is relatively cheap, attention training seems particularly suitable for ongoing post-treatment use to minimize relapse rates and enhance maintenance of treatment gains.

A powerful asset of this rapidly evolving evidence-based therapeutic approach is its rootedness in strong experimental cognitive science and cognitive neuroscience research. This rigorous scientific tradition propels both theory and practice and it is important that this thrust be integrated with a sensitive clinical approach. It has been rightfully pointed out (MacLeod, Koster, and Fox, 2009; Pine et al., 2009) that it would not be reasonable to expect that ABM will always yield therapeutic gains for any type of anxiety disorder. This must depend upon whether a specific bias does or does not play a causal role in the etiology and maintenance of a particular anxiety disorder and on whether the training process specifically and effectively targets this bias. The next few years will witness a growing number of clinical trials that will serve to establish and perfect the efficacy of attention training protocols across different anxiety disorders in children and adults. These trials will determine not only the technical parameters of the attention training protocols, but also whether it will serve as a standalone treatment or become an established part of existing treatments. Viewed from a broader perspective, threat-related attentional biases could be characterized as a specific target for therapies in anxiety, much like specific cognitive perturbations have been delineated as targets for novel therapies in schizophrenia (see Buchanan et al., 2005; Green et al., 2004; Nuechterlein et al., 2004). This approach has exerted an immense impact on how researchers and therapists think about new treatments and could be readily applied to current thinking about novel therapies such as ABM for anxiety disorders.

Acknowledgement

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Key points

- Anxiety disorders in both children and adults have been associated with threat-related attention biases.
- Recent studies have shown that threat biases can be modified via computer-based attention bias modification (ABM) protocols.
- Randomized control trials (RCTs) in adult patients have shown that ABM significantly reduces anxiety symptoms, revealing treatment effect sizes of similar magnitude as those reported in first line treatments (CBT, SSRIs).
- RCTs in pediatric populations are needed to provide conclusive evidence for ABM treatment efficacy for anxious children.

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