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A Review of Attention Biases in Women with Eating Disorders

V. Aspen, A. Darcy, and J. Lock

Department of Psychiatry and Behavioral Sciences, Stanford University, Stanford, CA, USA

Abstract

There is robust evidence that women with eating disorders (EDs) display an attention bias (AB) for disorder salient stimuli. Emerging data suggests that the presence of these biases may be due, in part, to neurological deficits, such as poor set shifting and weak central coherence. While some have argued that these biases function to predispose and/or act to maintain disordered eating behaviors, evidence supporting this view has rarely been examined. This report summarizes and integrates the existing literature on AB in EDs and other related psychiatric disorders to better understand its potential role in the development and maintenance of an ED. The domains reviewed include experimental data using the dot probe and modified Stroop task and neurobiological findings on AB in women with EDs as well as the role of AB in current theoretical models. We conclude by proposing an integrated model on the role of AB in EDs and discuss treatment approaches aimed at modifying these biases.

Keywords

attention bias; eating disorders; attention bias modification; information processing biases; meta analysis

Within the field of psychopathology, attention bias (AB) refers to a tendency to over focus awareness on information in the environment that is disorder salient. Over the last two decades, AB has been investigated across many areas of psychopathology including depression, anxiety and eating disorders (Yiend, 2010). It has been theorized that AB can predispose an individual to develop a disorder and/or operate to maintain it (Fairburn, 1991; Faunce, 2002; Power, Cameron, & Dalglish, 1996). Tasks used to measure AB were originally adapted from experimental psychology and are designed to measure AB without conscious awareness of the constructs of interest. These tasks display neutral and emotionally salient images or words to participants on a computer screen and measure the time in milliseconds (ms) it takes to respond to a simple instruction (e.g., name the color you see regardless of what the word says). Results from these studies have found that individuals with some psychological disorders attend to disorder salient stimuli (e.g., the word ‘danger’ as compared to the word ‘chair’ in anxiety disorders) for longer periods of time as compared to healthy controls. This over attention interferes with completing a simple task (e.g., name the color you see regardless of what the word says) by increasing the amount of time it takes to complete it. This delay and interference is attributed to the emotional salience of the overvalued word.

AB is relevant to eating disorders (EDs), because these disorders are characterized by an overvaluation of shape and weight (American Psychiatric Association, 2000) and preoccupation with body image. This overvaluation and preoccupation sometimes takes the

form of selective attention (i.e. AB) to disliked body parts and/or body comparisons to other women, a key variable leading to disordered eating behaviors. In this way, AB is intertwined with the core symptomatic cognitive components of an ED and thus may have a critical role in developing and/or maintaining them.

Theoretical Models

Although several theories purport to explain the role of AB in the context of anxiety disorders (Mogg & Bradley, 1998; Williams, Mathews, & MacLeod, 1996), a comprehensive account about how AB might operate in EDs has not been formulated. Many of the existing theoretical models on the development and maintenance of EDs suggest a role for AB. For example, the cognitive model (Vitousek & Hollon, 1990) proposes that individuals with EDs possess elaborate and inaccurate schemata centered around the body resulting in automatic thoughts about body weight and shape. These faulty schemata lead to systematic errors in thinking including selective attention and confirmatory bias to weight/shape related information resulting in more habitual and automatic ED related behaviors. A related formulation is Fairburn's cognitive model (1981) for bulimia nervosa (BN) which suggests that environmental pressures (e.g., a societal pressure to be thin) lead to an over value and over focus on body weight/shape. This over focus results in a preoccupation with and selective attention (i.e. AB) to disliked body parts that, in turn, leads to body dissatisfaction and extreme dietary restriction to improve self-image. Fairburn and colleagues (1999) also propose a model to explain the factors that maintain anorexia nervosa [AN]. Frequent checking of body parts (e.g., checking weight and/or the way clothes fit, intense scrutiny of particular body parts; pinching skin to assess fatness) leads to strengthened AN-related behaviors. This repeated scrutiny of body parts serves as a confirmation bias in which individuals with AN seek out supporting evidence of their AN-related beliefs (e.g., "I am enormous") while discounting any evidence that contradicts them (e.g., feedback from others on dramatic weight loss). Lastly, Heatherton & Baumeister's (1991) purport that women with EDs have extremely high standards and expectations of themselves. As a result, they have a heightened awareness of the self and particularly how they fare in comparison to others. This over focus on self/other comparison ultimately leads to disappointment when standards are not met, resulting in selective attention to negative self-related information (e.g., "I am a failure") and corresponding negative affect.

In addition to these formulations about the specific role of over attention to body, shape, and self, anxiety likely contributes to how AB might operate in EDs given the high rates of co-morbidity, similarity in symptom presentation (e.g., disorder specific rituals and phobias), genetic data linking EDs and anxiety disorders (Bulik, Wade & Kendler, 2001; Forbush et al., 2010; Keel, Klump, Miller, McGue & Iacono, 2005; Lilenfeld et al., 1998; Strober, Freeman, Lampert & Diamond, 2007), and the experience of exaggerated or irrational fear in patients who have these disorders. In addition, theories about how AB operates in anxiety maps nicely onto EDs and may suggest novel ideas on how and why AB might develop and function within the context of EDs. (See Cisler & Koster, 2010 for review). Anxiety disorders are fear-based disorders that are theorized to be maintained in part by overly attending to environmental cues that signal potential danger — this over attending then translates into safety/avoidance behaviors. Research has shown that individuals with anxiety disorders have cognitive structures that facilitate the processing of danger-related information (see neuroscience section below for details) resulting in a general response to disorder salient stimuli with the 'potential for danger' regardless of the probability (MacLeod, Mathews, & Tata, 1986; Mathews & MacLeod, 1985). Additionally, the level of interference (AB) has been shown to be affect dependent where increased anxiety results in higher rates of attending to and interpreting ambiguous stimuli as dangerous (Clark, Salkovskis, Ost, Breitholtz, Koehler & Westling, 1997; Mathews & MacLeod, 1985, 1994;

Thorpe & Salkovskis, 1997). Thus, anxiety in the context of an ED likely exacerbates or amplifies disorder specific AB and may therefore perpetuate the maintenance or worsening of ED symptoms.

Neuroscience of AB

AB operates through neural circuitry and neurocognitive function. However, there is limited research on the neural basis of AB in EDs. Because of the overlaps and likely contribution of anxiety to AB in EDs discussed above, studies of the neural basis of AB in anxiety disorders may shed light on similar processes in EDs and serves as the principal paradigm in this discussion.

A significant body of research on animals and humans implicates the limbic system (amygdala and insula) and prefrontal cortex (PFC; medial PFC and ventrolateral PFC) in the processing of threat-based stimuli (Monk, 2008). The processing of emotional stimuli in individuals with EDs likely involves similar circuitry (Ellison et al., 1998; Frank & Kaye, 2012; Miyake et al., 2010; Pietrini et al., 2011; van Kuyck et al., 2009). Within the field of anxiety disorders a limbic-medial prefrontal circuit is proposed wherein threat-based stimuli are interpreted initially by the limbic system (Etkin, 2010a; Hariri, Mattay, Tessitore, Fera, & Weinberger, 2003). This information is transmitted to the medial PFC (mPFC) where the stimuli are evaluated more extensively resulting in feedback to the limbic system on whether to inhibit or activate an emotional response to the stimulus. The mPFC is also believed to convey information to the ventrolateral PFC (vlPFC), which is responsible for explicit behavior including attention and avoidance. (see Etkin, 2010a and Figure 1 for a review of this proposed limbic-medial prefrontal circuit).

AB in anxiety disorders is hypothesized to originate separately from the amygdala and vlPFC. Specifically, neural models suggest that the amygdala response to threat produces an automatic deployment of directed attention (evoked unconsciously by the stimulus itself) followed by a more flexible response (conscious and effortful) from the vlPFC (routed from the amygdala through the mPFC to the vlPFC; pathway described above)(Bishop, 2007; Desimone & Duncan, 1995; Vuilleumier, 2005). Indeed, brain imaging studies using fMRI have found evidence for an attention-based circuit involving the amygdala and the vlPFC (Monk et al., 2006; Monk et al., 2008) with disruptions linked to anxiety-based symptoms and full threshold anxiety disorders (Hariri et al., 2003; Monk et al., 2006; Monk et al., 2008). In general, it appears that a threatening image/word (e.g., angry face) is interpreted by the amygdala in a universal way [no difference between patients and healthy controls; (Monk et al., 2006)] unless the threat is masked (Monk et al., 2008). In this instance, anxious individuals show an increased response, indicating that ambiguous stimuli may be interpreted as particularly “dangerous” for people with anxiety disorders, and fits nicely with the clinical descriptors for this class of disorders.

Only a handful of relevant studies in EDs examined amygdala response to threat. Miyake and colleagues (2010) investigated the effects of negative body image words on brain functioning in individuals (12 per group) with anorexia nervosa- restricting type (AN-R), anorexia nervosa- binge/purging type (AN-BP), bulimia nervosa (BN) and healthy controls. They found that presentation of negative body image words activated the amygdala in those with AN only (AN-R and AN-BP). Increased amygdala response has also been found in women with AN when viewing distorted images of themselves (Seeger, Braus, Ruf, Goldberger, & Schmidt, 2002) and high caloric beverages (Ellison et al., 1998). In contrast, two recent studies using nonED based stimuli (angry faces & negative self beliefs) in women with BN found reduced activity in the amygdala (Ashworth et al., 2011; Pringle, Ashworth, Harmer, Norbury, & Cooper, 2011) as compared with controls. While it is difficult to interpret these results given the lack of comparison studies, it appears that the

processing of threats in EDs varies dependent on the specific ED diagnosis and the type of threat-based stimuli. However, the findings suggest that threat-based words that are disorder salient (food and body related) evoke an emotional response (e.g., fear) in AN similar to the response seen in anxiety disorders when using a masked threat.

Individuals with anxiety disorders show decreased activity in the vIPFC in response to threat-based stimuli as compared to controls suggesting that response to threat at the executive level is diagnosis dependent. In addition, studies have found negative connectivity between these regions of the brain such that increased vIPFC results in decreased amygdala response and vice versa (Monk et al., 2008). These findings have led researchers to conclude that vIPFC acts as a modulator for threat-based stimuli by adjusting the initial deployment of attention based on feedback from the mPFC (e.g., decrease attending if unnecessary) leading to decreased anxiety (LeDoux, 1995). The mPFC (Shin et al., 2005) and vIPFC (Monk et al., 2006) has been found to be underactive in patients with anxiety disorders potentially explaining their higher levels of anxiety and AB.

No studies of EDs which examine the role of the vIPFC in regards to AB are available. Although the Miyake study reported above (2010) did not look at the effects of the stimuli on the vIPFC specifically, they found that those with AN-R did not engage the mPFC. Given that the mPFC is thought to mediate activity between the amygdala and the vIPFC, these findings suggest that the vIPFC may be underactive in AN-R as well. Alternatively, a recent review on functional neuroimaging found consistent aberrant activity in the dorsolateral PFC (dlPFC) amongst individuals diagnosed with AN (Pietrini et al., 2011). The dlPFC like the vIPFC is involved in higher order executive functions including attentional processes and appears to have a role in cognitive inhibition and appetite suppression (Brooks et al., 2012). Given the multiple functions of the dlPFC relevant to EDs and its similarities with the vIPFC, it is possible that AB in EDs is mediated through disturbances in an amygdala-mPFC-dlPFC circuit. Additional work in this area is needed, including investigation into whether the vIPFC is involved in the processing of threat in EDs.

In addition to imaging work, researchers have measured brain activity in response to specific threat-based stimuli, using event-related potentials (ERPs). ERPs are a non-invasive method of measuring brain response and are considered especially useful in providing information on the temporal sequence of neural activity. Results from these studies find that anxious individuals detect threat at pre-attentive levels in the visual cortex significantly faster than healthy controls (Eldar, Yankelevitch, Lamy, & Bar-Haim, 2010; Mueller et al., 2009). These findings provide support for the “hypervigilance” component of evidence-based theoretical models on anxiety disorders and the neural theory that attention is in fact deployed implicitly. Similar results are found in the processing of food pictures regardless of caloric content in EDs (Blechert, Feige, Joos, Zeeck, & Tuschen-Caffier, 2011) whereas the inverse pattern (decreased responding particularly in the temporo-occipital regions) is found in adolescents with AN in response to facial expressions of emotion (e.g., disgust, fear, sadness) (Hatch et al., 2010).

Taking together the ERP and fMRI data, biased attending in individuals with anxiety disorders begins at pre-attentive levels and remains potentially due to a disruption in the amygdala-mPFC-vIPFC circuit. Specifically, the vIPFC is hypoactive in individuals with anxiety disorders leading to increased anxiety and over attending to cues. The findings for EDs are less clear, but support a similar framework for over attending to disorder salient stimuli. The data on non-ED specific stimuli suggest an attentional response more consistent with avoidance.

While the exploration of the circuitry underlying AB in EDs is just beginning, research on neuropsychological inefficiencies in EDs has been underway for some years. Neuropsychological studies are relevant for understanding AB because general cognitive style likely provides an additional vulnerability for certain kinds of content biases. For instance, there is a growing body of evidence that individuals with EDs have weak central coherence (Lopez, Tchanturia, Stahl, & Treasure, 2008; Southgate, Tchanturia, & Treasure, 2008), a deficit in which extreme attention to detail results in poor integration of information and consequently, deficits in global understanding (i.e., the gestalt). Within the context of an ED, this bias is thought to take the form of an excessive and detailed focus on variables such as weight, calories, and exercise at the expense of an understanding of their increased risk of mortality and morbidity. Poor set shifting, another deficit reported amongst individuals with EDs (Holliday, Tchanturia, Landau, Collier, & Treasure, 2005; Roberts, Tchanturia, Stahl, Southgate, & Treasure, 2007) relevant to AB, occurs when individuals have difficulty changing focus based on environmental demands (Miyake et al., 2000) and results in cognitive inflexibility. Both over attention and difficulty changing focus represent phenotypic characteristics of AB. While it is unclear if these vulnerabilities in detail processing are specifically related to AB, it is possible that they could exacerbate the capacity for biased attending in EDs.

Experimental Tasks for Evaluating Implicit AB in EDs

The methods for evaluating implicit AB employ different paradigms including the modified Stroop task, dot probe task, visual search task, exogenic cueing task and eye tracking tasks. We chose to limit our review to the modified Stroop task and the dot probe task as this is where the majority of the experimental research has been conducted to date. ED threat-based stimuli used in attention tasks have almost exclusively been related to food and/or body/weight/shape. Threat stimuli have been presented as 1) words on either a computer screen/printed paper or 2) photographic images. Reaction times have been measured using voice activation, keyboard response time and in some cases stop watches. The original Stroop task was developed in 1935 (Stroop, 1935) to study basic cognitive competition specific to attention-based processes. The basic task involves presenting words that spell basic colors (the word “red”, “blue”, “green”) either congruent (the word “red” in written in red ink) or incongruent (the word “red” written in blue ink) with the actual color of the word. Participants are asked to simply read the word regardless of the color it is presented in. Participants take longer to name the incongruent pairs (the word “green” written in blue ink) as compared to the congruent pairs (the word “green” written in green ink). Scores derived from this task are either reaction times (RT; typically in ms) or an interference score, which is calculated by computing the difference in reaction time between the congruent and incongruent words.

In the 1980s this task was modified for use with clinical populations and is the most widely used instrument to measure biases in selective attention across the spectrum of psychopathology (Williams et al., 1996), including EDs (Dobson & Dozois, 2004). In the modified version of the Stroop task (often called the emotional Stroop Task), participants’ RTs in naming the colors of emotionally salient words (e.g., “fat” for ED populations; “danger” for anxiety based population) are compared with RTs in naming the colors of neutral words (e.g., “box” or “butterfly”), with longer RTs suggesting that the emotional relevance of the word category is causing interference.

The literature in this area on EDs is extensive and includes four reviews (including 3 meta analyses) describing the performance of the emotional Stroop task (Brooks, Prince, Stahl, Campbell, & Treasure, 2011; Dobson & Dozois, 2004; Johansson, Ghaderi, & Andersson, 2005; Lee & Shafraan, 2004). Overall, each of the meta analyses have been consistent in their

conclusions. Dobson and Dozois (2004) included 28 studies involving women with EDs and those endorsing restrained eating/dieting. Their meta-analysis of ED category separately (AN, BN and dieting/restrained) found moderate effect sizes (ESs; calculated using Glass' g) for women with bulimia nervosa (BN) across all categories (food, body and classic Stroop words) suggesting a potential overall deficit in processing conflicting information. The ESs for the AN sample were not as strong, with only body related words producing a moderate effect; the ES for food- and classic Stroop-related words were small. The impairment findings amongst the dieting/restrained sample were minimal across threat categories. Johansson and colleagues (Johansson et al., 2005) included 27 studies in their review that focused on the impact of food and body related words on women with EDs (ED categories grouped and separately) and women reporting over concern with body image and/or eating. They found the ES for all groups (including healthy controls) on food and body words to be positive indicating that the ED threat-based words caused some level of interference for all participants as compared to control words. They found a medium ES for the ED group combined and for each disorder separately (AN and BN) across both food and body words. A small ES was found for both the healthy controls and the women with over concern with body and/or eating (no difference between these two). The authors suggested that their results may have differed from the Dobson and Dozois (2004) review due to inclusion criteria and the way that ES was calculated (Glass' g vs Cohen's d , respectively). Brooks and colleagues (2011) evaluated 63 AB studies (studies other than emotional Stroop were included) specifically testing a bias amongst ED patients to food stimuli only. They excluded any studies that used an intermixed (e.g., food and body words) presentation of words or lacked a healthy control comparison. Women with AN ($n = 13$), BN ($n = 9$) and restrained eaters ($n = 9$) were included in the analysis for the emotional Stroop task only. Using Cohen's d , they reported a moderate ES for the BN sample and a small ES for the AN and the restrained eaters samples.

Two recent papers using the emotional Stroop task expanded the threat category to include facial expressions as opposed to ED words. Harrison and colleagues (2010a; 2010b) examined whether the social-interpersonal deficits common to this population are manifested as AB to social cues. In the first study (2010a), the authors administered the emotional Stroop task with images of angry and neutral faces to 50 women with AN, 50 with BN and 90 healthy controls. They found that women with EDs (women with BN and AN did not differ from one another) displayed significantly longer reaction times to angry face as compared to the healthy controls. In addition they found that AB to angry faces significantly predicted emotion regulation difficulties. In the second study (2010b), Harrison and colleagues compared 50 women with acute AN, 35 women recovered from AN, and 90 healthy controls on the same task. They found that women with AN (past or current) displayed a significantly higher AB for angry faces as compared to healthy controls, suggesting that the bias might represent a trait as opposed to a state variable.

Several critiques have been made regarding the emotional Stroop task. For instance, in spite of the many studies that have used this task, few have investigated what specific processes are causing the increased RTs. It has been theorized that increased RTs are due to a hyper vigilance towards threatening information. However, the way the task is constructed does not allow the investigator to disentangle whether it is an attention towards (i.e., hyper vigilance) or away from (i.e., avoidance) the threat based stimuli. In addition, there are numerous inconsistencies amongst the individual studies in terms of how reaction times are obtained and how the control words are selected (and in some cases not even provided)(Lee & Shafran, 2004). Finally, the emotional Stroop effect has been found in non-clinical samples, which some argue limits the usefulness of this task (Lee & Shafran, 2004). Given these limitations, many researchers have shifted towards other potential useful technologies to assess AB in EDs.

Regardless of inclusion criteria and calculation of ES, there is a clear and robust AB to ED related stimuli amongst women with EDs using the emotional Stroop task. In addition, all women, regardless of symptomatology, appear to display some interference (small ES) with minimal distinction between restrained eaters and healthy controls. Amongst ED diagnoses, the BN sample has the most consistent results with a moderate ES across food and body words. The findings for the AN sample are less uniform, with a consistent moderate ES for body-related words but ESs varying from small to medium for food-related words. Newer research suggests that individuals with EDs, regardless of symptom status, have biases towards social cues — suggesting that AB in this population may extend beyond the traditional ED threat-based categories of food and body words. Finally, due to well documented limitations of the emotional Stroop task, namely the lack of interpretability, other cognitive processing paradigms (i.e., the dot probe task, described next) have been modified for use in ED samples.

Dot Probe Task

The dot probe task (MacLeod et al., 1986), similar to the emotional Stroop task, is designed to tap implicit AB. In this task, a probe is presented (e.g., X in the center of the screen) prior to the presentation of the stimuli to center the participant's eyes. Following the initial probe, emotional and neutral stimuli are presented on the screen (stimulus presentation for this task includes words or images that are displayed either top/bottom or left/right). Immediately following the emotional/neutral stimuli, another probe (e.g., single letter "E" or "F") is presented in either the spatial location occupied by the emotional or neutral stimuli at which point participants are instructed to identify the probe as quickly as possible (e.g., press a key on the keyboard corresponding with the probe presented; press the 'E' key). The general idea here is that if the probe is displayed in the spatial location of the word/image that the person was already attending to (e.g., because of the emotional valence; the word 'fat'), response time will be faster than if the probe appears in the spatial location of the word/image they were not attending to (e.g., 'paper').

Although this task has been extensively used in the anxiety literature, it has been relatively underutilized in the ED field with only 6 studies published studies on individuals with EDs. Rieger and colleagues (Rieger et al., 1998) compared 33 participants with BN and AN to healthy controls. They found that participants with EDs looked away from positive shape- and weight-related words (significant difference) and tended to look towards (trend level) negative shape- and weight-related words. In 2007, Shafran and colleagues basically replicated these findings using photographs of food (as opposed to words) relating to eating, shape and weight in two separate studies (Shafran, Lee, Cooper, Palmer, & Fairburn, 2007). The initial study included 23 ED participants [AN, BN and ED not otherwise specified (EDNOS)] compared to 4 control groups (women with high levels of anxiety and low, medium and high shape concerns without eating pathology). In the follow-up study, Shafran and colleagues (2007) 50 women with EDs were compared with 44 healthy controls. The results from both studies replicated Rieger and colleagues (1998) findings except that they did not find as strong of a bias for shape-related words. The authors speculated that the shape component may need to be personally relevant (e.g., self photos) to capture AB.

In a more recent paper, Blechert and colleagues (Blechert, Ansorge, & Tuschen-Caffier, 2010) addressed the speculation made by Rieger and colleagues (1998)— specifically, do actual photographs of the self and others cause AB in healthy controls and women with AN and BN. The authors found no bias for the controls. Amongst the ED sample, women with AN demonstrated a significant bias for self photos whereas women with BN demonstrated the opposite (though non-significant; bias towards other women) suggesting a potential trend for differential biases depending on diagnoses.

Two studies have examined factors that influence AB on the dot probe task. Lee and Shafran (Lee & Shafran, 2008) examined the temporal factors related to AB (specifically, the inter-stimulus interval between when the word disappears and the probe appears) and found that when increasing the stimulus interval period from 500ms to 2000ms that the biases for (negative and neutral) eating and shape related stimuli disappeared, with an exception for weight-related stimuli. In the second study, (Smith & Rieger, 2010) 54 female undergraduates were recruited without any eating related pathology and primed before completing the dot probe task which contained negative shape and weight related words with either a 1) body dissatisfaction condition (scenario: on the beach in swimwear and overhearing negatively evaluations about body by attractive people); 2) negative mood condition (scenario: giving a presentation and overhearing negative feedback from others); 3) neutral condition (scenario: walking through the forest). The authors found that, contrary to their hypothesis, the negative mood induction, not the body dissatisfaction condition, created an AB to weight and shape related words. In fact, 78% of those in the negative mood condition vs. 33% in the body dissatisfaction condition displayed a tendency towards an AB on the task suggesting that mood, as opposed to body dissatisfaction, may be more central to inducing bias to threat related information.

In order to better interpret the existing literature, we conducted a meta-analysis on the studies that employed the dot-probe task to investigate AB group differences between female ED samples healthy controls. The studies included were identified through a search in the PubMed database using the following key words: dot-probe or probe detection task; EDs or anorexia nervosa or bulimia nervosa or binge eating disorder or ED not otherwise specified, AB or selective attention. We excluded studies that used mixed presentation of stimuli (negative shape and emotion); or did not provide data needed for the calculation of between group ESs. Of the 6 identified studies from 5 published reports, we excluded two. The first was excluded because the findings were based on a non-clinical university sample (Smith & Rieger, 2010), and the second because it employed a paradigm that was not comparable with the AB conceptualization that we were applying here (Blechert, et al., 2010). The above criteria led to the identification of 4 studies from 3 published articles (see Table 1).

We examined the question as to whether people with ED demonstrate AB on the dot probe task relative to healthy controls using the following stimuli: positive shape, negative shape, positive eating, and negative eating. Relevant data were extracted from text, tables and figures reporting mean AB scores and standard deviations. Due to the limited sample size we were most interested in ES differences as opposed to significant p values. Thus, Cohen's *d* ES index (difference between the means of the two groups divided by their pooled standard deviation) was used for all outcomes. Where multiple comparisons were made, we conducted four separate analyses on dot-probe task performance resulting in separate analyses for positive shape, negative shape, negative eating and positive eating stimuli. Given the small sample, for studies that reported results by phenotype, we combined the mean scores using the method outlined in (Borenstein, Hedges, Higgins, & Rothstein, 2009) to give a composite score corresponding to an ED group. Where means were reported for separate control groups the same method was applied. All meta-analytic computations and analyses were carried out using Review Manager 5 (Collaboration, 2011). We used random effects models to be more conservative since there were so few studies. For the summary tables depicting standard mean differences, positive *d* values indicate AB toward the stimuli whereas a negative *d* value indicates AB away from the stimuli.

The results of the analysis for positive shape stimuli are in Figure 2. We observed little evidence of significant AB differences between the total 117 ED subjects and 226 healthy controls for positive ($Z=0.72$; $p=0.47$) shape stimuli, but there was a large degree of

heterogeneity (Chi-square (3) = 11.04; $p=0.01$; $I^2 = 72\%$) though this would be expected with only 4 studies. The combined ES was -0.16 , however aside from the difficulty interpreting in the context of heterogeneity, the 95% confidence intervals indicated that the standardized mean difference may be 0.

The results of the analysis for negative shape stimuli can be seen in Figure 3. We failed to find a significant effect for negative shape stimuli ($Z = 1.33$; $p = 0.18$), however there was some, though non-statistically significant evidence of heterogeneity (Chi-square(3) = 6.98; $p=.07$; $I^2 = 57\%$). The combined ES was .26 and overall 95% confidence intervals crossed 0.

The meta-analysis for positive eating stimuli can be seen in Figure 4. As we might expect from only 3 studies based on a total of 84 ED and 194 healthy control subjects, there was a very large amount of heterogeneity between the studies (Chi-square (2) = 14.85; $p < .01$; $I^2 = 87\%$) making it difficult to interpret the meta-analysis. However, this preliminary meta-analysis suggests a significant AB away from positive eating stimuli ($Z=2.28$; $p=0.03$) with a total ES of -0.83 .

Similarly, there was a large amount of heterogeneity for the studies examining negative eating stimuli (Chi-square (2) = 10.65; $p = .01$; $I^2 = 81\%$). However this preliminary meta-analysis observed evidence of significant AB toward negative eating stimuli ($Z = 2.45$; $p = 0.01$) with a combined ES of .80.

The research using the dot probe task with ED samples remain preliminary. Descriptively, the findings suggest that women with EDs have a biased attention towards negative shape/weight related stimuli (words and images); within diagnostic ED categories, there appears to be differential biases in relation to self (AN bias) vs. other (BN bias) photographs. Finally, negative mood was found to induce AB to weight/shape related words suggesting that emotional states may play an important role in how information is processed (affect dependent) and interpreted by ED patients. From a meta-analytic standpoint, findings suggest that women with EDs demonstrate an AB toward negative stimuli (large ES for negative eating related stimuli and small ES for negative shape related stimuli) and away from positive stimuli (large ES for positive eating and small ES for positive shape related stimuli). However, given the few studies included, these findings should be interpreted with caution.

Summary and Proposed Integrated Model of AB in EDs

The major theoretical models of EDs implicate AB as a catalyst further perpetuating the disorder (i.e., maintaining factor). In addition, experimental studies conducted to date using the emotional Stroop and dot probe paradigms have found that individuals with EDs display an implicit and consistent AB to disorder salient stimuli (e.g., body size, food). One important distinction between the major theories and experimental studies is on the individual's awareness of the AB. Specifically, while the ED theoretical models all describe AB as a result of conscious focus with some level of insight and awareness, the experimental studies provide strong evidence for AB that is out of awareness and relatively automatic (unconscious). Taking together the phenotypic evidence for explicit AB and the experimental evidence for implicit AB a theoretical model that integrates both types of processing is needed for EDs.

The field of anxiety disorders has a large literature on the role AB. Given some of the similarities between the two conditions it may be reasonable to conjecture that the theories and findings in anxiety disorders on attention may be applicable to EDs. In particular, theories on the neural circuitry related to AB are comparatively well developed in anxiety disorders and suggest that initial attention to a stimuli is implicit and deployed from the

amygdala (the bias that is captured in experimental designs) and is maintained explicitly due to faulty/hypoactive processes (e.g., reappraisal) at the executive level. While the research to date on the neurocircuitry of attentional processes in EDs is limited, preliminary findings using disorder salient stimuli thus far in the limbic and PFC appear to support this type of framework. In addition, anxiety disorders are theorized to be propelled by fear which creates the AB to stimuli in the environment which represent the actual fear (specific fear and threat source differs by disorder). Fear may play a similar role for EDs. Specifically, it has been theorized (Fairburn et al., 2009) that individuals with EDs judge their self-worth primarily in terms of their weight and shape and that this over evaluation is what drives the ED. While at the surface level, individuals with EDs commonly endorse fear related to weight/shape (e.g., “weight gain” and/or “fatness”) it may be that these stimuli are a proxy of the feared outcome of being rejected as a result of the weight gain (akin to being humiliated in social phobia and dying in panic disorder). If correct, this underlying fear could help to explain why an ambiguous cue (e.g., reflection in a mirror) is threatening and creates anxiety, and why the AB begins to escalate (e.g., check reflection multiple times a day to prevent the feared outcome).

Figure 6 captures a possible conceptualization of how AB operates in the context of an ED. Specifically, the model describes that vulnerabilities (e.g., genetic predisposition; executive function disruptions; cognitive inefficiencies) significantly increase the likelihood of AB in high risk individuals. Environmental stressors (e.g., traditional societal pressure to be thin (Fairburn, 1981); negative interpersonal interaction; self/other comparisons; eating a meal) encourage an individual to become focused on weight and shape most likely in response to thoughts about self-worth. When disorder salient stimuli are present in the environment, these individuals over attend as a result of their predisposition creating intense uncomfortable emotion, (predominately anxiety) leading to a range of disordered eating behaviors (dependent on diagnosis) to either 1) avoid the emotional response and/or 2) avoid the feared outcome. The cycle is self-perpetuated either through the effects of starvation (for AN) or through feelings of low self-worth and/or fear of rejection. Essentially, figure 6 depicts the traditional model of the development and maintenance of an ED (Fairburn, Marcus & Wilson, 1993) with the added component of AB (and the vulnerabilities that make AB more likely to occur). The model as shown can be applied to unconscious or conscious processes. While there is clearly some awareness of the AB, the specific nature and degree remains under study. Furthermore, A limitation of our model as described is that it is transdiagnostic and it is currently unknown if anxiety operates in a similar way across ED diagnoses. The implication from our model as proposed is that AB may function as a mediator leading to anxiety and thus serve an important role in the maintenance of an ED.

Treatment Utilizing Attention Bias Retraining

Attention bias modification (ABM) was originally developed by MacLeod and colleagues (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002) for use in anxiety patients. The idea behind this intervention was to first identify the patients’ specific biases and then train the patient’s brain to stop attending to them. This training is typically done using the dot probe paradigm, and is accomplished by manipulating where the probe appears on the screen. Specifically, in the traditional dot probe task the patient is asked to identify the probe (letter or number) by pushing a key on the keyboard. The probe appears randomly following either a neutral or threat related word. Bias is measured by comparing the RT to identify the probe when it follows a neutral vs. threat word. In the re-training version of the task, the probe always follows the neutral word such that over time participants implicitly learn to turn their attention away from the threat words. Results from initial studies have been promising, such that a recent meta-analytic review found that just a handful of re-training sessions resulted in significant symptom reduction for those suffering from clinical anxiety

disorders (Hakamata et al., 2010). Additionally, two studies have examined neural plasticity after completion of ABM. In the first study (Browning, Holmes, Murphy, Goodwin, & Harmer, 2010), 53 healthy participants were randomized to either an “avoid threat” or “attend-threat” training condition. Training was found to 1) induce the expected bias based on condition and 2) alter the neural systems involved in attentional control. In particular, the training appeared to affect activity in the lateral PFC such that after training greatest activity was detected in this region when the direction of attention was incongruent with their training. Furthermore, connectivity analysis showed a relationship between the lateral PFC and the visual cortex providing some evidence that activity in the lateral PFC influences visual attention. In the second study (Eldar & Bar-Haim, 2010), 30 anxious and 30 non-anxious participants were randomly assigned to “avoid threat” or to a placebo condition. Decreased reaction time to threat words was only found for anxious participants in the “avoid threat” condition. Additionally, ERP data revealed that early visuo-spatial orienting of attention (P1 and N1 components) was unaffected by training, while, PFC regions associated with emotion evaluation and attention disengagement (particularly the P2 component) were impacted. Specifically, P2 amplitude decreased among anxious participants in the “avoid threat” condition and increased in the anxious participants in the placebo group. Their results suggest that ABM does not alter initial hypervigilance to threat, it appears however to change late cognitive processes in the PFC, which may reduce attentional resources allocated to threat. As a result of these findings, use of this task has become an important intervention being explored in the field of anxiety disorders and now is being adapted for use with other psychological disorders [e.g., depression; (Baert, De Raedt, Schacht, & Koster, 2010; Hallion & Ruscio, 2011)].

There are three studies within the ED field that have used the principles of ABM (Smeets, Jansen, & Roefs, 2011; Smith & Rieger, 2006; Smith & Rieger, 2009). Using a similar paradigm to the one described above, Smith and Rieger (2006), investigated whether attending to negative weight/shape related words or negative emotion words would impact body dissatisfaction in a general sample of undergraduate women. Results indicated that only an attention induction towards negative shape/weight related words significantly increased body dissatisfaction. In 2009, the authors successfully replicated this finding and also explored whether training a sample of undergraduate women to attend to high calorie (e.g., cake) food vs. low calorie (e.g., carrots) food words would impact dietary restraint; results indicated that those who were assigned to attend to high calorie food words intensified dietary restriction (Smith & Rieger, 2009). In the most recent study, Smeets and colleagues (2011) investigated whether training women highly dissatisfied with their bodies to attend to their least favored or most favored body parts would change their levels of body dissatisfaction., the authors were able to demonstrate that positive manipulations (attend to most favored body parts) were effective in improving body dissatisfaction in women with high body concerns and negative manipulations (attend to least favored body parts) were effective in decreasing satisfaction in healthy women. The results from these investigations are promising and suggest that interventions designed to decrease AB to disorder salient stimuli may decrease disordered eating behaviors or cognitions.

Future Directions

Given the success ABM has had in the anxiety research, the high overlap in co-morbidity between anxiety and EDs, the strength of the preliminary findings on AB in EDs, and the data from the few attention-based ED studies to date, it seems reasonable that ABM may have utility in treating ED symptoms. Additionally, one of the major obstacles in effectively treating EDs is resistance. For example, many patients with EDs have extreme difficulty letting go of their ABs (e.g., body/weight checking) because it serves the perceived role of protecting the patient from the feared outcome of weight gain, low self-worth and ultimately

social rejection. Treating these biases using ABM may be a new and exciting approach to treatment as the training occurs at the implicit level and could potentially circumvent this external resistance.

The next step in exploring the utility of ABM in EDs is to examine the association between AB and disordered eating to better understand the relation between specific threats (e.g., food, body) and their effect on ED-related behavior. Additionally, a critical question is whether ABM can reduce ABs, ED symptoms, and disordered eating behaviors. We were able to locate one study on this topic that found AB in a sample of women with clinical EDs decreased after a successful course of CBT (Shafran, Lee, Cooper et al., 2008). This study provides preliminary data on an association between disordered eating and AB but more specific research is needed. Pilot studies by the authors examining these topics are currently underway. It is also unknown if ABM can function as a stand-alone treatment or if it would be better considered as an adjunct to existing treatments and whether it could be administered after treatment (potentially as booster sessions) to prevent relapse. In the anxiety literature, ABM has been shown in several RCTs to be effective as a stand-alone treatment (Amir, Beard, Burns, & Bomyea, 2009; Amir, Beard, Taylor, et al., 2009; Amir, Taylor, & Donohue, 2011; Eldar et al., 2012; Hakamata et al., 2010) but it is unknown if this task could have similar success with EDs. Administration of the ABM task typically takes less than 20 minutes thus testing it as an adjunct to CBT, for example, would be relatively simple and could be completed prior to or after the therapy session. Other possible areas to explore within the realm of treatment include examining if different patient profiles (e.g., symptom presentation) would differ in response to ABM, helping to better personalize treatments.

Another direction for future research in EDs is to better characterize the neuro-circuitry involved in AB. Currently, we have a limited understanding of the neuro-cognitive processes amongst those with EDs in general, thus an initial step is to conduct larger scale studies on ED samples to better understand the type and range of deficits. Preliminary findings suggest a bias towards detail, cognitive inflexibility and limbic and executive function abnormalities; further work is needed to understand if these deficits are related to AB. This type of work is already being done in the fields of anxiety (Etkin, 2010b, 2011; Etkin & Schatzberg, 2011) and depression (Hamilton, Furman, & Gotlib, in press) and future studies in EDs might follow this lead. Our reasoning for using AB in anxiety disorders as a model for EDs has been reiterated throughout this review, however, EDs are co-morbid with a number of other conditions (e.g., mood disorders, substance use) and there are significant etiological and behavioral differences between these two classes of disorders. Future research evaluating the potential overlaps between anxiety disorders and EDs specifically in relation to neural circuitry and ABM is needed.

Though the research in EDs on the existence of AB is extensive, little has been done on taking these findings to the next level. Understanding the function of ABs and their circuitry will be an important next step in the field. Preliminary findings using the principles of ABM in ED based studies are promising and it is possible that it may offer an exciting adjunct and/or alternative to traditional therapy approaches.

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Figure 1.

A limbic-medial prefrontal circuit view of emotional processing of threat-based stimuli. Relevant structures are separated into three functional groups (core limbic, evaluation and regulation). Threat based material is processed by the limbic system which includes the amygdala and insula. More extensive evaluation of the stimuli occur in the prefrontal cortex, specifically the dorsomedial PFC (dmPFC) and the dorsal anterior cingulate (dACC). Regulation of emotion and core limbic processing occurs through the ventromedial PFC (vmPFC) and the rostral and subgenual anterior cingulate (sgACC, rACC). Finally, the lateral PFC including the ventrolateral PFC (vLPFC) is involved in explicit behavior (e.g., attention/avoidance) and thought to modulate limbic activity.

Figure 2.
 Meta-analysis and forest plot for positive shape stimuli

Figure 3.
 Meta-analysis summary statistics and forest plot for negative shape stimuli.

Figure 4.
 Meta-analysis summary statistics and forest plot for positive eating stimuli

Figure 5.
 Meta-analysis summary statistics and forest plot for negative eating stimuli.

Figure 6.
Proposed Model on the Role of AB in EDs.

Dot Probe Studies Included in Meta Analysis

Table 1

Source	Dot Probe Content	ED Stimuli	N	Mean (SD)	HC Mean (SD)	N	Mean (SD)	ES	Findings
Rieger et al., 1998	Words related to thin and large physique; positive and negatively valenced emotion words	Neg shape	33	31.68 (82.47)	32	2.47 (48.09)	.61	.55	ED participants displayed bias away from thin physique words and a trend towards large physique words.
		Pos shape		10.19 (54.09)		19.20 (61.90)			
Shafraan et al., 2007 (Study 1)	Photographs related to eating, body shape body weight	Pos eating	23	-130.79 (119.36)	75	-10.48 (58.84)	1.58	.88	Women with EDs displayed biases towards negative eating and neutral weight pictures and biases away from positive eating stimuli; no biases for shape stimuli.
		Neg eating		57.56 (120.40)		-15.92 (70.59)			
		Pos shape		5.87 (48.56)		-5.04 (71.67)	.16		
		Neg shape		18.31 (60.77)		9.23 (90.85)	.11		
Shafraan et al., 2007 (Study 2)	Photographs related to eating, body shape body weight	Pos eating	38	-68.65 (109.41)	44	-3.34 (44.66)	.81	1.35	Findings from Study 1 replicated. Biases were also found towards negative and neutral shape stimuli.
		Neg eating		110.70 (123.40)		-11.69 (50.95)			
		Pos shape		0.74 (152.42)		-12.00 (62.29)	.11		
		Neg shape		89.97 (182.22)		4.91 (76.54)	.63		
Lee & Shafraan, 2008	Photographs related to eating, body shape body weight. Interstimulus interval (ISI) or 500 ms compared to 2,000 ms	Pos eating	23	13.26 (112.07)	75	34.19 (117.29)	.18	.21	Biases were observed towards weight-related stimuli were evident at both ISI. Biases towards shape- and eating-related stimuli were only evident with the 500 ms ISI
		Neg eating		24.11 (88.44)		4.68 (92.89)			
		Pos shape		9.49 (98.60)		-4.89 (99.58)	.15		
		Neg shape		-9.39 (118.84)		10.33 (94.15)	.20		