Visual Attention Bias and Body Dissatisfaction in Eating Disorders

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A dissertation submitted in partial fulfillment of the requirements for the

degree of Doctor of Philosophy at Virginia Commonwealth University.

by

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Table of Contents

List of Tables

List of Figures

List of Abbreviations

AN: anorexia nervosa

BCQ: Body Checking Questionnaire

BED: binge eating disorder

BIAQ: Body Image Avoidance Questionnaire

BMI: body mass index

BN: bulimia nervosa

CBT: cognitive-behavioral therapy

CPSD: Center for Psychological Services and Development

DBT: dialectical behavior therapy

DSM-IV-TR: Diagnostic and Statistical Manual of Mental Disorders

EDE: Eating Disorder Examination

EDEQ: Eating Disorder Examination—Questionnaire Version

EDNOS: eating disorder, not otherwise specified

PASTAS: Physical Appearance State and Trait Anxiety Scale

Abstract

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Eating disorders, such as anorexia and bulimia nervosa, have profound negative effects on the

quality of life of both affected individuals and their families. Behavioral approaches such as

cognitive-behavioral therapy (CBT) are commonly used for the treatment of these disorders.

CBT teaches skills to restructure maladaptive thought patterns as a method of altering feelings

and behaviors. However, even after CBT, 50-70% of women with bulimia and 67-87% of

women with anorexia report continued eating disordered thoughts, feelings and behaviors.

Measuring underlying cognitive processes such as orienting, maintaining, and executive attention

in individuals with eating disorder symptomatology might be an important first step in improving

these existing therapies. Attentional biases can be identified using a variety of techniques,

including eye movement in response to stimuli (gaze patterns; focal points) as assessed by

sophisticated eye tracking tasks. The current project sought to evaluate eye movement behavior

related to body dissatisfaction, and to assess the feasibility of modifying attention. Participants

(N = 1017) completed survey measures assessing disordered eating and body image (n = 1011), and participants meeting eligibility requirements participated in the in-person eye-tracking assessment (n = 85). Overall, longer gaze duration was associated with more dissatisfying body regions, and the attention modification intervention decreased time spent looking at the most dissatisfying region. Gaze time on the most dissatisfying body region was not different for self images compared with other images, nor was there an influence of level of shape concern. Body image anxiety also reduced after the attention modification intervention. These results suggest that it is feasible to modify attention biases related to body dissatisfaction. Implications and future extensions of this study are discussed.

Visual Attention Bias and Body Dissatisfaction in Eating Disorders

Eating disorders such as anorexia (AN) and bulimia nervosa (BN) affect approximately 7.5 million women and 2.5 million men in the United States (Hudson, Hiripi, Pope, & Kessler, 2007). Eating disorders are classified into diagnostic categories in the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR; American Psychiatric Association, 2004). AN involves severe dietary restriction, low weight, and fear of gaining weight. BN involves feeling out of control and eating a large amount of food and then purging those calories by, for example, inducing vomiting. Eating disorder not otherwise specified (EDNOS) involves considerable distress and interference with other aspects of life, but symptoms do not meet severity and frequency criteria for AN or BN. These disorders are serious mental health problems with severe consequences such as irregular heart function, intestinal problems, and hormonal dysregulation (e.g., Klump, Bulik, Kaye, Treasure, & Tyson, 2009). Threshold AN and BN negatively impact psychosocial, vocational, and cognitive functioning (Klump et al., 2009). Eating disorders have a high premature mortality rate (AN standardized mortality rate 5.86%) compared with other psychiatric disorders; 20% of those deaths are the result of suicide (Arcelus, Mitchell, Wales, & Nielsen, 2011). Individuals with eating disorders use significantly more physical and mental health resources than individuals without eating disorders (Striegel-Moore et al., 2008) and direct medical costs associated with these conditions can average $5.5 billion annually (Striegel-Moore, Leslie, Petrill, Garvin, & Rosenheck, 2000). Eating disorders are also often comorbid with anxiety and depression, substance use, and interpersonal problems (e.g., Herzog, Nussbaum, & Marmor, 1996).

In addition, an individual can report AN and BN thoughts and behaviors without meeting the threshold for a clinical diagnosis (e.g., Hudson et al., 2007). As many as 19 to 32% of young adult women manifest these "subthreshold" forms of eating disorders, which are associated with increased risk of progressing to a threshold form (Kashubeck-West & Mintz, 2001). Subthreshold eating disorders are also linked to considerable emotional distress (Stice, Marti, Shaw, & Jaconis, 2009). Thoughts and behaviors associated with subthreshold forms of eating disorders involve comparisons with peers as well as negative self-image.

Although researchers do not have a comprehensive understanding of etiological and maintenance factors, eating disordered behaviors are considered by many to be maladaptive strategies for regulating negative emotions and stressful situations (Heatherton & Baumeister, 1991). Emotional distress is linked to body dissatisfaction in both threshold and subthreshold forms of eating disorders. Body dissatisfaction is when women dislike how their bodies look or feel, and feel discrepant (heavier) from their body ideal (Ogden, 2010). Body dissatisfaction, especially weight concern, is strongly associated with developing threshold eating disorder behaviors (Jacobi & Fittig, 2010).

Given the prevalence of threshold and subthreshold eating disorders, and their severe physical and psychosocial comorbidities (Klump et al., 2009), these conditions present a critical public health risk. However, cognitive-behavioral therapy (CBT), a common treatment for BN and AN (American Psychiatric Association, 2006; National Institute for Clinical Excellence, 2004), is only moderately effective with 50-70% of individuals with BN (Fairburn et al., 2009; Wilson, Grilo, & Vitousek, 2007) and 67-87% of individuals with AN (Fairburn, 2005) still reporting considerable emotional and physical symptoms post-treatment. CBT teaches skills to change maladaptive thought patterns, which are proposed to alter feelings and behaviors. Recent

efforts to improve treatment efficacy have focused on underlying cognitive processes to understand how they maintain eating disorders. Addressing the underlying cognitive processes, particularly those related to body dissatisfaction, is an important part of any effective treatment (Farrell, Lee, & Shafran, 2005).

Overview of the Review of Literature

The first section of the Introduction will review the overarching construct of attention. Attentional bias as a putative factor in the development and maintenance of eating disorders originates in behavior theory. Work from the anxiety disorder literature based on behavior theory informs the role of these biases in eating disorders. This section also includes information on the contributions of cognitive-behavioral theory in the conceptualization of attention. Although anxiety research has assessed attention using methodology such as the Stroop, dot-probe and eye tracking tasks, these will be reviewed only in the context of attention and eating disorders. Attention modification interventions from the anxiety and addiction literatures will also be reviewed, as these informed the intervention evaluated in the current study.

The next section of this Introduction will review literature related to attention and eating disorders. Specifically, known neurocognitive effects of eating disorders will first be described. Next, attention will be reviewed in depth, including alerting, orienting, and executive attention abilities (Finucane, Whiteman, & Power, 2010; Posner & Rothbart, 2007). Behavioral manifestations of these abilities, including body checking and body image distortion will be addressed, as will the measurement of visual attention in eating disorders. Visual attentional biases were first measured with modified Stroop tasks, and more recently have been examined using dot-probe and eye tracking tasks. Finally, attempts to modify attentional biases related to

body image and to incorporate cognitive processes into eating disorder treatment, will be reviewed.

The third section will review current recommended treatments for threshold eating disorders. The "gold standard" for psychotherapeutic treatment of eating disorders is CBT. Initially developed by Fairburn (e.g., Wilson & Fairburn, 1993), CBT for eating disorders has been revised to improve efficacy (i.e., CBT-E, Fairburn et al., 2009). Despite being the recommended treatment for BN, AN and EDNOS (American Psychiatric Association, 2006; National Institute for Clinical Excellence, 2004), this therapy is still only successful for approximately 50% of patients (Fairburn et al., 2009; Mitchell, Agras, & Wonderlich, 2007). Therapies based out of cognitive-behavioral theory are also reviewed in this section, including CBT for body image and shape concerns. Other therapies commonly used to treat threshold eating disorders, including dialectical behavior therapy (DBT) and cognitive remediation therapy (CRT), are also briefly reviewed.

The literature search was conducted using the PsycInfo and Pubmed/Medline databases to find peer-reviewed articles related to both eating disorders and attention, focusing on more recent articles. From there, relevant sources cited by those articles were obtained and included when applicable. Overall, there is a solid foundation of information about attentional biases in eating disorders, upon which methodology that depicts visual attention behavior can improve to provide further support of theoretical concepts about the development and maintenance of eating disorders.

Attention

Foundations in behavior theory. Behavior theory derives from learning theory and conceptualizes pathology as originating in classical and operant conditioning (Mowrer &

Lamoreaux, 1946). That is, an intrinsically aversive stimulus caused pain in the past and the pain was paired with a neutral stimulus. This once-neutral stimulus then begins to elicit fear because the individual anticipates the presence of the initial, aversive stimulus. In the presence of this fear, individuals respond instrumentally by avoiding, or escaping, the fear. This reinforces the connection between the threatening stimulus and the fear.

Avoidance, a key characteristic of anxiety disorders, is intentional ignoring of emotionally-threatening stimuli, such as dissatisfying body parts. Individuals feel rewarded when they avoid threatening stimuli because their fear is reduced in the immediate moment (McAllister & McAllister, 1995). When individuals avoid looking at stimuli they fear, they do not have the chance to experience those stimuli. Experiencing the stimuli, however, could have helped reduce their fear (McAllister & McAllister, 1995). For example, if an individual is afraid of driving, she might avoid driving a car. If she drove a car, she might disconfirm a distorted belief that driving is inevitably associated with serious injury or death. However, avoiding driving does not allow for a new experience, and therefore the fear cannot be disconfirmed. Over time and without disconfirmation, the fear might strengthen because the belief is automatically and frequently reinforced through avoidance. Likewise, if a woman with an eating disorder is afraid of being fat because of the emotional associations she has with being fat, she might avoid looking at body parts that she believes are fat, such as her thighs. If she looked at her thighs, she would disconfirm her belief that she is fat, but not looking at them perpetuates that fear, and over time without disconfirmation, that fear strengthens. Thus, the executive attention ability that drives avoidance (because it reconciles demands on attention) is one attentional bias that can maintain threshold and subthreshold AN, BN and forms of EDNOS with extreme shape concern as a central feature.

Many different stimuli often pair with an initial aversive stimulus, and therefore, numerous internal and external triggers can elicit anxiety. Having many triggers is useful in the treatment of anxiety because exposure to any trigger, paired with relaxation and inhibition of avoidance, can weaken the tie between the aversive stimulus and anxiety-inducing stimuli and provide different targets for subsequent exposures and novel, disconfirming learning experiences (McAllister & McAllister, 1995). Over time, avoidance reinforces the anxiety that triggers provoke about contact with the aversive stimulus, and individuals' fear can intensify. The response to one trigger stimulus can generalize to other, similar stimuli (McAllister & McAllister, 1995). For example, if an individual were initially afraid of losing control when she was driving, this might generalize to anxiety that someone else driving might lose control, which might generalize to leather seats producing anxiety because they remind her of driving. As more stimuli elicit anxiety, more anxiety-laden situations trigger avoidance, which perpetuates generalization of related stimuli in the development of specific phobias and other anxiety disorders.

Eating disorders are not anxiety disorders, but anxiety is part of the constellation of eating disorder attitudes and affect. For example, individuals with eating disorders often report body image anxiety and report avoiding situations and thoughts that evoke negative affect related to body image (e.g., Reed, Thompson, Brannick, & Sacco, 1991). Individuals with threshold AN also report a fear of fatness that extends beyond weight and shape concerns to include fear of food that might lead to fatness (American Psychiatric Association, 2004; Thompson, Roehrig, & Kinder, 2007). These fears often become social because individuals fear that others will evaluate them as fat. Body image is a persistent and distressing element of eating disorders (Cooper &

Fairburn, 1987). The anxiety that individuals with threshold eating disorders experience is closely related to cognitions that influence how they see the world and themselves.

Contributions of cognitive-behavioral theory. Behavior theory conceptualizes pathology as originating in the classical conditioning of an aversive stimulus and as being maintained through anxiety and the avoidance of anxiety-provoking stimuli. However, behavior theory in general and within the eating disorder treatment literature in particular has been criticized as not placing enough significance on the dysfunctional cognitions and cognitive biases that occur in eating disorders (Williamson, Müller, Reas, & Thaw, 1999). Cognitions are essential to consider in the conceptualization of eating disorders because they contribute to how individuals perceive stimuli—including whether stimuli are threatening, safe, or neutral—and how individuals respond behaviorally to those stimuli. In the treatment of women with threshold BN, CBT is more effective than behavior therapy alone (Wilson & Fairburn, 1993), suggesting that the addition of cognitive restructuring plays an important role in the reduction of eating disorder symptomatology.

According to cognitive theory, how an individual thinks about and interprets events influences her emotions and behaviors (Beck, 1995). Core beliefs are the fundamental, global, and often rigid beliefs that an individual has about herself, the world, and herself in the world. These core beliefs lead to intermediate beliefs, which are rules and attitudes an individual establishes for herself, and which then lead to automatic thoughts. Automatic thoughts are brief and rapid and thus individuals often uncritically accept them as true. When an individual is presented with a situation, these automatic thoughts can be triggered and lead to a reaction that is emotional, behavioral and physiological.

Cognitive-behavioral theory conceptualizes the etiology of psychopathology as rooted in

inaccurate or distorted cognitive schemas (Ainsworth, Waller, & Kennedy, 2002). Schemas are considered dysfunctional if they bias perception of information, and if the individual finds them distressing. Early maladaptive schemas in individuals who develop eating disorders are thought to include preoccupation with thinness, fear of fatness (Williamson et al., 1999), and fear of environmental or relational instability (Ainsworth et al., 2002). CBT addresses maladaptive cognitions and related behaviors through psychoeducation, identification and correction of cognitive distortions, development of coping behaviors, self-monitoring and behavioral interventions such as exposure to feared stimuli concurrent with response prevention (Fairburn et al., 2009). Cognitive biases in eating disorders, in the form of distorted or dysfunctional cognitions, are conceptualized as part of the underlying mechanism of eating disorders through their shaping of individuals' schemas about themselves and others. In particular, cognitive-behavioral theory proposes that the importance individuals with AN and BN place on weight- and shape-related cognitions plays a major role in the maintenance of their eating disorders (Fairburn, Cooper, Doll, Norman, & O'Connor, 2000). Weight- and shape-related cognitions include excessive evaluation based on weight and/or shape, exaggeration of the importance of appearance concerns, an intense fear of gaining weight and a disturbed experience of shape (American Psychiatric Association, 2004).

Attention is a behavioral and cognitive construct that is central to the conceptualization of how psychopathology is developed and maintained. Eating disorder behaviors, such as binge eating or severe calorie restriction, function to avoid negative weight- or shape-related cognitions and affect. This is similar to blocking behaviors in anxiety and impulsive disorders (Ainsworth et al., 2002). Attention is behavioral, as it involves actively focusing on a stimulus, such as an image (visual attention), message (auditory attention) or sensation (physical attention). Attention

8

is also cognitive, as the brain interprets which stimuli to take in from the environment, encode and access. Cognitive-behavioral theory suggests that attentional biases influence how an individual perceives the world and herself by giving preference to certain aspects of the environment over others (Williamson et al., 1999).

  Attention abilities. Attention includes three abilities: alerting, orienting, and executive attention (Finucane et al., 2010; Posner & Rothbart, 2007). The alerting ability involves achieving and maintaining high awareness of and sensitivity to some stimuli (Finucane et al., 2010). It is associated with both craving and addiction (e.g., Kemps & Tiggemann, 2009), and emotionally threatening stimuli (e.g., Mogg, Millar, & Bradley, 2000). For example, in eating disorders, individuals can be alert to feared words (e.g., fat) or images. The orienting ability involves focusing on some stimuli and ignoring others, and when there is an orienting attention bias, individuals show overattention to specific stimuli. For example, in eating disorders, individuals might orient to stimuli that confirm their beliefs about the world and themselves, promoting thinness as an ideal and highlighting the discrepancy they perceive between themselves and that ideal. Orienting pulls attention away from other, simultaneously available stimuli; an overattention to anxiety-provoking or dissatisfying stimuli can create a distorted perception of an increased frequency of these stimuli. The executive attention ability involves intentional focus or avoidance (ignoring) when there are multiple demands on attention (Posner & Rothbart, 2007).

  Attention is fundamental to how threats are processed. Individuals with anxiety use attention to search their surroundings preconsciously with visual hypervigilance, or an alerting attentional bias (Ainsworth et al., 2002; Mathews & MacLeod, 1985). The alerting ability scans for threats preconsciously—before threats are in awareness—and alerts individuals when they

must attend to a threatening stimulus. Initial attention in anxiety is automatic and involuntary and thus might not be susceptible to willful change (Ainsworth et al., 2002; McNally, 1995). However, orienting and executive attention might impact conscious functioning beyond preconscious alerting to include monitoring or choosing to avoid threats.

One way to measure attentional bias is the Stroop task, which measures the time it takes individuals to name the color ink of words that are either neutral or schema-activating. A slower reaction time infers bias towards the content of the word rather than the color ink; this cannot differentiate whether the bias occurs in the alerting, orienting or executive function ability, all of which could prolong reaction time. Another way to assess attentional bias is the dot-probe task. This task involves determining if, upon first glance, a person focuses on a threatening image. This task might be limited by emphasis on where the individual glances first, and reaction time as the primary outcome measure. These limitations can be addressed by assessing gaze patterns using equipment that tracks eye movement behavior. Eye tracking technology takes frequent measures of the position of gaze, and these frequent timepoints can be clustered to determine where an individual actively focuses (orienting ability) and ignores (executive attention). These tasks have been used in their original forms, as well as in forms specific for attentional biases related to anxiety, depression and social cognition, with some adaptations made to the methodology and measures. Because these tasks have all been adapted for use with eating disorder-specific stimuli, these methodological approaches to studying attentional biases will be discussed in the context of measuring attentional biases for eating disorder stimuli.

Modifying attention. Researchers have attempted to modify attentional biases related to alcoholism (Schoenmakers et al., 2010), tobacco use (Field, Duka, Tyler, & Schoenmakers, 2009), depression (Baert, de Raedt, Schacht, & Koster, 2010), and food cravings (Kemps &

Tiggemann, 2009). However, research with individuals with threshold eating disorders uses attention as an objective outcome to measure treatment efficacy rather than the focus of the intervention (Black, Wilson, Labouvie, & Heffernan, 1997; Carter, Bulik, McIntosh, & Joyce, 2000; Cooper & Fairburn, 1994).

Individuals with depression manifest an attentional bias for negative information such that they appear to have difficulty disengaging from negatively valenced words. Specifically, when presented with two stimuli, individuals with depression showed overattention to negative information, and decreased attention to positive information. As with eating disorders, this attentional bias is thought to influence the development, maintenance, and recurrence of depression. In one study, researchers attempted to modify this bias in mood dysphoric students ($n = 48$) with mild to severe depression symptoms (Baert et al., 2010). Students learned not to bias attention towards negative stimuli using a dot-probe training task. The dot-probe activity consistently paired the probe with the positive word, which was hypothesized to increase visual scanning toward positive rather than negative stimuli. Students practiced the same dot-probe activity at home (online) for 10 sessions, and returned for a follow-up appointment to measure depressive symptoms. Mildly depressed students showed improved mood, but symptoms increased in moderately and severely depressed students. It is possible that students with moderate to severe symptomatology did not show an effect because the intervention was not sufficiently rewarding to motivate them to disengage from the negative stimuli, which compounded time spent during the rest of the day orienting toward negative stimuli (Baert et al., 2010). Thus, the intervention inadvertently provided additional negative stimuli and opportunity for rumination.

When applied to eating disorders, these results suggest that focusing on areas of overattention would be the most beneficial, and that there might be utility in training individuals with lower levels of eating disorder symptomatology, such as those with subthreshold eating disorders. By addressing initial alerting and subsequent orienting and executive attention related to body dissatisfaction and body image anxiety, and by pairing this with relaxation rather than exposure alone, it is not likely that subthreshold or threshold symptomatology would worsen because the increase in depression was related to the initial engagement with the negative stimulus and difficulty disengaging after that engagement. This previous work also provides a rationale for the current study's use of a college population, where mild eating disorder attitudes and behaviors are described as a "normative discontent" (Rodin, Silberstein, & Striegel-Moore, 1984).

Attentional biases have also been modified to supplement the established CBT protocol for alcohol dependence (Schoenmakers et al., 2010). Craving-related attentional biases are associated with severity of the addictive disorder, as well as treatment outcomes and relapse rates. In a study by Schoenmakers and colleagues (2010), study staff trained participants ($n =$ 43) to disengage their attention from craving-related stimuli using a pairing dot-probe task. Participants were able to disengage from craving-related stimuli at post-testing, and this change persisted three to four days after testing. However, participants' reported level of cravings did not significantly change. The authors explain this discrepancy as potentially rooted in affect being more sensitive to change initially, with potential cognitive-behavioral effects over time. The strong affective component to eating disorders supports the current study's hypothesis that initial change in attentional patterns might be observed affectively and behaviorally (through eye movements).

Cognitive Processes in Eating Disorders

Cognitive-behavioral theory of AN and BN proposes that distorted cognitions maintain eating disorder thoughts, feelings, and behaviors (Wilson, Fairburn, & Agras, 1997). Thus, understanding how cognitions are distorted could improve prevention and treatment strategies. Many cognitive processes are impaired in women with active threshold AN or BN (Shafran, Lee, Cooper, Palmer, & Fairburn, 2008). Two established examples of impaired cognitive processes are set-shifting errors in cognitive flexibility tasks, chiefly associated with AN and consistent with rigid and obsessive thinking (e.g., Tchanturia et al., 2004), and cognitive impulsivity, chiefly associated with BN and consistent with impaired decision-making (e.g., Fischer, Smith, & Cyders, 2008). Biological evidence also points to cognitive impairment. Women with threshold eating disorders have reduced gray matter in the frontal lobe (Katzman et al., 1996), further suggesting that AN and BN are tied to cognitive biases of memory, planning, and attention (Dobson & Dozois, 2004; Lee & Shafran, 2004). Attention is an executive function that involves focus on a stimulus (Craighead & Nemeroff, 2001). Eating disorder stimuli (e.g., food, thin figures) are thought to pull attention away from other stimuli, leading to distorted cognitions about food and body (Dobson & Dozois, 2004). Although many cognitive processes are impaired by eating disorders, the relation of attention to distorted cognitions makes this an especially important area of study.

Attention and Eating Disorders

Cognitive-behavioral theory proposes that one way thoughts can be distorted is by filtering in only the information that supports a schema. This has implications for the role of attentional biases in maintaining eating disorder symptomatology. Individuals with eating disorders might pay more attention to stimuli that confirm their beliefs about the world and

themselves, promoting thinness as an ideal and highlighting the discrepancy they perceive between themselves and that ideal. Preoccupation with food and body image can distract individuals from what is happening externally, and lead them to focus on internal, eating disorder-congruent experiences (Dobson & Dozois, 2004). Eating disorders can become the sole focus of an individual's experience, and because there is stigma associated with eating disorders, maintaining a public persona while hiding stigmatized eating disorder attitudes and thoughts can impair attentional processes (Soetens, Braet, Dejonckheere, & Roets, 2006). Suppression of food- and eating-related thoughts can also lead to increased negative affect, cognitive disruption, and binge eating (Soetens et al., 2006).

Ability to attend without bias might also be an indicator of recovery status, because cognitive processes appear to be impaired in individuals with threshold but not subthreshold eating disorders; thus, when an individual moves from threshold to subthreshold, she might not sustain the same degree of impairment or the same intensity of cognitive distortions (Shafran et al., 2008). This objective assessment of attentional biases is potentially more accurate than self-report items: attention deficits are less susceptible to demand characteristics because attention can be preconscious or more difficult to manipulate. One study tested this hypothesis by assessing changes in how women with threshold BN performed on a Stroop test with eating disorder-relevant interference stimuli before and after CBT (Carter et al., 2000). Participants responded more slowly to all stimuli pre-treatment compared with post-treatment, and responded more slowly to food and body words compared with neutral words at both pre-and post-treatment. However, participants did not show particular improvement in biases toward eating disorder-relevant words post-treatment, as hypothesized. Therefore, the modified Stroop might not be sensitive enough to track treatment-related changes in cognitive processes that focus on

food and body content. Alternatively, this study might indicate that the goal of treatment should be to decrease the intensity of overattention to eating disorder-related stimuli, rather than the erasure of all bias.

More recent studies have focused on whether dot-probe tasks can effectively measure treatment progress. Women with threshold BN and EDNOS showed reduced bias toward negative weight and shape words post-treatment compared with pre-treatment levels (Wilson, Fairburn, Agras, Walsh, & Kraemer, 2002) and compared with waitlist controls (Shafran et al., 2008). However, this reduced bias was not associated with reduced self-reported eating disordered thoughts, attitudes and behaviors. This suggests, consistent with theory, that a reduction in attentional biases might be an early indicator of cognitive success, and that attitudinal and behavioral changes could follow or could require more intensive intervention. However, research has not yet explored whether attentional biases post-treatment are related to the likelihood of relapse; such research is needed given the high rates of relapse within threshold eating disorders. Research suggests that attentional biases are likely correlated with relapse prognosis given that residual levels of weight and shape concerns are the cognitive variables most strongly associated with relapse (Farrell, Shafran, & Lee, 2006).

Self-monitoring. Self-monitoring is attention directed at the self; at extreme levels, this can be a form of overattention. Individuals with threshold and subthreshold eating disorders engage in frequent self-monitoring and pay more attention to eating disorder-related behaviors and experiences such as appearance comparison and assessment of changes in body shape. For example, individuals can self-monitor what they eat, how much they eat, and the speed at which they eat. Individuals can also monitor the social situations in which they participate to avoid those that involve eating or focus on physical appearance, such as going to the beach (Rosen,

15

Srebnik, Saltzberg, & Wendt, 1991; Smith & Rieger, 2010). Social scanning to make comparisons is another form of self-monitoring. Individuals might judge others' body shape and weight to make social comparisons (de Berardis et al., 2007), or engage in "tray gazing," or scanning other individuals' food choice and quantity in college dining halls (Sanderson, Darley, & Messinger, 2002). Self-monitoring can also include seeking frequent reassurance from others about weight or shape (Shafran, Lee, Payne, & Fairburn, 2007).

Self-monitoring by making comparisons to the self or others is frequently negative, and maintains body dissatisfaction because individuals attend to eating disorder-relevant stimuli and experiences that confirm their body dissatisfaction and the thin ideal (Shafran et al., 2007). When individuals compare themselves to others, the target of comparison is as important as the process. In one study, social comparison moderated the relation between the effect of a body image intervention and eating disordered behavior such that women who compared themselves to peers reported less disordered eating at follow-up than women who compared themselves to media figures who fit an extreme thin ideal (Mutterperl & Sanderson, 2002).

How women process media images that are consistent with the thin ideal might inform the type of self-monitoring they do (Tiggemann, Polivy, & Hargreaves, 2009). For example, in one study, women ($n = 144$) viewed thin-ideal magazine images of women and were asked to assess the images neutrally, make social comparisons, or imagine themselves as the thin image. In all groups, exposure to thin-ideal images increased negative mood and body dissatisfaction compared with control images. Social comparisons showed especially increased negative mood and body dissatisfaction, consistent with other findings about thin-ideal internalization and the media (e.g., Blechert, Nickert, Caffier, & Tuschen-Caffier, 2009). However, women who imagined themselves as the thin image showed increased positive mood, which the researchers

16

suggest might be because that fantasy allowed for internalization of the possibility of obtaining

that ideal rather than reinforcing a feeling of discrepancy from a desired shape (Tiggemann et al.,

2009).

Women with threshold and subthreshold eating disorders are likely to overattend to how

others see them. This focus on appearance can lead to an overall tendency (trait) or situational

(state) effect where the individual sees herself through others' eyes and emphasizes external over

internal experiences, which in turn increases body dissatisfaction in women who have

internalized the culture's thin ideal (Grippo & Hill, 2008). Trait self-objectification is a

persistent pattern of an individual seeing herself through others' eyes and is related to

experiences such as attending ballet lessons as a child (Tiggemann & Slater, 2001), belonging to

a gym (Prichard & Tiggemann, 2005), and reading beauty magazines (Morry & Staska, 2001).

State self-objectification can be induced in situations, and is related to experiences such as trying

on a swimsuit (Fredrickson, Roberts, Noll, Quinn, & Twenge, 1998), anticipating a male gaze

(Calogero, 2004), or being in a room with scales, magazine covers, and large mirrors

(Tiggemann & Boundy, 2008). When the environment was manipulated to prime image-related

anxiety and self-objectification, individuals high in trait self-objectification reported increased

body shame.

Body checking. Body checking is ritualistic self-monitoring behavior. Examples of

body checking behaviors include obsessive grooming or frequently seeking out mirrors or

reflective surfaces to check physical appearance and possible shape changes (Reas & Grilo,

2004). Individuals can also pinch flesh, attempt to feel bones, use particular clothes (such as "fat

pants") to measure changes in body shape by the feel of those clothes, or measure the distance

between their thighs when standing in a particular posture (de Berardis et al., 2007; Reas,

17

Whisenhunt, Netemeyer, & Williamson, 2002). Body checking is a visual and proprioceptive form of orienting attention toward the body, which increases overattention to imperfections or flaws (de Berardis et al., 2007).

Body checking serves an important function in the cognitive-behavioral conceptualization of eating disorders. Body checking is a common behavior associated with eating disorders, as individuals with threshold eating disorders appear to scrutinize disliked body parts more than healthy controls (Shafran et al., 2007). Body checking reinforces preoccupation with body shape and weight that is a core aspect of eating disorder pathology. Body checking is a way that individuals can regulate their emotions, similar to how compulsions can distance individuals from emotions in obsessive compulsive disorder. Specifically, body checking regulates emotions negatively by confirming individuals' fears that their shape is larger than desired (or has become larger), or positively by attenuating fears that their shape has become larger (de Berardis et al., 2007). Shafran and colleagues (2007) posit that individuals with threshold eating disorders might engage in body checking behaviors more frequently when they are in a high, negative arousal state. In addition to reinforcing preoccupation, this pairing of strong, negative emotion with body checking can make memories of imperfections more salient than other exposures, which would increase global body dissatisfaction. In addition, body checking can serve as motivation to maintain other eating disordered behaviors such as restrained eating or induced vomiting (de Berardis et al., 2007).

One study experimentally manipulated the level of body checking in which individuals with threshold eating disorders engaged to evaluate the effect of this behavior on eating disorder symptomatology (Shafran et al., 2007). Researchers randomly assigned participants to scrutinize their body repeatedly or to examine their body neutrally (control condition). Participants who

18

scrutinized their body reported increased body dissatisfaction and feelings of fatness. Low body checking decreased feelings of fatness. Neither condition influenced body size estimation or reported discrepancies between ideal and actual body size. Despite these findings, it is important to note that the "neutral" condition might be distressing to some individuals who are low on body checking because they avoid looking at their body rather than ritualistically checking for changes.

Body checking appears to be related to body dissatisfaction among many women, not just those with threshold eating disorders. For example, women who are overweight and dissatisfied with their appearance also report body checking behaviors such as pinching and avoidance of clothes that make them especially aware of their bodies (Grilo et al., 2005; Reas, Grilo, Masheb, & Wilson, 2005). In one study, body checking behaviors were significantly associated with dietary restraint, and avoidance behaviors were significantly associated with binge eating (Reas et al., 2005). This suggests that body checking might reinforce the dissatisfaction that maintains dietary restraint in overweight, similar to the proposed function in threshold AN. Further, avoidance might be a response to intense body-related anxiety, given that binge eating is a maladaptive form of emotional coping.

Body image distortion. Body image distortion is a pervasive overestimation of body size. Although some researchers believe that body image distortion maintains threshold AN (e.g., Baker, Williamson, & Sylve, 1995; Fairburn, Shafran, & Cooper, 1999; Williamson, Cubic, & Gleaves, 1993), others have described it as a manifestation of anxiety about stigma associated with reporting their body size to be smaller than it actually is, and fear of receiving feedback from researchers or therapists that they are indeed larger (Farrell, Lee et al., 2005). Body image distortion has been called a core feature of eating disorder pathology that manifests

cognitively, behaviorally, and affectively (Williamson et al., 1993), and it has been targeted as a treatment goal. In one study that included women with AN, BN, and healthy controls, participants estimated their current and ideal body sizes in silhouettes (Williamson et al., 1993). After controlling for their actual body size, women with AN and BN estimated their current body size to be larger than it actually was, with a discrepancy that was significantly different from healthy controls' estimation discrepancy. However, when researchers did not control for actual body size, women with AN did estimate thinner body sizes compared with female healthy controls (Williamson et al., 1993). Therefore, it is important to assess actual body size when using that variable in research on eating disorders because of a subtle bias in self-report.

Body size overestimation has been linked to both body dissatisfaction and overall negative mood. Depressed patients report some body size overestimation even when they do not endorse other eating disorder attitudes or thoughts (Farrell et al., 2006). In one study, women with high or low body dissatisfaction were randomly assigned to receive a negative mood induction or a control condition (Baker et al., 1995). Women who received the negative mood induction overestimated their body size with greater discrepancy overall. However, this overestimation was exacerbated in women who had pre-existing high body dissatisfaction. Although researchers did not control for the potential anxiety that estimating body size might provoke, these results still provide useful information. Results suggest that negative mood and body dissatisfaction interact to influence women's attitudes about their body, and possibly their perceived vulnerability to weight-related criticism.

Another question researchers have asked related to body image distortion is whether the distortion occurs for particular body parts, or whether it occurs for the entire body (de Berardis et al., 2007; Freeman et al., 1991). Some researchers believe that attentional bias towards

20

dissatisfying body parts might account for body size overestimation (Fairburn et al., 1999; Freeman et al., 1991). One study showed that women with BN overestimate body size because of their view of specific body parts (Sunday, Halmi, Werdann, & Levey, 1992). Similarly, attentional bias towards body sensations such as "body wobble" that seem to provide evidence of fatness might exaggerate individuals' perception of their actual body size (Lee & Shafran, 2004).

Researchers have used several methodologies to investigate body image disturbance. The most common methodology is self-reported scales, either visual analog scales or figure rating scales, which researchers compare to measured size. Other methods include manipulating a virtual image or video of the body from wide to thin until the participant reports that the image is accurately proportioned (Farrell, Lee et al., 2005).

Using a mirrored video image can increase ecological validity of studies exploring whether body image disturbance occurs because it mimics how participants most commonly see themselves (Farrell, Lee et al., 2005). When asked to estimate their body size, 17% of individuals with threshold eating disorders overestimated their size, whereas only 6% of healthy controls overestimated their size. However, this result appears to be due to demand characteristics. When participants were asked to "drop their guard," the amount of overestimation and the number of participants with threshold eating disorders who overestimated was reduced compared with the original finding. This suggests that participants might have been reacting to a fear of either admitting they were too thin, which would require them to gain weight (Farrell, Lee et al., 2005), or a fear of being told they are actually bigger than they thought they were. Another study assessed subtle misperceptions of body size when they looked at multiple images of their bodies that each differed only slightly from the next in the degree of distortion. Participants with AN had normal sensory sensitivity, meaning that they detected their true body

size at a level of distortion that was not significantly different from the level of distortion at which healthy controls detected their true body size (Gardner & Moncrieff, 1988). This is especially notable for the current study, as a change in visual ability rather than attention would be physiological rather than cognitive.

Other variables that appear to influence whether body image distortion occurs include recently eating, instructions given, and potentially whether the whole body or select body parts were the focus of the estimation (Farrell, Lee et al., 2005). The instructions given to participants can ask them to estimate the body size they "feel" they are, the body size they "see" themselves as, or the body size "others see" the participants as being. Feminist theory suggests that one reason why the wording of this question might provoke different responses is the extent to which eating disorders are associated with self-objectification (Tiggemann & Boundy, 2008) .

Not knowing the process of how women estimate their body size also confounds overestimation interpretation. One study asked women to give weight ranges that would be extremely underweight, underweight, normal weight, overweight, obese, and extremely obese (Whisenhunt & Williamson, 2002). Although women were more accurate for their own height than other heights, women who were normal weight underestimated weight ranges compared with women who were overweight, who were more accurate. This potential knowledge and norm perception bias might contribute to the normative discontent women feel about their bodies even when they are normal weight.

Attentional bias towards body regions. Cognitive-behavioral theory focuses on identifying and modifying maladaptive cognitions and behaviors, including the tendency to focus on schema-congruent stimuli and discount schema-incongruent stimuli (Cassin, von Ranson, & Whiteford, 2008; Vitousek & Hollon, 1990). This selective processing reinforces the world view

of individuals with eating disorders, particularly as it relates to the prevalence and importance of thinness, and to dissatisfaction with overweight. Within the construct of body image and body dissatisfaction, this could manifest as attention to particular body regions that confirm an individual's view about her body (Shafran, Farrell, Lee, & Fairburn, 2009). For example, individuals might overattend to body regions with which they are dissatisfied to reinforce overall body dissatisfaction, while ignoring body regions about which they feel satisfied or neutral (Fairburn, Cooper, & Shafran, 2003; Shafran, Fairburn, Robinson, & Lask, 2004; Shafran et al., 2009; Williamson et al., 1999). Individuals with eating disorders might also intentionally avoid looking at body regions about which they are highly anxious, and by not looking, not allow their fear to diminish through behavioral exposure (Shafran et al., 2009). That is, avoidance makes it difficult to learn new, contradictory information. This pattern is supported in the anxiety literature, specifically for panic disorder (Clark, 1986) where there is selective attention to anxiety-like symptoms that build fear of an imminent panic attack.

Measuring attention toward eating disorder-relevant stimuli. Evidence of attentional bias in eating disorders comes from methodology such as the dichotic listening task, which shows increased sensitivity for eating disorder-relevant content. However, the majority of studies have focused on visual attention because of the putative emphasis on visual perception in the development and maintenance of appearance-centered eating disorders. Tasks measuring visual attentional bias in eating disorders include modified Stroop, dot-probe and, more recently, eye tracking tasks.

Eating disorders and the Stroop task. For a table of studies that have used Stroop methodology in eating disorders, please see Table 1.

The Stroop task is one of the most widely used measures of attention (Ainsworth et al., 2002). The classic Stroop task (Stroop, 1935) assesses information processing ability and attention. Color words printed in incongruent colored ink (e.g., the word BLUE printed in green ink) were presented in the classic task, and participants named the ink color. The content of the word distracted from naming the ink color, increasing the time for the task. Outcomes are measured as the time difference between naming colors of neutral words, and naming colors of words that provide cognitive interference because of their content. Attentional biases have been shown in anxiety disorders using modified versions of the Stroop task that include threatening words as interference instead of color words. For example, individuals with generalized anxiety disorder took longer to name the color of emotionally threatening words (e.g., Ainsworth et al., 2002; Lee & Shafran, 2004; Mathews & MacLeod, 1985). The Stroop task has also been modified for phobia-relevant stimuli, such as spiders (Watts, McKenna, Sharrock, & Trezise, 1986) and snakes (Ainsworth et al., 2002). The Stroop task has been adapted for eating disorders such that the content of the words is either neutral or eating disorder-relevant (e.g., "food," "fat"). A meta-analysis of performance on modified Stroop tasks among individuals with threshold and subthreshold eating disorders found an overall effect of increased task time with eating disorder-related stimuli (Dobson & Dozois, 2004).

Despite the overall effect of increased task time with eating disorder-related stimuli, there were many discrepancies in the results reviewed (Dobson & Dozois, 2004; Johansson, Ghaderi, & Andersson, 2004; Lee & Shafran, 2004). Specifically, there have been mixed findings about the nature of the interference, and whether women with threshold AN differ from women with threshold BN in the category of words that provide stronger interference. Although there is a consistent trend overall that eating disorder Stroop tasks contain words related to the body and

24

words related to food, there is no standard modified Stroop to measure interference due to eating disorder stimuli (Dobson & Dozois, 2004; Johansson et al., 2004; Lee & Shafran, 2004). Likewise, the administration procedure also varied across studies. The Stroop task has been delivered via paper and computer, and reaction times measured by stopwatch, computer response, voice activation, and number of responses within a set time (Lee & Shafran, 2004). Overall, results suggest that women with threshold AN show more interference with the Food Stroop compared with healthy controls (Brooks, Prince, Stahl, Campbell, & Treasure, 2011). Women with threshold BN show more interference with the Body Stroop compared with healthy controls; they also show some interference for the Food Stroop, but results are not as strong as those for the Body Stroop (e.g., Aspen et al., 2011; Black et al., 1997; Cooper, Anastasiades, & Fairburn, 1992; Dobson & Dozois, 2004).

Two other meta-analyses specifically addressed the effect size of attention measured by eating disorder-modified Stroop tasks (Brooks et al., 2011; Johansson et al., 2004). Overall, the mean effect size across studies for interference in women with threshold eating disorders was moderate (Cohen's d = 0.39 - .48). This was significantly larger than the small effect size of interference that both women with subthreshold eating disorders and healthy controls demonstrated (Cohen's d = 0.21) (Johansson et al., 2004).

Other versions of the Stroop, modified for eating disorder saliency, that contribute to our knowledge of potential attentional biases have explored the effects of hunger, images, and threat orientation. The Stroop effect does not appear to be related to hunger (Smith & Miles, 1986). However, one review of Stroop research in eating disorders suggested that this study is insufficient to show that hunger in AN is not associated with attentional bias. Temporary hunger, as measured in this study by having healthy controls fast, is not comparable to chronic

25

semi-starvation (Lee & Shafran, 2004). The effect of using images, figure sizes ranging from thin to fat, produced an interference effect similar to that of using words (Walker, Ben-Tovim, Paddick, & McNamara, 1995). Both women with threshold AN and BN and healthy controls took longer to name the color of interference figures compared with neutral stimuli. However, the effect was significantly more pronounced in women with threshold eating disorders.

One possible difference in the results lies in the emotional valence of the words used as interference stimuli. Most studies have used negative words such as "fat" or "calorie" rather than positive words that might also activate an eating disorder schema, such as "thin" or "skim" (Cassin et al., 2008). One study looked at the emotional valence of words, and found that both positive and negative words produced an interference effect in women with threshold AN, but not women with subthreshold eating disorders (Sackville, Schotte, Touyz, Griffiths, & Beumont, 1998).

The discrepancy in outcomes among studies using modified Stroop tasks to assess selective attention to eating disorder stimuli might also be due to the intensity of eating disordered attitudes and thoughts. Women with threshold AN and BN are consistently susceptible to an interference effect of eating-disorder relevant words. However, women with subthreshold AN and BN do not appear to be susceptible to a significant interference effect (e.g., Dobson & Dozois, 2004; Johansson et al., 2004). When participating in a research study, some participants might be preoccupied with eating disordered attitudes and thoughts, but others might be able to distance themselves from that preoccupation temporarily. This difference in saliency might explain why some women with high-risk subthreshold eating disorder symptomatology do not show an attentional bias (Labarge, Cash, & Brown, 1998). One study primed eating disorder

Table 1

Results of the Stroop task in eating disorders

Study	Population	Groups	IV(s)	Stroop content	Results
Channon et al., 1988	Clinical women	AN (*n*=20); Controls (*n*=20)	Group; Content	Food; Body	AN and HC slower for food than neutral words; AN slower than HC overall
Ben-Tovim et al., 1989	Clinical women	AN (*n*=17); BN (*n*=19); Controls (*n*=38)	Group; Content	Classic; Food; Body	AN and BN slower than HC for food, shape words
Channon & Hayward, 1990	Healthy men and women	Fasting (*n*=16); Nonfasting (*n*=16)	Group; Content	Classic; Food; Body	Fasting slower than nonfasting for classic and food, but not body words
Ben-Tovim & Walker, 1991	Clinical and Subthreshold women	AN (*n*=22), BN (*n*=27), High DT (*n*=29), Low DT (*n*=37)	Group; Content	Classic; Food; Body	AN and BN slower for food, shape than neutral words; No subthreshold effect
Fairburn et al., 1991	Clinical women	BN (*n*=24); Female controls (*n*=50); Male controls (*n*=24)	Group; Content	Classic; Food; Body; Weight	BN slower for food, shape, weight words than female HC; No HC gender effect
Cooper & Fairburn, 1992	Clinical women	AN (*n*=12); BN (*n*=12); Healthy dieters (*n*=12); Symptomatic dieters (*n*=12); Controls (*n*=12)	Group; Content	Classic; Food; Body	HC no effect; sAN and AN slower for food and weight than neutral words
Cooper et al., 1992	Clinical women	BN (*n*=36); Controls (*n*=18)	Group; Content	Classic; Food; Body; Eating	BN slower than HC for food, body, eating than control; No effect for classic Stroop
Cooper & Fairburn, 1993	Clinical women	BN (*N*=75)	Content	Classic; Food; Body; Eating	BN slower for weight, shape, eating than control words; Correlated with frequency of purging
Green & McKeena, 1993	Healthy girls and boys	Age 9 (*n*=40); Age 11 (*n*=40); Age 14 (*n*=40)	Age; Gender; Content	Food; Body; Neutral	14 yo girls slower for food, body words compared with neutral; No effect for other age groups or boys

Study	Population	Groups	IV(s)	Stroop content	Results
Green & Rogers, 1993	Subthreshold women	Dieters (*n*=13); Restained eaters (*n*=15); Controls (*n*=27)	Group; Content	Food; Body	Restraint slower for shape, food than neutral words
Mahamedi & Heatherton, 1993	Subthreshold women	Dieters; Controls (*N*=47)	Group; Caloric load; Content	Food; Body	Dieters and nondieters slower for shape words when preloaded; No effect for food words
Ogden & Greville, 1993	Subthreshold women	Dieters (*N*=28)	Content; Caloric load	Food; Body	Dieters slower for food, body words when preloaded compared with not preloaded
Perpina et al., 1993	Clinical women	AN (*n*=18); BN (*n*=14); Controls (*n*=32)	Group; Content; DT	Classic; Food; Body	AN and BN slower for classic words than HC; AN slower for food than classic words; BN slower for shape than classic words; DT related to food word bias for HCs
Cooper & Fairburn, 1994	Clinical women	BN (*N*=75)	Pre/post-treatment; Content	Classic; Food; Body	Pre slower than post for food and body words; No effect for classic words
Green et al., 1994	Clinical women	AN (*n*=20); Controls (*n*=41)	Group; Time; Content	Food; Body	AN slower for food, body words than HC; Habituation for shape not food words
Long et al., 1994	Clinical and Overweight women	AN (*n*=37); Obese restrained eaters (*n*=45); Controls (*n*=51)	Group; Pre/post-weight restoration; Content	Food; Body; Neutral	AN slower for food, body than neutral words; No effect of weight restoration; No effect of word content for other groups
Overduin et al., 1995	Subthreshold women	Restrained (*n*=26); Controls (*n*=25)	Group; Caloric load; Content	Food; Body; Neutral	Controls slower for food words when preloaded compared with not preloaded; Restrained slower for food than body, neutral words
Walker et al., 1995	Clinical women	AN or BN (*n*=20); Controls (*n*=20)	Group; Content	Figures	AN, BN and HC slower for figures than neutral images; AN, BN slower than HC for figures

Study	Population	Groups	IV(s)	Stroop content	Results
Formea & Burns, 1996	Subthreshold women	Subthreshold BN (*n*=22); Depressed (*n*=12); Controls (*n*=25)	Group; Content	Food; Weight; Shape; Neutral	sBN slower for food, weight, shape than neutral words; No effect for D and HC
Green et al., 1996	Healthy women	Fasting (*n*=26); Nonfasting (*n*=27)	Group; Caloric load; Hunger	Food	No effect for group or caloric load; Higher hunger generally related with slower responses, but not at highest level
Huon & Brown, 1996	Subthreshold women	Dieters (*N*=30)	Content	Food; Body; Neutral	Dieters slower for food than body, neutral words
Waller et al., 1996	Subthreshold women	High and low BN (*N*=80)	Group; Content	Social threat; Physical threat; Ego threat	High BN slower for self-directed ego threats than low BN; No effect for other words
McManus et al., 1996	Clinical women	BN (*n*=30); Controls (*n*=30)	Group; Content	Social threat; Physical threat; Ego threat	BN slower than controls on three types on threat
Black et al., 1997	Clinical and Subthreshold women	BN (*n*=16); Restrained eaters (*n*=16); Controls (*n*=13)	Group; Pre/post-treatment; Content	Food; Body; Classic	BN, Restrained, and HC slower for food, body words than classic; No effect for treatment
Cooper & Todd, 1997	Clinical women	BN (*n*=12); AN (*n*=12); Controls (*n*=18);	Group; Content	Eating; Weight; Shape	AN slower than controls for eating, weight, shape words; BN slower than controls for eating, weight words
Lovell et al., 1997	Clinical women	BN (*n*=24); Recovered BN (*n*=11); AN (*n*=31); Recovered AN (*n*=23); Controls (*n*=33)	Group; Content	Food; Body	AN, BN and Recovered AN slower than HC and Recovered BN for body words; No effect for food words

Study	Population	Groups	IV(s)	Stroop content	Results
Francis et al., 1997	Subthreshold women	Restrained (*n*=14); Controls (*n*=14)	Group; Content	Forbidden food; Unforbidden food; Neutral	Restrained slower than HC for food words; No effect for forbidden vs. unforbidden foods
Léonard et al., 1997	Clinical women	AN-r (*n*=18); AN-b (*n*=25); BN (*n*=20); Controls (*n*=29)	Group; Content	Eating; Body	AN-r, AN-b and BN slower than HC for eating words; No effect for body words
Jones-Chesters et al., 1998	Clinical women	BN (*n*=16); AN (*n*=16); Controls (*n*=32)	Group; Content	Food; Weight; Emotional; Neutral	BN slower for food, weight, emotional than neutral words; BN slower than controls; AN slower for food, weight than neutral words
Rubino et al., 1998	Clinical women	BN (*n*=45); TMJ (*n*=45)	Group	Classic	No effect for group
Sackville et al., 1998	Clinical and Subthreshold women	AN (*n*=20); Restrained (*n*=20); Controls (*n*=33)	Group; Content	Food; Body; Emotional	AN slower for body words (+ and - valenced) than HC; No effect for food, emotional words; No effect for valence
Jansen et al., 1998	Subthreshold women	Restrained (*n*=13); Controls (*n*=15)	Presentation format; Group; Content	Body; Neutral	No effect for group, content, or format (subliminal vs. supraliminal)
Green et al., 1999	Clinical women	AN (*n*=34); Controls (*n*=39)	Group; Content	Body; Neutral (3)	AN slower for body words than two sets of controls words; AN slower than HC for body and bird (control) words
Carter et al., 2000	Clinical women	BN (*N*=98)	Pre/post-treatment; Content	Classic; Food/Body; Neutral	Pre slower than post for all words; Food/body slower than control words for both times between time and word type were found. Increase in speed across all three word types; limits the utility of looking at Stroop with food/ body words as indicator of clinical usefulness of intervention.
Mendlewicz et al., 2001	Clinical women	AN (*n*=16); Controls (*n*=16)	Group; Content	Food; Body; Neutral	No effect for group or content
Davidson & Wright, 2002	Clinical women	BN (*n*=20); Controls (*n*=46)	Group; Content	Classic; Food; Body; Neutral	BN slower than HC for body words; Body dissatisfaction related to food, body words

Study	Population	Groups	IV(s)	Stroop content	Results
Fassino et al., 2002	Clinical women	AN (*n*=20); Controls (*n*=20)	Group; Content	Food; Body; Neutral	AN slower for positive body than neutral words; HC slower for food than neutral words
Stormark & Torkildsen, 2004	Clinical women	AN or BN (*n*=20); Controls (*n*=24)	Group; Content	Classic; Food; Emotional; Neutral	ED slower than HC for all words; ED slower than HC for food pictures but not other pictures; ED slower for food and emotional than neutral stimuli
Lokken et al., 2006	Clinical and Subthreshold women	BN (*n*=30); Subthreshold (*n*=30); Controls (*n*=30)	Severity; Content	Eating; Body; Weight	Slower for body and weight words as BN symptoms increased
Johannson et al., 2008	Clinical and Subthreshold women	AN (*n*=13); BN (*n*=20); Subthreshold (*n*=27); Controls (*n*=31)	Group; Content	Food; Body; Neutral	BN slower for body than neutral words; AN slower for food than neutral words; No effect for other groups
Wallis & Hetherington, 2009	Healthy women	Controls (*n*=89)	Content	Ego-threat; Neutral	Ego-threat associated with greater hunger in in women with higher restraint
Pringle et al., 2010	Subthreshold women	Subthreshold (*N*=82)	Content	Weight; Shape; Eating; Depression; Neutral	Higher disordered eating had more interference for shape; this effect did not predict ED one year later (Pringle et al., 2011)
Ridout et al., 2010	Subthreshold and Healthy women	Subthreshold (*n*=23); Controls (*n*=22)	Content	Classic	No difference
Aspen et al., 2011	Subthreshold women	Subthreshold (*N*=31)	Content	Classic; Body; Neutral	Higher shape concern and more overeating episodes predicted greater interference with body words, but this difference was nonsignificant compared with neutral words
Markis & McLennan, 2011	Healthy women	Controls (*N*=56)	Group; Content	Body; Neutral	Women primed with thin model images showed more interference with body words and more body dissatisfaction

Study	Population	Groups	IV(s)	Stroop content	Results
Fagundo et al., 2012	Clinical, Subthreshold, Healthy women	AN (*n*=35), Obese (*n*=52), Controls (*n*=137)	Group	Classic	Obese slower than AN and Controls
Harrison et al., 2012	Clinical, Recovered, Healthy women	AN (*n*=50), BN (*n*=50), Recovered AN (*n*=35), Controls (*n*=90)	Group; Content	Emotions	ED and Recovered slower than Controls, but not different from each other
Van den Eynde et al., 2012	Clinical, Healthy controls	BN (*n*=40), EDNOS (*n*=30), Controls (*n*=65)	Group	Classic	No difference
Wilson & Wallis, 2013	Healthy women	Controls (*n*=48)	Content	Food; Ego-threat; Neutral	Slower disengagement from food and ego-threat words, particularly for those with high restraint

Abbreviations: HC=Healthy control; DT=Drive for thinness; s*AN*= Subthreshold AN; s*BN*=Subthreshold BN; AN-r= AN restrictive

subtype; AN-b=AN binge-purge subtype; ED=Eating disorder

thoughts in a group of participants by showing photographs of swimsuit models, compared with a control group shown images of sports cars. Women high on thin-ideal internalization but without threshold eating disorders did not exhibit the predicted cognitive bias even when appearance and body concerns were activated, suggesting that the lack of attentional bias was not due to insufficient saliency (Cassin et al., 2008). However, the authors suggest that future research should prime personally relevant eating disorder thoughts (e.g., by asking participants to make social comparisons) to assess whether that degree of saliency might lead to an attentional bias.

Despite these findings, researchers have criticized the eating disorder-modified Stroop task because results cannot explain why attentional biases occur (Dobson & Dozois, 2004). That is, the task measures attentional conflicts, thus utilizing executive attention, but is not specific enough to assess alerting or orienting abilities. For this reason, more specific tasks are necessary. Some authors also differentiate between preoccupation, which would present as overattention, and anxiety, which would present as avoidance, but are otherwise difficult to parse apart with the Stroop task. For example, if women with AN are preoccupied with food, but anxious about their body, they could show interference effects for any of those stimuli, but might evidence more interference for the words they are preoccupied by because they read the words that made them anxious as fast as possible. Likewise, if women with BN are preoccupied with food and their body, but anxious about their body, they could show interference effects for both food and body words (Cassin et al., 2008).

Eating disorders and the dot-probe task. For a table of studies that have used dot-probe methodology in eating disorders, please see Table 2.

The dot-probe task moves beyond the Stroop task in its ability to measure alerting and orienting attentional biases. This task involves determining if, upon first glance, a person focuses on a threatening image (e.g., food or an overweight individual; Kemps & Tiggemann, 2009). In this task, a pair of stimuli (e.g., a threat image and neutral image) is presented side-by-side for a very short time and, after they disappear, a dot is presented on either one side of the screen or the other. Participants report the location of the dot as quickly as possible. They react faster when they were looking at the image that was on the same side as the dot is presented (MacLeod, Mathews, & Tata, 1986). The dot-probe task was developed to measure attentional biases in anxiety disorders. In patients with generalized anxiety disorder, response time latencies were slower on trials that involved a threat (physical or social), compared with neutral stimuli, which suggests an attentional bias for threatening stimuli (MacLeod et al., 1986). The dot-probe task in populations of women with threshold eating disorders shows faster response times toward negative stimuli related to eating disorders, demonstrating alerting ability, but not stimuli consistent with thinness (Lee & Shafran, 2004; Rieger et al., 1998). Women with subthreshold eating disorders do not have the same biased effect (Lee & Shafran, 2004).

The dot-probe task also provides evidence of attentional bias related to food cravings. One study used pairs of words and pairs of images depicting chocolate (the craving-relevant stimuli) or highly desirable foods (the non-craving stimuli) (Kemps & Tiggemann, 2009). Then the dot appeared behind where one of the images had been located, and participants reported which side the dot was on as fast as they could. Individuals who endorsed high trait chocolate craving had biased attention toward chocolate stimuli. Individuals with high trait craving responded with similar biases to individuals with (induced) state chocolate craving. These results were not due to group differences in restraint, hunger, eating disorder symptomatology,

processing speed, or attention. Because of the inclusion of non-craving stimuli, researchers were able to assess whether the attentional bias was due to speeded search toward the craving-relevant stimulus, or whether the attentional bias was due to difficulty disengaging with the craving-relevant stimulus. This suggests that environmental cues for foods are particularly salient for individuals who crave those particular foods. This may have particular implications in the development and maintenance of BN, where binge eating is often described as an addiction-like craving for certain foods (e.g., Stice & Shaw, 2002; Wansink, Cheney, & Chan, 2003), and where difficulty disengaging from the thought or image of foods could enhance the likelihood of a binge.

Because of the potential confound of hunger weakening attention capability, research has also assessed whether attentional biases detected by the dot-probe task were a result of being in a hunger state. One study randomly assigned healthy men and women ($N = 32$) to either abstain from breakfast and lunch before the assessment, or to eat normally (Mogg, Bradley, Hyare, & Lee, 1998). Men and women who had fasted had greater attentional bias toward food words compared with men and women who had not fasted. However, this attentional bias disappeared when the stimuli were presented pre-attentively, that is, over a shorter time than needed to be consciously detected, but long enough to capture vigilance if it were occurring. This builds on other attention studies because it assesses a physical motivation behind a cognitive process, whereas other studies generally focus on emotional motivation (i.e., threat orientation and anxiety reduction). It further suggestions that physical and emotional motivation might differ in whether alerting attention occurs in a preattentive state.

The theoretical relation between overattention and body dissatisfaction is causal: overattention toward negative weight and shape stimuli is thought to create and maintain eating

disorder attitudes, thoughts, and behaviors. However, some researchers hypothesized that the relation might be bidirectional such that body dissatisfaction and attentional biases would mutually reinforce each other. To evaluate this hypothesis, Smith and Rieger (2010) experimentally manipulated body dissatisfaction in undergraduate women (N = 54) and then assessed their attentional biases for weight and shape-related words. Participants receiving the body dissatisfaction induction were instructed to imagine themselves walking on the beach and receiving criticism. Participants receiving the negative mood induction were instructed to imagine themselves giving a class presentation and receiving criticism. Participants receiving the control induction were instructed to imagine themselves walking in the forest. The induction manipulation did not account for attentional biases. Although participants in the body dissatisfaction group reported higher levels of body dissatisfaction after the imagery activity, they did not show attentional biases toward weight or shape words. However, participants in the negative mood group had greater attentional bias toward body words compared with the body dissatisfaction group, which the authors suggest might have been the result of the scenario including a presentation in front of peers. Although walking on the beach is more explicitly body focused, giving a presentation is social, and peers can encourage greater social comparison than strangers on a beach.

With the dot-probe task, it is possible to vary the time interval between stimuli (i.e., inter-stimulus interval). This manipulation allows for assessment of initial and delayed areas of focus. One study varied the inter-stimulus interval to determine if there was a threshold at which the dot-probe task could detect an interference effect (Lee & Shafran, 2008). Women with threshold eating disorders completed a dot-probe task that included eating disorder-relevant words and neutral stimuli (animal words). Comparison groups were women with other psychiatric

Table 2

Results of the dot-probe task in eating disorders

Study	Population	Groups	IV(s)	Dot-probe content	Results
Mogg et al., 1998	Healthy men and women	Fasted (*n*=16); Nonfasted (*n*=16)	Group	Food words	Fasted faster for food words than nonfasted
Rieger et al., 1998	Clinical and Subthreshold women	AN (*n*=16); BN (*n*=17); Controls (*n*=32)	Group; Content	Shape words; Emotional words	AN and BN slower than HC for thin shape words; AN and BN faster than HC for fat shape words
Placanaica et al., 2002	Healthy men and women	Fasted; Nonfasted (*N*=56)	Group; Content	Food words; Body words	Fasted faster for food words compared with body words and nonfasted
Shafran et al. 2007	Clinical women	1: ED (*n*=23); Anxiety (*n*=19); Controls (*n*=75); 2: ED (*n*=82); Controls (*n*=44)	Group; Content	Eating; Shape; Weight; Neutral	1: ED faster for eating and weight stimuli compared with other images; ED faster than Anxiety and HC; 2: ED faster than HC for eating, weight, shape stimuli
Lee & Shafran, 2008	Clinical women	AN or BN (*n*=23); Psychiatric (*n*=19); Control (*n*=65)	Group; Content; ISI	ED vs. Neutral (animal) images	ED faster than Psychiatric and HC for ED stimuli at 500ms, not 2000ms
Shafran et al., 2008	Clinical women	ED (*n*=31); Waitlist (*n*=24)	Pre/post treatment; Content	Eating; Shape; Weight; Neutral	Faster pre- than post-treatment Faster WC than post-treatment
Blechert et al., 2010	Clinical women	AN (*n*=19); BN (*n*=18); Control (*n*=21)	Group; Content	Self-photo; Other-photo	AN faster for self- than other-photo; No effect for BN
Glauert et al., 2010	Subthreshold women	Undergraduate women (*N*=50)	Content; Body dissatisfaction	Thin figure; Fat figure	Faster for thin than fat cues; Weaker bias in women with higher body dissatisfaction
Smith & Rieger, 2010	Subthreshold women	Undergraduate women (*N*=54)	Priming condition; Content	Body dissatisfaction prime; Negative mood prime; Neutral prime	Negative mood faster for negative body words than neutral; No effect for Body dissatisfaction and Neutral condition

Abbreviations: HC=Healthy controls; ED=Eating disorder; WC=Waitlist controls

disorders and healthy controls. When researchers increased the inter-stimulus interval from 500 milliseconds to 2000 milliseconds, women with threshold eating disorders continued to display attentional bias for weight stimuli, but not for body shape or food stimuli. This suggests that the dot-probe task is able to detect initial, automatic attentional biases, but might not be able to detect attentional biases that occur over a longer period. This limitation can be addressed by assessing continuous, detailed gaze patterns using equipment that tracks eye movement. Also of note, the sampling rate for eye tracking is 16 milliseconds, with reliability when focus points of at least 100 milliseconds are determined by an algorithm, as described in the Method section.

   Eating disorders and the eye tracking task. Eye tracking moves beyond the dot-probe task in its ability to provide information about where an individual actively focuses (orienting) and ignores (executive attention). Eye tracking measures the location and time of gaze. Technology that tracks eye movements was originally designed to assess how individuals read and it remains a common research area for this technology (e.g., Johnson, 2009). Eye tracking technology has also been used in applied contexts to determine where individuals look on control panels to improve the efficiency of control panel design (Brown, Vitense, Wetzel, & Anderson, 2002; Geri, Martin, & Wetzel, 2002). More recently, eye tracking tasks have been used to assess potential attentional biases in psychological disorders, such as schizophrenia (O'Driscoll & Callahan, 2008), autism (Brenner, Turner, & Müller, 2007; Rommelse, Van der Stigchel, & Sergeant, 2008), addictions (Field, Eastwood, Bradley, & Mogg, 2006), depression (Caseras, Garner, Bradley, & Mogg, 2007) and anxiety disorders (Bradley, Mogg, & Millar, 2000; Calvo & Avero, 2002; Hermans, Vansteenwegen, & Eelen, 1999).

   Eye tracking studies show attentional biases in the context of eating disorders and body image. However, results from these studies are inconsistent. Studies with continuous measures of

40

subthreshold eating disorder attitudes (e.g., drive for thinness, eating concerns) find attentional bias for gaze time. Symptomatology is positively associated with gaze time on dissatisfying body regions (e.g., waist, hips, Hewig et al., 2008; Jansen, Nederkoorn, & Mulkens, 2005), although one study found an inverse relation between symptomatology and gaze time on weight-related regions of endomorph images. Dissatisfying body parts in these studies were either identified by participants (Jansen et al., 2005), or assumed to be areas associated with weight (Hewig et al., 2008; Janelle, Hausenblas, Fallon, & Gardner, 2003). Other studies found that obese individuals with BMI-related body dissatisfaction focused on dissatisfying body parts, whereas normal weight individuals focused on satisfying body parts (Gardner, Morrell, Watson, & Sandoval, 1990; Roefs et al., 2008). Similarly, individuals with low symptomatology focused on satisfying body parts (Jansen et al., 2005). These results suggest a lack of avoidance in healthy control participants. In another study, overweight women showed overattention toward images of food compared with normal weight individuals, and this effect was exacerbated when participants engaged in the eye tracking tasks in a non-fasting compared with fasting state (Castellanos et al., 2009). Taken together, these studies suggest that eating disorder attitudes are linked to the ability to orient toward dissatisfying body parts and other visual stimuli related to eating attitudes, but that there may be differential effects of executive attention on whether an individual chooses to look at those regions or avoid them.

Studies looking at differences between threshold BN and healthy groups also find attentional bias for gaze time. Participants with BN show increased attention to thin, compared with normal and overweight, figures (Blechert et al., 2009). Notably, these results show a bias in the opposite direction from continuous symptomatology studies. In another study, both AN and

41

Table 3

Results of the eye tracking task in eating disorders

Study	Population	Groups	IV(s)	Eye tracking content	Results
Gardner et al., 1990	Obese men and women	Obese (*n*=20); Controls (*n*=20)	Gaze time	Self-photo	OB and HC looked longer at chest, waist, to estimate body size; OB gazed longer than HC at waist
Janelle et al., 2003	Subthreshold women	High DT; Low DT (*N*=40)	Gaze to images of others	Endomorph, ectomorph, mesomorph figures	Low DT gazed longer than High DT at legs of all figures; Low DT gazed longer than High DT on waist of endomorph;
Jansen et al., 2005	Subthreshold women	High ED (*n*=13); Controls (*n*=13)	Gaze to self-identified unattractive and attractive parts	Self-photo and other-photo	High ED gazed more at own unattractive than attractive body parts; HC gazed more at own attractive than unattractive parts; High ED gazed more at attractive than unattractive parts of others; HC gazed more on unattractive than attractive parts of others
Hewig et al., 2008	Subthreshold men and women	High DT; Low DT (*N*=51)	Gaze to waist, hip, legs, arms	Images of attractive men and women	Higher DT looked longer at waist, hips, legs, arms than Lower DT
Roefs et al., 2008	Healthy women	Undergraduate women (*N*=51)	Gaze to unattractive and attractive parts	Self-photo and other-photo	Gazed longer at dissatisfying body part on self, satisfying body part on other
Blechert et al., 2009	Clinical women	BN (*n*=20); Controls (*n*=22)	Gaze to images of others	Higher and lower BMI images	BN gazed longer than HC at images with lower BMIs; HC gazed longer than BN at images with higher BMIs

| Gao et al., 2011 | Subthreshold women | Weight-dissatisfied; Weight-satisfied (*N*=40) | Latency for fat and thin words | Fat, thin, neutral words | Weight-dissatisfied had shorter latency for fat words, and longer gaze duration on fat words, compared with neutral |
| Horndasch et al., 2012 | Clinical adolescents | AN (*n*=11), BN (*n*=6), Controls (*n*=25) | Gaze to clothed vs unclothed body parts | Thin, normal, overweight other images | All gazed longer at dissatisfying body parts; ED gazed longer at unclothed parts |

Abbreviations: OB=Obese; HC=Healthy controls; DT=Drive for thinness; ED=Eating disorder

BN individuals gazed longer at dissatisfying body parts, and also gazed longer when presented images were unclothed (i.e., in underwear) rather than clothed (Horndasch et al., 2012). These results provide evidence that women with threshold eating disorders show attentional biases for anxiety-provoking food or body stimuli, and that a variety of stimuli can produce this effect.

Taken together, these studies highlight that eye tracking can investigate associations between attention and core eating disorder symptomatology. However, more research is needed on attentional bias to explore inconsistent results and to determine whether modifying these biases is feasible. The Stroop, dot-probe and eye tracking tasks all measure attentional biases in eating disorders. Of the three, eye tracking provides the most detailed and continuous information that can address important attentional abilities including: orienting and executive attention. Importantly, eye tracking studies might be used to improve current eating disorder treatments that emphasize cognitive processing.

Modifying attentional biases in eating disorders. Just as researchers have attempted to modify attentional biases in addictive disorders, research has also investigated the possibility of modifying attention in eating disorders. Smith and Rieger (2006) induced an attentional bias toward negative body words, negative emotion words, or neutral words using a dot-probe training task that trained participants to anticipate where the probe would be based on the content of the words. Participants ($N = 70$) were then exposed to a body image challenge that involved either rating image-focused advertisements objectively or by comparing the images to themselves. Participants then completed questionnaires about their level of body dissatisfaction. Although there were no pre-intervention between-group differences in body dissatisfaction, induced attentional bias toward negative weight and shape words, but not negative emotion words or control words, led to greater post-intervention body dissatisfaction. This intervention

showed that it was possible to induce attentional bias toward negative weight and shape stimuli. Moreover, the establishment of the association and subsequent change in body dissatisfaction suggest that an intervention aimed at reducing body dissatisfaction by the same mechanism might have utility.

Researchers have also investigated whether distracting individuals during imagery tasks could reduce food cravings (Kemps, Tiggemann, Woods, & Soekov, 2004). Kemps and colleagues (2004) assessed dietary restraint and categorized women as dieters or non-dieters. Participants imagined food and non-food items while performing a visual working memory task. Images were less vivid and cravings less intense for both groups when the visuospatial task competed with mental images for attention. They found the same results when participants engaged in a self-directed forehead tapping and tracking task, which required them to tap their forehead from temple to temple while tracking progress with their eyes (McClelland, Kemps, & Tiggemann, 2006). These findings suggest that altering attention patterns and interrupting attentional biases might reduce eating disordered thoughts.

Current Eating Disorder Treatments

Cognitive-behavioral therapy (CBT) is one of the most prevalent forms of treatment for eating disorders (American Psychiatric Association, 2006; Fairburn et al., 2009; Mitchell et al., 2007; National Institute for Clinical Excellence, 2004). CBT protocols exist for all threshold eating disorder diagnoses: BN (Agras, Walsh, Fairburn, Wilson, & Kraemer, 2000; Fairburn, 1981), AN (Fairburn, 2005), binge eating disorder (Carter & Fairburn, 1998), extreme shape concern (Shafran et al., 2009), and a transdiagnostic CBT for eating disorders (Fairburn et al., 2009). CBT-based protocols specifically targeting threshold body image concerns and body checking behaviors have also been developed (Butters & Cash, 1987; Rosen, Saltzberg, &

45

Srebnik, 1989). In addition, clinicians often use dialectical behavior therapy (DBT) to treat threshold eating disorders (Safer, Telch, & Chen, 2009).

       Treatment of threshold eating disorders. Threshold eating disorders, both AN and BN, are commonly treated with CBT (American Psychiatric Association, 2006; National Institute for Clinical Excellence, 2004). CBT conceptualization holds cognitive components of AN and BN maintain the disorder, beyond cyclical behaviors of restriction, binge eating and purging (Fairburn, 1981). CBT includes three areas of intervention: (1) psychoeducation about the disorder and stimulus control to reduce triggering antecedents, (2) cognition restructuring, and (3) exposure to feared stimuli while practicing relaxation to reduce the reinforcement intrinsic to the anxiety-avoidance cycle (Wilson & Fairburn, 1993). Psychoeducation about the disorder outlines the consequences of current attitudes and behaviors, and allows the patient to build confidence that her thoughts and behaviors can be treated. Cognition restructuring involves identifying irrational thoughts, thought patterns and maladaptive beliefs, challenging them, and creating alternative (rational) ways of thinking.

       Distorted cognitions and maladaptive beliefs maintain eating disordered behaviors, and thus, CBT targets and emphasizes these thought patterns. For example, individuals with BN often have "trigger" foods that they will not eat because they believe eating a small amount will cause them to lose control over their eating, and subsequently binge and purge. Therapists counter these thought patterns by challenging their irrationality and facilitating corresponding behavioral changes. For example, they recommend patients eat three meals a day to disprove the assumption that consuming that much food will lead to drastic weight gain. Some versions of CBT also include exposure to feared foods with response prevention: patients eat their "trigger" food in the presence of a therapist until they feel the urge to induce vomiting, and then the

therapist will help the patient cope with her anxiety through relaxation until the urge has receded (Wilson & Fairburn, 1993).

The short-term goal of CBT for threshold eating disorders is to reduce and eliminate eating disordered behaviors such as severe restricting, binge eating, and purging. The long-term goal of CBT is to alter thought patterns including distorted thoughts and maladaptive beliefs about body image, interpersonal relationships, emotional dysregulation, and control (Mitchell et al., 2007). Ainsworth and colleagues (2002) suggest that to treat threshold eating disorders, therapists must move beyond treating eating disordered behaviors and thoughts to address early maladaptive schemas that developed related to food, body image, and ultimately how individuals interact with the world. Emotions and observable threats can provide information regarding the development of early maladaptive schemas (Ainsworth et al., 2002).

Cognitive remediation therapy (CRT) is a form of CBT strongly influenced by neuropsychological findings in eating disorders. This therapy addresses how individuals think with the aim to address dysfunctional thinking patterns such as cognitive inflexibility. CRT successfully addresses cognitive flexibility and planning (Tchanturia, Davies, & Campbell, 2007). Paired with psychotherapy to address underlying issues, CRT can enhance an individual's capacity to engage in therapy. Overall, evidence clearly supports CBT as the method of choice for treating threshold eating disorders. However, despite this evidence supporting CBT as more effective compared with other forms of therapy, CBT is only moderately effective with 30-50% of individuals with BN (Fairburn et al., 2009) and 13-33% of individuals with AN (Fairburn, 2005) reporting symptom improvement post-treatment. Considering other forms of CBT and components from other evidence-based therapies is essential to improving the current treatment protocols for threshold eating disorders. Likewise,

47

addressing attentional biases might be an appropriate, novel addition to existing CBT and CRT protocols to increase treatment efficacy.

      Body image treatment. The treatment of body image concerns and anxiety must address the cognitive, affective, behavioral and sociocultural components of body image (Cash, 2004). Some forms of CBT include sessions devoted to body image anxiety and body shape concerns. These sessions have also been developed as independent modules that can be used in any population with threshold body image concerns, including individuals with medical disorders and body dysmorphic disorder, as well as eating disorders (Farrell, Shafran, Lee, & Fairburn, 2005; Shafran et al., 2009). Therapists administer body image-specific CBT in one two-hour session. The session includes a behavioral exposure where the therapist directs the patient to look at each body part in a mirror as she reads a list of body parts aloud and practices relaxation, to ensure that the patient checks each body part, thus avoiding attentional biases. This can be organized through an exposure hierarchy based on how much anxiety different body parts provoke (Shafran et al., 2009). Patients also engage in cognitive processing where they practice describing themselves neutrally and mindfully. The therapist also provides psychoeducation about body checking and avoidance, and collaboratively creates interfering behaviors that can help the patient reverse the habit, such as making fists to confront the desire to pinch flesh. Lastly, body image-specific CBT involves giving video feedback to patients to provide a novel but realistic viewing experience. This activity also includes giving accurate feedback about perceptions of body size and shape to instill confidence in patients that they are viewing themselves as they actually are, and corrective feedback when they appear to overestimate (Reas & Grilo, 2004). Body image-specific CBT was more effective than the relaxation-only control group, and more effective than the waitlist control group (Shafran et al., 2009). However, these

researchers suggest that a dismantling study is warranted to determine which aspects of the therapy have the greatest efficacy.

Dialectical behavior therapy and mindfulness. DBT, like CBT, has its roots in behavior therapy. DBT addresses distorted cognitions, behavioral responses to threatening stimuli, and psychoeducation about the dialectical philosophy that two opposite pulls can coexist in their entirety at the same time (Linehan & Schmidt, 1995). At its core, DBT uses mindfulness skills to encourage individuals to accept themselves nonjudgmentally and focus on awareness of the present moment to decrease negative affect and increase perceived control over thoughts, emotions, and behaviors (Safer et al., 2009). Mindfulness is consistent with the body image anxiety exposure intervention because it promotes present focus on the threatening stimuli and neutral evaluation of the entire body. Mindfulness can decrease avoidance of threatening stimuli, and help individuals tolerate distress without using negative coping strategies (Ainsworth et al., 2002).

Summary and Hypotheses

Threshold and subthreshold eating disorders involve complex profiles of behavioral, biological, psychosocial, and cognitive factors. Previous research has established that visual attentional biases for eating disorder-relevant stimuli occur in women with threshold eating disorders, and might occur in women with subthreshold eating disorders. However, much of the assessment of attentional biases to date has evaluated a limited number of outcomes, such as reaction time (Stroop). Questions remain about how individuals with threshold and subthreshold eating disorders might have different gaze patterns that reinforce body dissatisfaction compared with healthy controls. Eye tracking tasks can provide rich, continuous data on overattention to eating disorder-consistent stimuli and areas where individuals choose to focus.

Attentional biases are theoretically part of the development and maintenance of threshold eating disorders and thus, are potential areas for treatment. Adding training in a body image attention skill to existing treatment protocols for threshold eating disorders has the potential to improve efficacy by targeting behavioral and cognitive elements of distorted cognitions. Eye tracking might identify specific behavioral processes that underlie disordered thoughts and feelings and could then be used to develop and test tasks that help patients modify attentional biases. Similar interventions have been shown to alter gaze patterns in other populations (Field et al., 2009; Schoenmakers et al., 2010). Enhancing existing treatments for eating disorders can help reduce the significant personal and public health costs of eating disorders.

In the current study, eye tracking was used to assess orienting and executive attentional abilities. Eye movement behavior related to specific body regions and dissatisfaction evaluated these abilities. Gaze time on dissatisfying body regions was hypothesized to be positively associated with body dissatisfaction. When individuals spend more time looking at areas of their body with which they are dissatisfied, this influences how they see themselves such that they emphasize this negative information without equally weighing more positive information by looking at areas with which they are more satisfied. Individuals meeting threshold, subthreshold, and low symptomatology criteria were included in the current study to ensure a range of shape concern and to assess whether shape concern severity influences these attentional biases.

Stimuli were images of the participant ("self image") and images of normal weight confederates ("other image"). Consistent with prior research, it was hypothesized that participants would have longer gaze time on their own dissatisfying body regions and satisfying regions of others because this social comparison would contribute to overall body dissatisfaction.

The brief intervention proposed in this study was hypothesized to change gaze patterns so that participants show a lower level of overattention towards dissatisfying body regions and more attention towards satisfying regions than at pre-intervention assessment. Thus, the attention training intervention aimed to modify attentional biases. The intervention included training along alerting, orienting and executive attention biases; although alerting cannot be assessed in this study, overattention orienting biases and avoidance executive attention biases are hypothesized to improve from pre- to post-testing. Self-reported physical appearance anxiety related to specific body parts was assessed pre- and post-intervention to determine whether attention modification influenced body image anxiety. Eye tracking findings could enhance current CBT treatment by providing initial data on feasibility on whether attention training can modify attentional biases. Feasibility findings also provide direction for future research exploring factors that cause and maintain eating disorder thoughts, feelings, and behaviors.

Method

This study explored potential differences in eye movements of women with threshold eating disorders, subthreshold eating disorders, and healthy controls. The following sections detail design and recruitment procedures and statistical analyses.

Design

This study used a mixed design in which participants completed measures during two data collection sessions. Participants ($N = 1011$) completed self-report questionnaires online through SONA systems. These questionnaires assessed disordered eating, body checking and avoidance. The eating disorder assessment allowed for participants to be screened into groups of low subthreshold eating disorder symptomatology, high subthreshold symptomatology, and threshold symptomatology. Then, participants meeting these criteria (or referred by clinicians), attended an in-person session. The single in-person session involved a structured interview and baseline eye tracking assessment of attentional biases, and training in a brief body image attention skill. After the attention training intervention, participants completed a follow-up eye tracking task similar to the baseline task, and follow-up questionnaires.

Participants

Participants heard about the study through either the SONA Systems website administered by the VCU Department of Psychology, or through a clinician referral. For a visual depiction of participant involvement, see Figure 1. Clinicians affiliated with the Eating Disorder Treatment Team at VCU referred participants for this study. To be eligible to participate,

52

individuals had to be female and between the ages of 18 and 25. This age range was selected to

control for potential age effects in the study, because age is a known correlate of eating disorder

symptomatology (Hudson et al., 2007). This age range is also typical of other studies that have

used an undergraduate sample (e.g., Mitchell & Mazzeo, 2004) and has known EDEQ norms

(e.g., Luce, Crowther, & Pole, 2008). Undergraduates are an appropriate study population

because the prevalence of eating disordered thoughts and behaviors is high among females in this

population (e.g., Cohen & Petrie, 2005; Hudson et al., 2007; Luce et al., 2008). Males were not

included because of the preponderance of women with eating disorders, and to reduce potential

confounding effects of gender (e.g., Hudson et al., 2007).
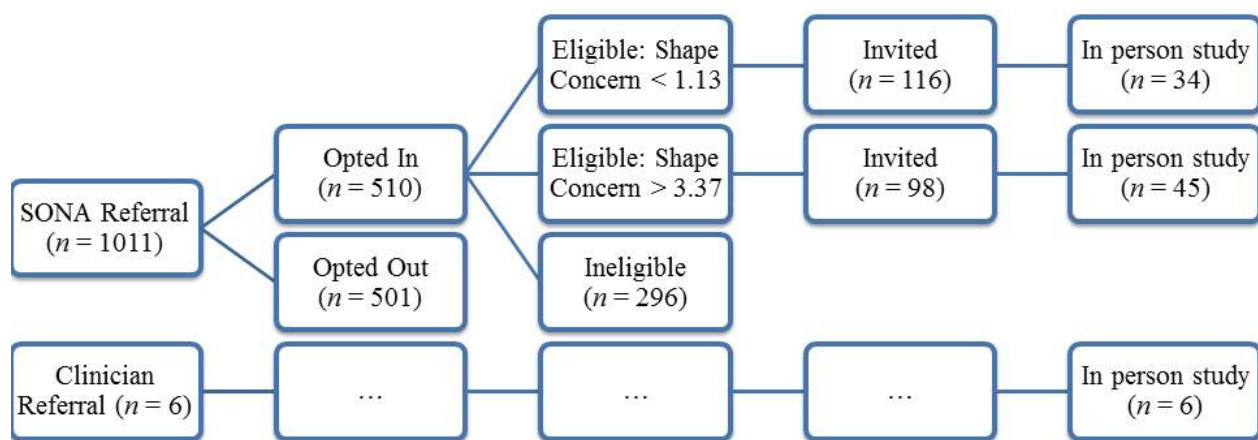
Figure 1. *Participant Involvement*

SONA participants completed the screening surveys for 0.5 research credits. Most

psychology courses that participate in the Psychology department subject pool require between

three and nine hours of research credit, and some psychology courses offer participation as a

source of extra credit. Participants indicated at the start of that survey whether they were

interested in being contacted to participate in the in-person part of the study. Approximately

50.45% of participants indicated that they were interested in completing the in-person study ($n =$ 510). All participants who indicated interest were contacted via email regarding their eligibility for the in-person study. Participants who completed the in-person study received an incentive of $5 and 3.5 credits. Eligibility criteria for shape concern using the Eating Disorder Examination Questionnaire (EDEQ; Fairburn & Beglin, 1994) were 1.13 (25th percentile) for the low symptomatology healthy controls and 3.37 (75th percentile) for the high symptomatology healthy controls. For a full description of EDEQ norms in female college students, see Luce and colleagues (2008). Of note, the suggested clinical cutoff for a probable eating disorder is a global or subscale score of 4.0. Participants with threshold eating disorders recruited from clinicians and not enrolled in Psychology classes offering research credit received $15 and the opportunity to have their eating disorder assessment written as a clinical report for the referring clinician. Students who met criteria for an eating disorder at the in-person visit but who were not in treatment were classified in the threshold group and referred to University Counseling Services.

Participants were ineligible for the in-person component of the study if they identified an underlying condition that could significantly influence their eating behavior (e.g., diabetes mellitus or Crohn's disease), or visual disability (e.g., blindness). Participants using glasses or contact lenses as visual aids were eligible to participate in the study because the eye tracking technology functions without impairment when visual aids are present. Participants whose self-reported weight was in the overweight range of BMI (i.e., above 25 kg/m^2) were not eligible for the in-person component because of the unknown influence of body size on body image perception (Schwartz & Brownell, 2004).

The in-person component of the study occurred in the clinical research space at the Center for Psychological Services and Development, a department-run Psychology clinic located

on VCU's main campus. Participants were identified by an individual code number to maintain

confidentiality, and data were kept in a secure, locked location.

Measures

The measures below were administered in both the online and in-person parts of the

study. Participants completed some measures in an online survey format, and other state-based

measures both before and after the eye tracking tasks and attention training to assess changes due

to the intervention. For details about when each measure was administered (i.e., online, before

the intervention, or after the intervention), please see Table 4. The current study has both an

investigator-based structured interview and self-report measures that assess specific eating

disorder symptomatology that might be sensitive for participants to report (Fairburn & Beglin,

1994).

Demographic questionnaire. Participants reported their age, year in school, race and

sex and indicated whether they had an underlying biological condition that influences their

eating behaviors or visual impairment. Participants also reported height and weight, which was

measured if they also completed the in-person component.

Eating Disorder Examination (EDE). The "gold standard" for eating disorder

diagnosis and exploration of specific pathology is the Eating Disorder Examination (Cooper &

Fairburn, 1987). This structured interview is widely used and well-validated (Fairburn & Beglin,

1994). It assesses thoughts, feelings and behaviors related to eating disorders within the past 28

days and includes four subscales: restraint, eating concern, weight concern, and shape concern,

as well as a composite "global" score (Cooper & Fairburn, 1987). Diagnostic items are

consistent with time and frequency specifications in the DSM-IV-TR. Behavioral items such as

binge eating, severe calorie restriction, and self-induced vomiting are rated according to the

Table 4

Measures in the Current Study

Instrument and Scales	Online	Pre-intervention	Post-intervention	Mean ± Standard Deviation	Cronbach's Alpha
Demographic Questionnaire	A	B			
Eating Disorder Examination Questionnaire					
Shape Concerns	A			2.43 ± 1.72	.93
Weight Concerns	A			2.19 ± 1.68	.87
Eating Concerns	A			1.10 ± 1.26	.82
Restraint	A			1.52 ± 1.46	.85
Eating Disorder Examination					
Shape Concerns		AB		2.41 ± 1.82	.93
Weight Concerns		AB		2.00 ± 1.67	.87
Eating Concerns		AB		1.01 ± 1.28	.82
Restraint		AB		1.56 ± 1.70	.85
Physical Appearance State and Trait Anxiety Scale					
Trait Weight	A	B		1.59 ± 1.00	.89
Trait Non-weight	A	B		0.54 ± 0.60	.82
State Weight		AB	AB	1.45 ± 1.19	.93
State Non-weight		AB	AB	0.35 ± 0.61	.87
Body Image Avoidance Questionnaire					
Exposure	A		B	1.32 ± 0.79	.80
Social Activities	A		B	0.51 ± 0.74	.82

Body Checking Questionnaire				
Feeling for Fat	A	B	1.34 ± 1.05	.91
Reassurance	A	B	0.71 ± 0.72	.87
Thin Ideal	A	B	2.13 ± 0.92	.83
Mindfulness Attention Awareness Scale				
Trait Mindfulness	A	B	3.68 ± 0.83	.88
State Mindfulness		AB	1.69 ±1.06	.74
Body Region Dissatisfaction Hierarchy	AB			

Note. Measure administration for participants referred through SONA is marked "A." Participants referred by clinicians had an

alternative timing for select measures, denoted "B." Means and alphas calculated from SONA data except when only administered in

person.

number of days on which these behaviors occurred and the number of times these behaviors occurred on those days. Binge eating items are further divided into objective and subjective episodes. Objective binge episodes are times when individuals ate a quantity of food that others would consider large or excessive. Subjective binge episodes are times when individuals felt that they lost control and ate more than they would like, but recognize that the amount of food they ate would not be considered by others to be large or excessive. Attitudinal items that comprise the subscales were rated by the interviewer on a seven point scale of severity or frequency, where higher scores indicate more severe pathology.

The EDE has manifested evidence of discriminant validity by effectively differentiating individuals with threshold AN and BN from healthy controls. Individuals with threshold AN and BN scored higher than healthy controls on every item of the subscales, without overlapping standard errors (Cooper, Cooper, & Fairburn, 1989). Subscales from threshold and normal populations were correlated, as would be expected because they measure the same construct in different levels. Internal consistency of subscales is also high: restraint, *Cronbach's α =* 0.75, eating concern, *Cronbach's α =* 0.78, shape concern, *Cronbach's α =* 0.82, and weight concern, *Cronbach's α =* 0.68 (Cooper et al., 1989). The investigator was trained in administration of the EDE as part of an existing grant, and was the sole interviewer in the current study.

Eating Disorder Examination Questionnaire (EDEQ). The EDEQ was developed as a self-report version of the EDE (Fairburn & Beglin, 1994). Items assess the same attitudinal subscales—restraint, eating concern, weight concern, shape concern—but the EDEQ is not considered sufficient to diagnose eating disorders. Rather, the EDEQ screens for likely threshold and subthreshold eating disorders. In the initial development study, researchers found no significant difference between subscale scores on the EDE and EDEQ, suggesting that there is

concurrent validity between these measures (Mond, Hay, Rodgers, & Owen, 2006). They found

that there was a high percent agreement within one point, 64-79% in a community sample and

55-75% in a patient sample. An independent study assessed the internal consistency of the

subscales in a female undergraduate sample: restraint, *Cronbach's α =* 0.84, eating concern,

Cronbach's α = 0.78, shape concern, *Cronbach's α =* 0.93, and weight concern, *Cronbach's α*

= 0.89 (Luce & Crowther, 1999). The EDEQ also shows evidence of two week temporal

stability, with correlations ranging from 0.81 to 0.94. In the current study, the internal

consistency of the full measure was 0.92.

Normative data (*M ± SD*) for the EDEQ were collected in a sample of undergraduate

women (Luce et al., 2008; Mond et al., 2006) and are as follows: global score (1.74 ± 1.30),

restraint (1.62 ± 1.54), eating concern (1.11 ± 1.11), shape concern (2.27 ± 1.54), and weight

concern (1.97 ± 1.56). These studies also provided standard scores and percentiles (Luce et al.,

2008; Mond et al., 2006) that informed the current study's determination of threshold,

subthreshold, and healthy control criteria prior to the administration of the EDE.

Physical Appearance State and Trait Anxiety Scale (PASTAS). The PASTAS is a

self-report measure of body image state and trait anxiety yielding internally consistent state,

Cronbach's α = 0.90, and trait, *Cronbach's α =* 0.88, subscales (Reed et al., 1991). This scale

was used with permission of the scale's developer. Participants rate fifteen items assessing how

anxious, tense, or nervous they feel about specific body parts. The state form asks participants

how anxious they feel about their body "right now" on a five-point scale from *0 = not at all* to *5*

= exceptionally. The trait form specifies participants report how often they feel body anxiety "in

general" on a five-point scale from *0 = never* to *5 = almost always*. The PASTAS has weight

and nonweight appearance anxiety subscales. The weight subscale includes thighs, buttocks,

hips, stomach, legs, waist, muscle tone, and the extent to which a person looks overweight. The nonweight subscale includes ears, lips, wrists, hands, forehead, neck, chin, and feet. Two-week temporal stability for the trait form was $r = 0.87$. The PASTAS shows some evidence of convergent validity with the Drive for Thinness, $r = 0.62$, Body Dissatisfaction, $r = 0.74$, subscales of the Eating Disorder Inventory and a moderate but significant positive correlation with the State-Trait Anxiety Inventory, $r = 0.37$. In the present study, the PASTAS yielded internally consistent scores for the overall measure, $\alpha = 0.89$.

Body Checking Questionnaire (BCQ). The BCQ is a 23-item self-report measure of body checking behaviors (e.g., laying down to feel whether bones touch the floor, looking for fat in the mirror) with subscales assessing overall appearance checking, specific body part checking, and body checking rituals (Reas et al., 2002). The BCQ is temporally stable, $r = 0.94$, and its subscales are internally consistent (*Cronbach's α* = 0.83 to 0.92; current study *Cronbach's α* = 0.94). The BCQ is related to excessive attention on the body, which is thought to play a part in maintaining eating disorder thoughts (Reas et al., 2002). Evidence of concurrent validity has been shown with the Body Shape Questionnaire, $r = 0.86$, and the Eating Attitudes Test, $r = 0.70$, and the BIAQ, $r = 0.66$. The BCQ has also shown evidence of criterion validity with participants with threshold eating disorders (82.1 ± 18) scoring significantly higher than healthy controls (56 ± 16) (Reas et al., 2002). The factor structure of this measure was examined in the current study, and subscales assessing feeling for fat, reassurance, and behaviors related to the thin ideal were a better for the data than the factors described in the development sample.

Body Image Avoidance Questionnaire (BIAQ). The BIAQ is a 19-item self-report measure of body image avoidance behaviors (Rosen et al., 1991), including subscales related to clothing, social activities, eating restraint, and grooming. This scale demonstrated internally

consistent scores (*Cronbach's α* = 0.89; current study *Cronbach's α* = 0.81). The clothing

subscale indicates a desire to avoid appearance by disguising or covering up the body. The

social activities subscale assesses avoidance of social situations that emphasize food, weight, or

body image. The eating restraint subscale measures restriction and dieting, and the grooming

and weighing subscale evaluates avoidance of body checking behavior such as looking at oneself

in the mirror and weighing. Two week temporal stability was good, $r = 0.87$. The BIAQ

demonstrated evidence of convergent validity with avoidance items on the Body Shape

Questionnaire, $r = 0.74$ (Grilo et al., 2005). The clothing subscale seems to be particularly

relevant within overweight samples, and has shown evidence of convergent validity with the

Body Dissatisfaction subscale of the Eating Disorder Inventory, $r = 0.57$, and the Bulimia Test,

Revised, $r = 0.48$ (Trautmann, Worthy, & Lokken, 2007). The factor structure was examined for

this measure in the current sample, and better fit was found when the restraint items were

dropped and remaining items clustered into avoidance of exposure and avoidance of social

situations subscales.

       Mindfulness Attention Awareness Scale (MAAS). The MAAS is a self-report measure

of mindfulness, or the state of mind in which attention, informed by a sensitive awareness of

what is occurring in the present, simply observes what is taking place (Brown & Ryan, 2003).

This measure was administered in its trait form as part of the screening measures, and after the

eye tracking task to assess the participant's experience during the intervention. This scale yields

internally consistent scores in a variety of populations (α = 0.80 to 0.90; current study

Cronbach's α = 0.88), including college students and medical patients. This measure also shows

evidence of construct and convergent validity.

Body Region Dissatisfaction Hierarchy (pre). To inform the exposure in the attention modification intervention, participants ranked body regions (torso, waist, thighs, lower legs) in order from least to most dissatisfying. This hierarchy of body region dissatisfaction guided the orienting skill in the intervention and informed interpretation of gaze patterns.

Eye Movement Behavior. The eye tracking equipment measures the location of linear gaze, and the angle of change between gaze locations. Eye movement behavior defined by position and duration can be described as "fixations" and "dwells." Technical definitions of these behaviors and how algorithms calculate them are described below. Fixations and dwells can be measured as counts or can be used to gain a total gaze duration time. In addition, eye tracking equipment can measure average pupil diameter.

Over time, algorithms have been developed to group data into fixations and dwells based on set criteria. A fixation is defined as eye movements that stabilize the retina over a visual object of interest for longer than a minimum threshold of time. The Applied Science Laboratories' algorithms for fixations and dwells are contained in the Results program, and use the dwell-time fixation detection method (Applied Science Laboratories, 2011; Duchowski, 2007). Initially, fixation detection was based on physiological times for events to be transmitted by the nervous system so that the brain could receive and process visual information. That is, fixations are the minimum amount of time that can correspond to a desire to maintain gaze on an object of interest (Duchowski, 2007). Conservative definitions of fixations have latencies that range from 100 milliseconds to 300 milliseconds. More recently, data have suggested that latencies are more typically more than 200 milliseconds, but when targets are predictable, latencies can be 90 to 120 milliseconds (Applied Science Laboratories, 2011). The algorithm used by the Applied Science Laboratories Results program is 100 milliseconds. Data are

collected at 60 Hz (or every 16 milliseconds), meaning that seven data points in the same area would result in a fixation, because the time associated with the number of data points must exceed the 100 millisecond time frame. Inherent in this definition of fixation is the requirement that the position be the same; however, the nature of eye movement behavior is such that gaze is not static. Therefore, to meet the requirement of a fixation, the algorithm in the Applied Science Laboratories Results program also specifies that there must be no more than a 1° change in gaze position over three consecutive samples; again, this is more conservative than definitions that can allow fixations to range up to 5° (Duchowski, 2007). Miniature eye movements are generally smaller than 1°. In addition, the Applied Science Laboratories Results program ensures measurement accuracy by terminating fixations if pupil loss or cornea reflection loss occurs for more than 200 milliseconds.

Another eye movement behavior is the "dwell." Similar to the fixation, the dwell requires a minimum gaze duration to meet the threshold to be classified as a dwell. A dwell assesses contiguous fixations in the same area of interest (Applied Science Laboratories, 2011); in the current study, each area of interest corresponds to a body region. Two or more fixations in the same area of interest meet the minimum requirements for a dwell.

Finally, pupil diameter data were collected during the eye tracking task. Pupil diameter is measured horizontally across the eye and length is noted in pixels to correspond with camera length units. The horizontal diameter is considered more accurate than the visual diameter because sampling is not inhibited by the amount of pupil visible between eyelids (Applied Science Laboratories, 2011). Pupil diameter is associated with interest in the viewed item, which can be due to image novelty, cognitive difficulty, engagement with images, and unpredictable or surprising images. The relation of pupil diameter with anxiety is complex. Within each fixation,

shocking images may produce initial dilation and gradual constriction over time as individuals cognitively avoid processing the image; more commonly, pupil dilation is associated with affect intensity (Andreassi, 2007). The current study produced average pupil diameter for each fixation, which appears to be a measure of the level of threat a stimulus holds.

Procedure

First, participants completed the online survey portion of this study, with measures previously described. Then, eligible and interested participants were invited to the in-person session. When participants arrived, they completed informed consent. They had their picture taken in a pre-determined outfit: participants brought their own light-colored shorts (such as they might wear to the gym) or wore light gray shorts provided by the investigator, and they wore a white t-shirt provided by the investigator. Participants were instructed to pick the shirt that fit them from a range of sizes. The picture was taken in the same position for all participants: standing close to but not against a plain wall, with arms loosely at their side, feet shoulders-width apart and hair behind shoulders. Pictures did not include the head to protect confidentiality. Participants had their height and weight measured in this outfit, and then changed back into casual clothing. Next, participants were interviewed by the investigator using the EDE structured interview (Cooper & Fairburn, 1987). At the end of this interview, participants completed the body region hierarchy and a state measure of physical appearance anxiety. Concurrent with the completion of these surveys, the investigator finalized the participant-specific slide show by adding their image to the "self" slides. Participants then completed the baseline eye tracking assessment, intervention, post-intervention assessment, and post-assessment survey measures.

The investigator began the eye tracking assessment by orienting participants to the eye tracking equipment. This included calibration of the machine to their individual characteristics:

syncing the head tracking measures that would track the participant along an X, Y, Z axis, and syncing the eye tracking eye data collection with cornea reflections and pupil glints. Point of gaze was fit to participants by using a nine-point calibration screen with points known to the eye tracking equipment software. After calibration criteria were met, participants completed the baseline eye tracking task, which involved looking at six sets of five images (one "self" and four "other" confederate images), each for ten seconds. Participants were then trained in the attention modification skills.

Eye Tracking Assessment Task. Participants completed a similar task prior to and following the intervention to evaluate eye movement patterns and potential attentional biases. For the baseline task, participants viewed thirty slides (i.e., "events") for ten seconds each; therefore, the entire baseline assessment task lasted five minutes. Each slide had one image on it that served as the stimulus. Five images repeated in six sets over the course of the assessment task: four confederate images ("other" images), and one participant-specific image of the participant ("self" image) taken at the beginning of the in-person session in a standardized outfit, as previously described. Other images included one African American confederate image, one Hispanic confederate image, two White confederate images, and participant-specific images. The order of images presented was the same for each participant, and images were presented in sets of five with the five images randomly ordered within each set. The purpose of ordering images in this fashion was to make the order unpredictable to participants but still have each image appear at time points spanning the assessment tasks. To make images discernible events, the same image could not appear consecutively. Participants were instructed to look at baseline images as they would normally look at any image. The post-intervention assessment task had the same protocol as the baseline assessment task; however, images were in a different order. Before the post-

intervention task, participants were instructed to look at images while keeping in mind the three skills they had just learned. Gaze time and counts were collapsed into pre- and post-intervention values but not across stimuli. They were collapsed into pre- and post-intervention values because pre- and post- events were not in the same order.

Intervention. The intervention aimed to alter body image attentional patterns to reduce potential biases that might maintain eating disorder symptomatology. Three attention modification skills corresponding to the three attention abilities (alerting, orienting, executive attention) comprised the intervention (Posner & Rothbart, 2007; Tang & Posner, 2009). Even though alerting attention was not able to be assessed in the current study, it was addressed in the intervention because of the theoretical association of alerting attention with body anxiety and dissatisfaction. The intervention was modeled after existing CBT protocols for body image (Reas & Grilo, 2004; Shafran et al., 2009) and was designed to be brief so that, in future research and clinical practice, this intervention could be implemented as part of full psychotherapy protocols. Existing treatments have similar exposure hierarchies and skills training, but have not assessed attention subprocesses or evaluated treatment efficacy using eye movement behavior as outcomes.

Alerting Skill. The first attention subprocess addressed was the alerting ability, referring to an initial and maintained sensitivity (or alertness) to eating disorder stimuli (Posner & Rothbart, 2007). The investigator told participants that they would first see a warning signal ("plus sign") that would cue them where to look, and instructed them to maintain their gaze on that body region when a full body image replaced the plus sign. Each participant's intervention was informed by and personalized according to the body region dissatisfaction hierarchy they reported prior to the intervention. For example, Participant A constructed this dissatisfaction

hierarchy from least to most dissatisfying: torso, lower legs, waist, thighs. The alerting attention task had a warning signal for the torso region, then a full body image of a confederate, then a warning signal for the lower legs region, then a full body image of the same confederate, then a warning signal for the waist region, then a full body image of the same confederate, then a warning signal for the thighs region, then a full body image of the same confederate. Then, the same sequence was repeated with the participant's own picture.

> "For the first teaching activity, we will focus on how you look at images. First you will see a plus sign. I want you to focus on the plus sign--where the lines meet--and hold your gaze there. Then, a slide with an image of a person will appear. I want you to keep your focus where the plus sign was. You might be tempted to look at other parts of the picture, but try to keep your gaze steady for ten seconds, until the next slide appears. Then, another plus sign will appear in a different spot, so keep your eyes on that new spot when the next picture comes up. We'll do this activity with two pictures, each of which has four plus signs."

Orienting Skill. Orienting refers to spending more gaze time on dissatisfying stimuli rather than neutral stimuli (Posner & Rothbart, 2009). This attentional bias was addressed in part by the alerting attention skill, because participants maintained their gaze on each body region for equal time. To move beyond that level of directed gaze, the investigator next gave participants the task to describe two images aloud (one confederate, one self) to maintain attention on different areas. The investigator asked them to spend equal time on all regions and taught them how to describe the images using nonjudgmental language (i.e., neutral and descriptive).

Participants had ten seconds to think about and anticipate how they would describe the images before the images appeared. For this skill, participants described images progressively from shoulders to toe, and then reversed back up if time remained. They were given forty seconds to describe each image aloud; no participants ran out of time, and many were encouraged to reverse back up the body.

> "For the next activity, we will focus on how you talk about how
>
> people look. I want you to describe two images as though you were
>
> describing them to someone who was blind, or to a sketch artist
>
> who cannot see the image. You will have 40 seconds to describe
>
> each image. Start at the shoulders and go down to the toe, and then
>
> reverse back up to the shoulders if you have extra time. Do not
>
> skip over or dwell on any parts or features, but give equal attention
>
> to everything you see. Do not use critical or unkind language. For
>
> example, you can describe the image in terms of color, texture,
>
> proportion, shape, or symmetry, but not unkind words like 'fat,'
>
> 'too big,' or 'gross.'"

Executive Attention Skill. Executive attention refers to reconciliation of attentional conflict when there are multiple demands on attention. One example of attention conflict would be looking *away* from an emotionally threatening stimulus (e.g., the waist) and also being pulled to look *toward* the area where the intervention requires an individual to look (e.g., the waist) (Rueda, Posner, & Rothbart, 2005). Reconciliation of this conflict would be the choice, typically away from the emotionally threatening stimulus (e.g., to the torso), of where the participant looks. To address this, conflict was reduced by reducing images' threat through relaxation. After

relaxing, only the intervention would have a strong demand on attention. The investigator taught

participants one relaxation skill, diaphragmic breathing (Safer et al., 2009). Participants practiced

this for thirty seconds and then when looking at two images (one confederate, one self).

> "For the next activity, we will focus on relaxing while looking at
>
> pictures. For this activity, you will learn how to breathe deeply.
>
> Breathing deeply can help you when you feel stressed, or tense, or
>
> any intense emotion. To practice this, put one hand on your chest,
>
> and one hand on your abdomen. Take a deep, slow, flowing breath
>
> by breathing in while you count to three. Then breathe out while
>
> counting to 10. If it helps you relax, you can say 'relax' or 'calm'
>
> silently to yourself as you breathe out. The hand on you abdomen
>
> moves up and down, but the hand on your chest stays still—this
>
> means you're breathing deeply. Go ahead and practice until the
>
> screen comes up. When the images do appear, look at them in any
>
> way you want, just make sure you are breathing deeply."

After the intervention, participants completed the state physical appearance anxiety

measure and the state version of the MAAS that asks participants the extent to which they were

cognitively present during the task.

Eye tracking equipment. The eye tracking equipment was manufactured by Applied

Science Laboratories (Bedford, MA) and is their D6 model. The D6 model is a desktop remote

eye tracking device. Stimuli are presented on a computer monitor located directly above the D6

camera. Equipment includes a tracking camera, computers and software used to measure a

variety of eye and head movements including horizontal and vertical eye movement, head

position, coordination between eye and head movement, and pupil diameter. Software uses X, Y, and Z coordinate data of eye and head position to gauge fixations and dwells based on algorithms that calculate when eye gaze remains in a similar location for an amount of time that surpasses a minimum threshold. These algorithms were described previously in the measures section. Because the device uses X, Y, and Z coordinates, participants have leeway to move their head in the course of the eye tracking assessment without compromising data. Movement flexibility is approximately one foot, and therefore a head restraint is not necessary with this equipment and external validity is higher than with eye tracking equipment that uses head-mounted devices or head restraints. Eye movements are measured using both pupil and cornea reflections. Data are collected at a sampling rate of 60 Hz. After calibration, the device is able to accurately record eye movement behavior with an accuracy of 0.5^o visual angle and a visual range of 50° horizontal and 40° vertical eye movement. Software allows analysis of eye movements within investigator-identified regions of interest, time spent within any identified region and counts of fixations and dwells within each region (Applied Science Laboratories, 2011).

To assure the reliability of eye movement data, the investigator was trained by Applied Science Laboratories in proper calibration and verification procedures. Each participant's head and eye position were calibrated prior to their baseline assessment using a standard procedure. Participants viewed a "target points" calibration screen on the stimulus computer, and the investigator saw a screen image overlayed with eye position cursor on the research computer. Participants were instructed to look at each of nine points successively, and then the researcher verified that the product score of horizontal spread by vertical spread was not greater than 40, in line with recommendations by Applied Science Laboratories for the D6 equipment. If any points

70

had a spread greater than this range, that point would be recalibrated until it was within limits. All participants met these reliability requirements. In addition, participants demonstrated accurate eye tracking by looking at points two, five, and eight, which were those most important to the intervention, and to all four corners.

Analysis Plan

IBM SPSS 19 (IBM SPSS Inc., 2010) and SAS/STAT 9.3 (SAS Institute Inc., 2011) were used for data entry and analyses. Survey data were entered by the online survey system or by undergraduate research assistants and verified by the investigator. Descriptive statistics ensured all data were in range, and also depict characteristics of the sample of participants who completed the survey ($n = 1011$) and eye tracking ($n = 85$) phases of the study. Internal consistencies were calculated for survey data using Cronbach's alpha to assess reliability of all scales used in this study.

For the main outcomes of this study, analyses of covariance (ANCOVAs) assessed the change in physical appearance anxiety from the intervention using a repeated measures design. Multilevel models (MLMs) assessed the effect of the intervention on eye tracking outcomes including fixation count and total duration, dwell count and total duration, and pupil diameter. MLMs were estimated using the PROC MIXED and PROC GLIMMIX programs in SAS. Models were first estimated for participants' visual attention behaviors on images of themselves, then in models that compared self and other stimulus patterns. For models that compared self and other stimuli, average fixation and dwell duration were also included because of their relation with visual comparison (Duchowski, 2007). Models were calculated using an unstructured variance-covariance matrix to allow for best fit.

Data Preparation

Eye tracking data were imported from the equipment-specific software by Applied Science Laboratories, the ASL Results program (Applied Science Laboratories, 2011). Prior to the generation of this data, data were cleaned by the investigator. The first data cleaning step was recording the real time of events (i.e., each discrete slide with an image on it pre and post intervention). Next, images were paired with each event to ensure an accurate underlying background was paired with the eye movement data. Next, areas of interest were designated for each background (i.e., for all four confederates and all 85 participant-specific self images). Next, areas of interest, backgrounds, events, and participants were all paired and verified for accurate pairing. Applied Science Laboratories Results software then calculated fixations and dwells (counts and total durations) using algorithms previously described, and these data were imported into SAS and SPSS.

Results

Description of the Sample

A total of 1017 female university students participated in this study; six were referred by clinicians and completed self-report measures on paper rather than online; 1011 completed online surveys. Of these, 510 (50.45%) indicated interest in the in-person study session; 81 were eligible for the low-symptomatology healthy control group, and 73 were eligible for the high-symptomatology group. Comparisons of participants who opted-in to the in-person session with those who opted-out revealed only one difference: the BIAQ was significantly different, with higher avoidance in participants who opted-in to the study, t (967) = -2.09, p = 0.04. The age requirement was between 18 and 25; 34 students were outside of this age range. The sample included diverse ages weighted toward younger participants; 476 (47.1%) were 18 years old, 202 (20.0%) were 19 years old, 105 (10.4%) were 20 years old, 81 (8.0%) were 21 years old, 50 (4.9%) were 22 years old, 31 (3.1%) were 23 years old, 20 (2.0%) were 24 years old, and 12 (1.2%) were 25 years old. Participants' year in school also varied, but was weighted towards the earlier years, consistent with typical enrollment in introductory Psychology classes that comprise the majority of the SONA population. Participants were first-year students (n = 599, 59.2%), second year students (n = 176, 17.4%), third year students (n = 117, 11.6%), fourth year students (n = 81, 8.0%), fifth year undergraduates (n = 14, 1.4%), or graduate students (n = 6, 0.6%); 18 students did not indicate their year in school as one of those categories.

The sample was racially and ethnically diverse. Participants selected multiple boxes to reflect their racial and ethnic identities. Participants identified as American Indian ($n = 16$, 1.58%), Asian or Asian American ($n = 140$, 13.85%), Black or African American ($n = 260$, 25.72%), White or Caucasian ($n = 534$, 52.82%), or Other ($n = 43$, 4.25%); 83 of these participants identified as multiracial (8.21%). For ethnicity, 84 participants identified as Hispanic or Latino (8.31%), and 911 did not identify as Hispanic or Latino (90.11%). Overall, 16 participants chose not to provide their race or ethnicity.

A small number ($n = 15$) of participants described having underlying biological or psychological conditions that they believed affected their eating behaviors. These students were excluded from the in-person study. Disorders included brain injury ($n = 1$), gastro-intestinal problems ($n = 2$), fibromyalgia ($n = 1$), Grave's disease ($n = 1$), hyperthyroid ($n = 2$), hypothyroid ($n = 2$), food allergy ($n = 4$), and lupus ($n = 1$). Forty-four students self-identified as taking medication to treat ADHD. Two participants were excluded because they reported blindness ($n = 1$) or a congenital eye disease that made it difficult to see images on a computer screen ($n = 1$).

Overall, participants reported a wide range of eating disordered attitudes and cognitions. The mean level of shape concern was 2.43 ($SD = 1.72$), and participants in the sample endorsed the full range of possible responses. The mean level of weight concern was 2.19 ($SD = 1.68$), eating concern was 1.10 ($SD = 1.26$), dietary restraint was 1.52 ($SD = 1.46$), physical appearance anxiety was 1.59 ($SD = 1.00$) for weight-related items and 0.54 ($SD = 0.60$) for nonweight-related items. Participants reported body checking attitudes and behaviors ($M = 1.27$, $SD = 0.78$), and body image avoidance attitudes and behaviors ($M = 26.18$, $SD = 10.84$).

Avoidance and Checking Behaviors

Independent *t*-tests determined whether BCQ and BIAQ scores differed according to levels of eating disorder pathology. The clinical cutoff for probable threshold shape concern on the EDEQ is 4.00 (Luce et al., 2008). Scores on the EDEQ-Shape subscale were dichotomized into below and above threshold scores, and then *t*-tests evaluated whether the BCQ and BIAQ total scores differed by these groups. Levene's test suggested that equal variances could not be assumed, so the adjusted *t*-test values are reported. BCQ and BIAQ were higher in groups with more shape dissatisfaction, t (339.60) = 20.75, $p < 0.001$ and t (323.14) = 17.41, $p < 0.001$, respectively, with the participants meeting the clinical threshold having higher scores on both the BCQ and BIAQ.

A binary logistic regression evaluated whether BCQ and BIAQ significantly improved the prediction of whether a participants' shape concern would exceed the clinical threshold. With both predictor variables considered together, they significantly predicted whether or not a participant had an EDEQ-Shape score above 4, χ^2 (2) = 388.89, $p < .001$, and correctly predicted 84.0% of cases. The model effect size was large, with Nagelkerke $R^2 = 0.51$. According to the Wald criterion, both BCQ and BIAQ were significant predictors of shape concern, Wald (1) = 94.44, $p < 0.001$ and Wald (1) = 42.49, $p < 0.001$, respectively. The change in odds associated with a one-unit change in BCQ score was 5.42 (95% CI 3.85 – 7.62) and the change associated with BIAQ was 1.08 (95% CI 1.06 – 1.11).

Mindfulness can be conceptualized as actively unbiased attention. As such, trait mindfulness was hypothesized to moderate the relation between body anxiety and body checking and avoidance behaviors. MAAS significantly moderated the relation between PASTAS-Weight and the Feeling for Fat and Reassurance subscales of the BCQ, ΔF (1, 732) = 12.53, $p < 0.001$

and ΔF (1, 726) = 34.20, $p < 0.001$; however, the relation with the Thin Ideal subscale was not moderated, ΔF (1, 732) = 2.20, $p = 0.14$. MAAS also significantly moderated the relation between PASTAS-Weight and the Exposure and Social subscales of the BIAQ, ΔF (1, 720) = 4.07, $p = 0.04$ and ΔF (1, 723) = 33.89, $p < 0.001$. MAAS acted to buffer the relation between anxiety and behavior such that those who were low on mindfulness showed greater behavior when they had higher physical appearance anxiety.

Eye tracking Models

Mixed multilevel models were estimated to evaluate the effect of the intervention on eye movement behaviors. Because the data were repeated and hierarchically nested, their non-independence precluded the use of traditional linear modeling approaches. Analyses with continuous outcome variables assessing eye movement behavior were performed using the SAS PROC MIXED procedure, and analyses with count outcome variables were performed using the SAS GLIMMIX procedure.

Fixation and Dwell Duration in Self Images. Models were estimated to assess eye movement behavior patterns across the body region dissatisfaction hierarchy before and after the attention modification intervention. Variables (body region, time) were fixed; the variance-covariance matrix used to estimate these models was unstructured, which allows random effects to vary at all points. Contrasts at each level of the body region hierarchy assessed whether the change from pre-intervention to post-intervention was significant. Bar graphs depicting results of these models can be found in Figure 2.

Body region and time significantly predicted total fixation duration, χ^2 (54) = 210.31, $p < 0.0001$. Specifically, there was a significant interaction effect of body region and time, F (4, 73.1) = 4.88, $p = 0.0015$. Contrasts were significant for the most dissatisfying body region, F (1,
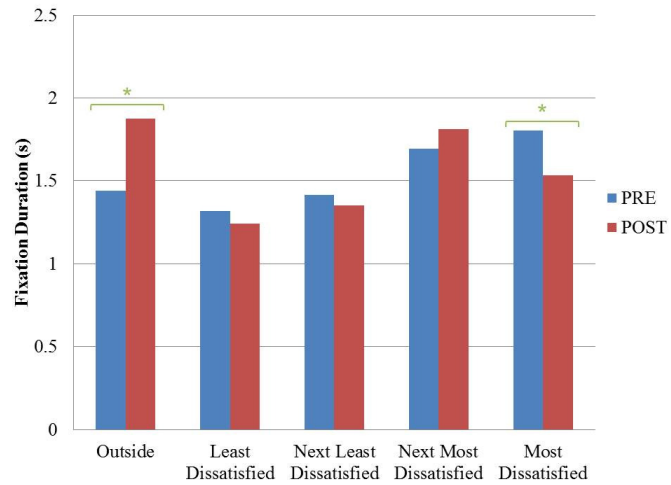
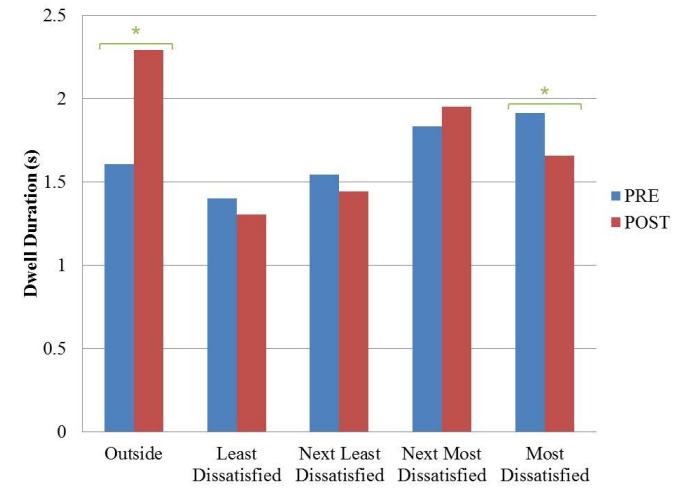Figure 2A. *Total Fixation Duration in Self Images.*

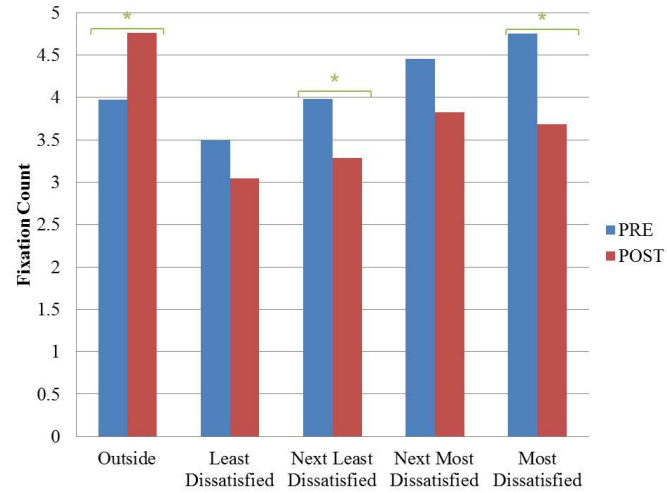Figure 2B. *Total Dwell Duration in Self Images*
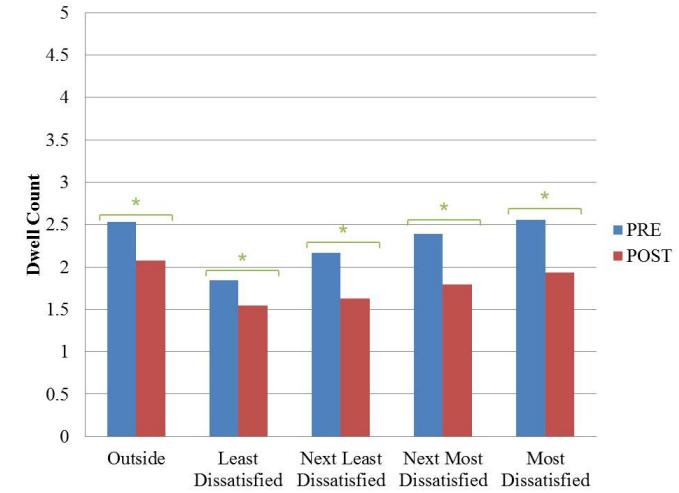

Figure 2C. *Fixation Count in Self Images.*

Figure 2D. *Dwell Count in Self Images.*

77

73.1) = 10.32, p = 0.0020 and the outside region, F (1,73.3) = 8.44, p = 0.0048. Group, defined

as high (>75th percentile) or low (< 75th percentile) shape concern, did not have a main effect, F

(1, 72) = 0.31, p = 0.58, or interaction effect, F (1, 72) = 1.42, p = 0.24, for the most dissatisfying

region. Likewise, neither group nor the interaction of group by time had a significant effect on

the outside region, F (1, 72) = 2.13, p = 0.15 and F (1, 72) = 0.08, p = 0.78, respectively.

Contrasts were not significant for the least dissatisfying body region, F (1, 73) = 1.32, p =

0.2545, next least dissatisfying region, F (1, 73.2) = 1.29, p = 0.2598, or the next most

dissatisfying region F (1, 73) = 0.47, p = 0.4934. See Figure 2A.

Body region and time also significantly predicted total dwell duration, which is the total

time individual spent with a longer gaze at each region, χ^2 (54) = 293.33, p < 0.0001.

Specifically, there was a significant interaction effect of body region and time, F (4, 73.1) = 4.92,

p = 0.0014. Contrasts were significant for the most dissatisfying body region, F (1, 73.1) = 7.50,

p = 0.0078 and the outside region, F (1, 73.4) = 12.50, p = 0.0007. Neither the main effect of

group nor the interaction of group and time significantly predicted dwell duration for the most

dissatisfying region, F (1, 72) = 0.08, p = 0.78 and F (1, 72) = 2.28, p = 0.14, respectively.

Likewise, neither group nor the interaction of group by time had a significant effect on dwell

duration on the outside region, F (1, 72) = 1.37, p = 0.25 and F (1, 72) = 0.50, p = 0.48,

respectively. Contrasts were not significant for the least dissatisfying body region, F (1, 73) =

0.65, p = 0.4243, next least dissatisfying region, F (1, 73.2) = 1.50, p = 0.2244, or the next most

dissatisfying region F (1, 73) = 0.54, p = 0.4643. See Figure 2B.

Fixation and Dwell Count in Self Images. Models were estimated to assess whether

body region and time predicted the amount of fixations and dwells. Although these variables are

similar to the total gaze time variables reported previously, they are distinct in that they show an

additional level of the pattern of eye movement behavior. Gaze time alone does not differentiate between several points of focus within a region and one long point of focus in that same region. As previously noted, because these are count variables, the assumption of a normal distribution in the outcome variable was violated, and data were better described according to a Poisson distribution. PROC GLIMMIX allows models to be estimated according to this Poisson distribution instead of the normal distribution, and thus, was used for these models. Bar graphs depicting results of these models are also presented in Figure 2.

There was a significant interaction effect of body region and time on total fixation count, $F (4, 292) = 5.53$, $p = 0.0003$. Contrasts were significant for the most dissatisfying body region, $F (1, 292) = 8.64$, $p = 0.0036$, the next least dissatisfying region, $F (1, 292) = 4.72$, $p = 0.0307$, and the outside region, $F (1, 292) = 8.63$, $p = 0.0036$. Neither group nor the group by time interaction significantly predicted total fixation count in the most dissatisfying region, $F (1, 72) = 0.45$, $p = .50$, and $F (1, 72) = 0.29$, $p = .59$. Likewise, neither group nor the group by time interaction significantly predicted the next least dissatisfying region, $F (1, 72) = 0.45$, $p = .50$, and $F (1, 72) = 0.29$, $p = .59$, or the outside region, $F (1, 72) = 1.42$, $p = 0.24$ and $F (1, 72) = 0.01$, $p = 0.93$, respectively. Contrasts were not significant for the least dissatisfying body region, $F (1, 292) = 3.04$, $p = 0.0823$ or the next most dissatisfying region $F (1, 292) = 2.61$, $p = 0.1071$. See Figure 2C.

There were significant main effects of body region, $F (4, 292) = 12.17$, $p < 0.0001$, and time, $F (1, 73) = 64.84$, $p < 0.0001$, on total dwell count; however, the interaction effect was not significant, $F (4, 292) = 0.43$, $p = 0.7870$. See Figure 2D.

Fixation and Dwell Duration in Self and Other Images. Participants viewed images of themselves and also viewed images of four confederates. Because of the consistent, significant

contrasts at the most dissatisfying body region, models were estimated to determine whether gaze time on self images differed from gaze time on other images. Other images were entered as discrete data points, but contrasts compared self images with all other images rather than each confederate image independently because hypotheses did not suggest differential attention between confederate images. Bar graphs depicting results of these models can be found in Figure 3.

Image and time significantly predicted total fixation duration on the most dissatisfying body region, χ^2 (54) = 602.88, $p < 0.0001$. Specifically, there was a significant main effect of image, F (4, 71.5) = 4.81, $p = 0.0017$, and a trend towards a main effect of time, F (1, 69.8) = 3.92, $p = 0.0516$; however, the interaction between the two variables was not significant, F (4, 72) = 1.87, $p = 0.1245$. See Figure 3A.

Image and time significantly predicted total dwell duration on the most dissatisfying body region, χ^2 (54) = 592.97, $p < 0.0001$. Specifically, there was a significant main effect of image, F (4, 71.4) = 4.82, $p = 0.0017$, and a trend towards a main effect of time, F (1, 69.9) = 3.65, $p = 0.0602$; however, the interaction between the two variables was not significant, F (4, 71.7) = 1.75, $p = 0.1495$. See Figure 3B.

Average Fixation and Dwell Duration in Self and Other Images. Of particular interest in comparing self and other images is the average duration of fixations and dwells because of the link between greater average fixation time and using visual information to make comparisons (Duchowski, 2007). Bar graphs of these results can also be found in Figure 3.

Image and time significantly predicted average fixation duration on the most dissatisfying body region, χ^2 (54) = 462.81, $p < 0.0001$. There was a trend towards significance for the interaction of image and time, F (4, 70.1) = 2.22, $p = 0.0752$. The contrast between self and other
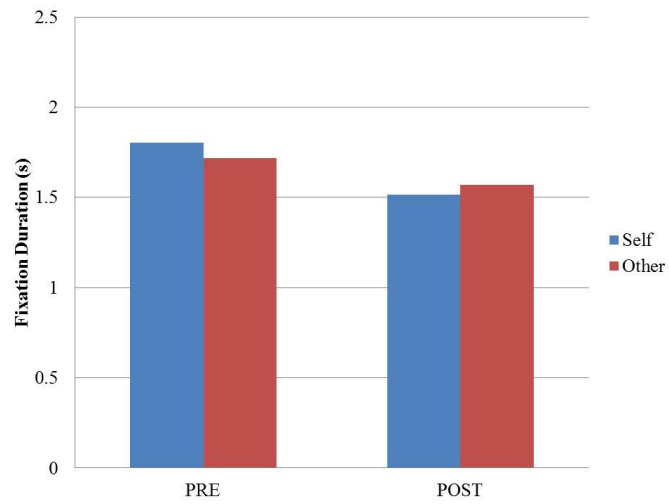
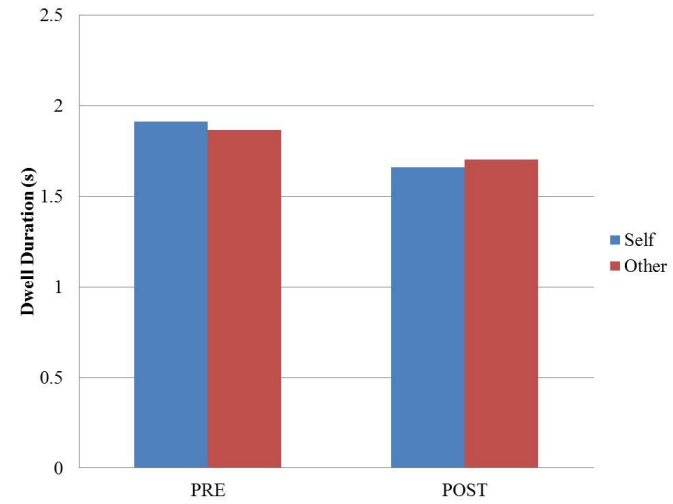Figure 3A. *Total Fixation Durations in Self and Other Images.*

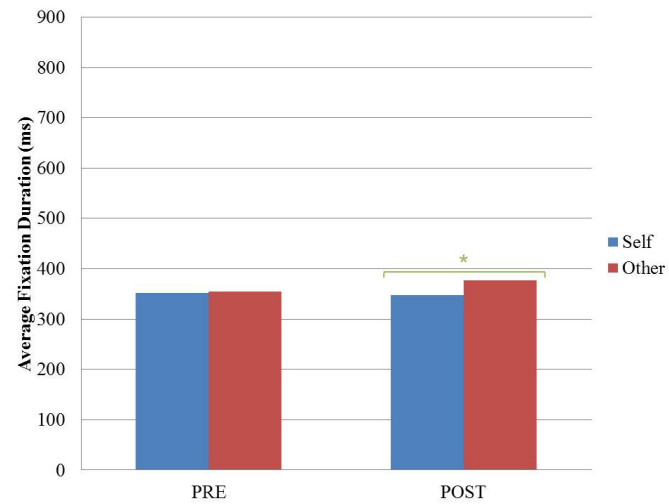Figure 3B. *Total Dwell Durations in Self and Other Images.*

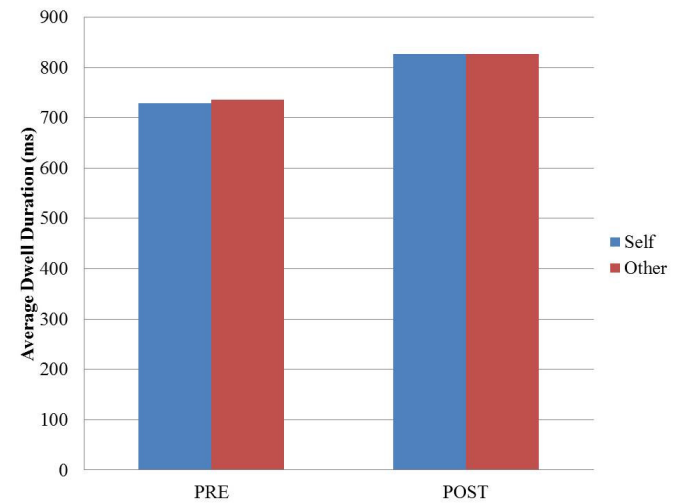Figure 3C. *Average Fixation Duration in Self and Other Images.*

Figure 3D. *Average Dwell Duration in Self and Other Images.*

81

images pre-intervention was not significant, $F (1, 73.1) = 0.05$, $p = 0.8206$. However, the contrast between self and other images post-intervention was significant, $F (1, 69.1) = 4.05$, $p = 0.0480$, such that participants had a longer average fixation on other images than on self images. Average fixation duration on the most dissatisfying region was significantly predicted by the interaction of group and time, $F (1, 72) = 5.23$, $p = 0.03$, such that participants in the low shape concern group had a longer average fixation post-intervention than they did pre-intervention, but the high shape concern group had a longer fixation at pre-intervention than they did at post-intervention. See Figure 3C.

Image and time significantly predicted average dwell duration on the most dissatisfying body region, $\chi^2 (54) = 417.03$, $p < 0.0001$. Main effects of image, $F (4, 72.4) = 4.04$, $p = 0.0052$, and time, $F (1, 69.3) = 4.51$, $p = 0.0373$ were significant, however the interaction of time and image was not, $F (4, 71.6) = 1.45$, $p = 0.2276$. There was a trend for the interaction of group and time to predict average dwell duration, $F (1, 72) = 2.98$, $p = 0.09$. See Figure 3D.

Pupil Diameter in Self Images. Body region and time significantly predicted average pupil diameter, $\chi^2 (54) = 456.04$, $p < 0.0001$. There was a significant interaction between body region and time, $F (4, 70.3) = 5.58$, $p = 0.0006$. Contrasts were significant for the most dissatisfying body region, $F (1, 68.9) = 11.42$, $p = 0.0012$, next most dissatisfying region $F (1, 58.3) = 13.54$, $p = 0.0005$, next least dissatisfying region, $F (1, 57.8) = 11.97$, $p = 0.0010$, and the least dissatisfying body region, $F (1, 71.5) = 12.72$, $p = 0.0006$. Neither group, $F (1, 72) = 0.20$, $p = 0.65$, nor the group by time interaction, $F (1, 72) = 0.69$, $p = 0.41$, had a significant effect on pupil diameter for the most dissatisfying body region. Likewise, neither group nor the group by time interaction significantly predicted the next most dissatisfying region, $F (1, 72) = 3.61$, $p = .06$ and $F (1, 72) = 0.13$, $p = .72$, or the next least dissatisfying region, $F (1, 72) = 1.50$, $p = .23$

and $F(1, 72) = 0.02$, $p = .89$. Group, $F(1, 72) = 3.96$, $p = .05$, but not the group by time

interaction, $F(1, 72) = 1.52$, $p = .22$, significantly predicted pupil diameter for the least

dissatisfying region, such that those in the low shape concern group had larger pupil diameter

than those in the high shape concern group both pre and post intervention. Pupil diameter when

looking at the outside region was not significantly different pre-intervention to post-intervention,

$F(1, 69.8) = 1.49$, $p = 0.2263$. See Figure 4A.

Pupil Diameter in Self and Other Images. Image and time significantly predicted

average pupil diameter on the most dissatisfying body region, $\chi^2(54) = 619.07$, $p < 0.0001$.

There were significant main effects of image, $F(4, 69.5) = 2.55$, $p = 0.0468$, and time, $F(1,$

$68.7) = 13.86$, $p = 0.0004$, on average pupil diameter, and a trend towards a significant

interaction of image and time, $F(4, 69.8) = 2.11$, $p = 0.0888$. Contrasts revealed a significant

effect at pre-intervention, $F(4, 72.9) = 5.54$, $p = 0.0212$, but not post-intervention , $F(1, 66.7) =$

0.58, $p = 0.4509$. At pre-intervention, participants average pupil diameter was larger on self

images compared with other regions. See Figure 4B.

Physical Appearance Anxiety

Mixed ANOVAs examined participants' self-reported physical appearance anxiety before

and after the intervention using the PASTAS total score, which is comprised of both weight-

related and nonweight-related items. There was a significant time by group interaction, with

group defined as above or below the seventy-fifth percentile, $F(1, 83) = 6.21$, $p = .02$. The

interaction was such that those in the high shape concern group showed more improvement than

those in the low shape concern group after the intervention. Three items on the PASTAS

corresponded to body regions included in the hierarchy: thighs, waist, and legs. These individual

items were matched with individuals' body dissatisfaction hierarchies, and compared using
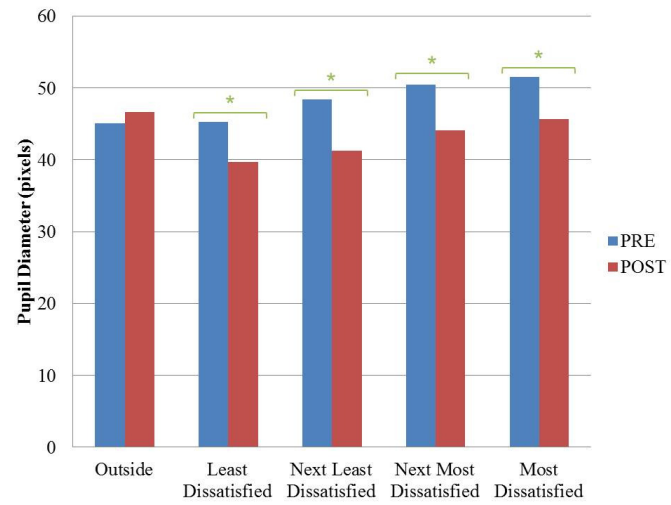
Figure 4A. *Pupil Diameter in Self Images*.
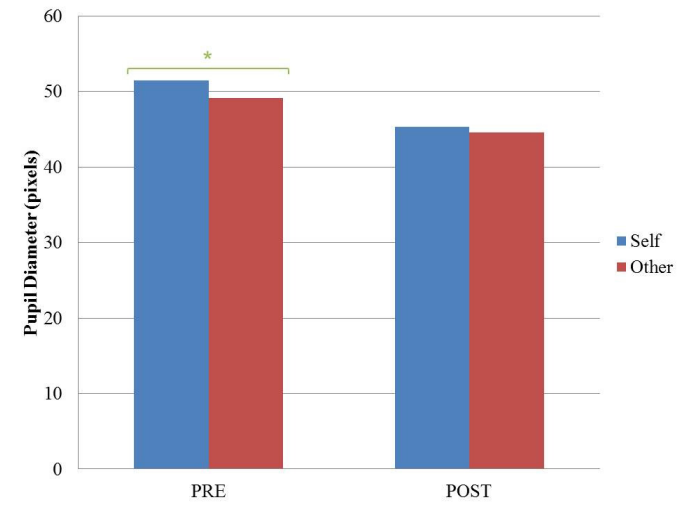
Figure 4B. *Pupil Diameter in Self and Other Images*.

mixed ANOVAs to assess whether anxiety related to those body regions changed after the intervention. There was a significant drop in anxiety about the most dissatisfying region, F (1, 69) = 4.35, p = 0.04, but not the next most dissatisfying, F (1, 66) = 0.86, p = 0.36, next least dissatisfying, F (1, 65) = 0.29, p = 0.59, or least dissatisfying regions F (1, 47) = 1.35, p = 0.25. Group was also entered as a between-subjects variable in these analyses; no interactions were significant, but group was a significant predictor of physical appearance anxiety in each of these regions (most dissatisfying: F (1, 69) = 64.89, p < .001; next most dissatisfying: F (1, 66) = 52.68, p < .001; next least dissatisfying: F (1, 65) = 25.35, p < .001; least dissatisfying: F (1, 47) = 35.91, p < .001).

Discussion

Eating disorders have known associations with attentional biases, but these attentional biases have not yet been the target of intervention with behavioral eye movement outcomes. Given the severity and chronicity of threshold eating disorders, an intervention that aims to modify these visual-behavioral attentional biases is warranted. Although there have been eight studies using eye tracking methodology and assessing eating disordered attitudes and behaviors, there remain inconsistencies and gaps in the literature that need to be addressed before attentional biases can be addressed in an applied, clinical setting for either individuals meeting threshold eating disorder criteria or to target at-risk populations with subthreshold body image concerns, such as college women. The current study contributed to this research by investigating the effects of a pilot body image attention modification intervention and adding evidence to existing literature.

Attention subprocesses addressed in this study's intervention included those described by Posner and Rothbart (2009): alerting, orienting, and executive attention abilities. Hypotheses for this study were that participants would gaze longer on their own dissatisfying, compared with satisfying, body regions, demonstrating an overattention to dissatisfying body regions. Consistent with prior research, participants were also hypothesized to have longer gaze time on their own dissatisfying body regions and satisfying regions of others because this social comparison would contribute to overall body dissatisfaction (Roefs et al., 2008). Exploratory hypotheses also evaluated pupil diameter to observe whether pupil dilation, putatively associated

with threat and intense emotion, would occur with more dissatisfying body regions. The attention modification intervention was predicted to improve attentional biases and self-reported physical appearance anxiety.

Self Images

One strength of this study is its use of participants' own images as stimuli. It was hypothesized that participants would gaze longer at dissatisfying regions compared with satisfying regions. Gaze was operationalized as total fixation duration, meaning that gaze time that met minimum time and position stability requirements was totaled for this outcome. Gaze time was also operationalized as total dwell duration, which has a stricter time threshold and thus shows more prolonged gaze. Prior to the intervention, participants had longer total gaze duration (i.e., both fixation and dwell) on their most dissatisfying region, then their next most dissatisfying region, then their next least dissatisfying region, then their least dissatisfying region. There was a significant interaction effect between body region and time, and participants gazed significantly longer at the outside region post-intervention compared with pre-intervention, and gazed significantly shorter at their most dissatisfying region post-intervention compared with pre-intervention. The purpose of the intervention was to encourage participants to look at all regions in their hierarchy for the same amount of time, and also to decrease the anxiety related to more dissatisfying regions. Although the same pattern generally held at post-intervention, it is notable that participants decreased their gaze at their most dissatisfying region because it suggests that the intervention successfully diverted attention away from a region they showed an overattention bias towards previously.

Fixation and dwell counts also assessed eye movement behavior patterns as participants looked at images of themselves. Although the same criteria define fixations and dwells as when

duration is calculated, count data are discrete from total duration because they reflect how many times participants focused on a region. For example, two participants with the same gaze duration could have different counts: one might focus on their waist five times for one second each, whereas the other might focus on their waist one time for five seconds. Although they would have each gazed at their waist for five seconds, their behaviors still vary. Pre-intervention, participants had higher fixation and dwell counts on their most dissatisfied region, then their next most dissatisfied region, then their next least dissatisfied region, then their least dissatisfied region. There were also interaction effects showing that within each region, the number of fixations and dwells decreased between pre-intervention and post-intervention. Part of the intervention encouraged participants to move their gaze over an image rather than skipping over or settling on any one part. This might have directed the decreased counts. Alternatively, as will be discussed in the limitations section, the decreased counts may also have been due to habituation.

These findings are similar to those of earlier eye tracking studies. Of the two studies that included self image stimuli, one found an association between body dissatisfaction and gaze and weight-related areas (Gardner et al., 1990), and two found that participants showed overattention toward more dissatisfying body regions (Jansen et al., 2005; Roefs et al., 2008). However, two of these studies found that healthy control participants did not show overattention towards dissatisfying body regions (Gardner et al., 1990; Jansen et al., 2005). It is possible that the main effect of body region in the current study was related to how the images were presented to participants. Specifically, the studies that did not show an effect in healthy controls asked them to code body regions as attractive and unattractive or ugly and beautiful; this may be a different construct for healthy controls compared with image-critical subthreshold eating disorder

participants. In the current study, participants were asked to rank regions by body dissatisfaction, which is established as an experience of many college women, and thus, might have been more relatable for healthy controls compared with identifying regions of their body they considered to be ugly.

Self and Other Images

Extant studies have focused on images of others, either confederates or models. Thus, an important set of findings from the current study is the within-subjects comparison of eye movement behavior related to self and other images. The initial hypothesis was that gaze would be longer on dissatisfying regions of self images compared with other images because the self image was expected to be a stronger and more threatening stimulus than the other images. Fixation and dwell durations did not vary based on the image stimulus participants viewed. This finding suggests that we draw information to inform our body dissatisfaction and satisfaction from ourselves and also from other people. Other studies have found that gaze duration focused on different regions based on the stimulus, and that participants gazed longer at their dissatisfying body regions on themselves and longer at their satisfying regions on others (Jansen et al., 2005; Roefs et al., 2008). However, other studies that only included other image stimuli showed a bias towards dissatisfying body regions on those stimuli (Hewig et al., 2008; Janelle et al., 2003). It is possible that specific situations and stimuli might encourage looking at dissatisfying or satisfying body regions on other images, and further investigation could explore stimulus characteristics that influence gaze.

It was also hypothesized that participants would have a longer average gaze at images of themselves before the intervention rather than after. Contrary to this hypothesis, average fixation duration did not vary between self and other images pre-intervention, but average fixation

duration was longer for other images compared with self images post-intervention. Average dwell duration did not vary. These results are surprising because of the putative link between making visual comparisons and longer fixation duration. However, it is possible that an effect would have been seen had participants looked at non-person images. The post-intervention effect of average fixation duration lengthening for other images but not self images may have been due to a reduced threat to the self image that allowed participants to compare other images to each other (for example, confederate 1 with confederate 2). Alternatively, it is possible that participants habituated more to self image stimuli during the intervention compared with other images. Participants viewed one self and one other image for each skill in the intervention, and therefore were not exposed to the other images for the same number of times as they were to the self image.

Existing eye tracking body image studies have focused on total fixation duration on stimuli. The current study adds to this literature by providing evidence of the value of assessing average fixation duration as well as total fixation duration. Future research should investigate further whether this outcome does indeed evaluate social comparisons with body image stimuli; visual comparison associations have been suggested based on other eye tracking studies using art as stimuli (Duchowski, 2007), but not with the social element.

Pupil Diameter

Pupil diameter has been described as a physiological measure of greater cognitive load and greater emotional intensity (Andreassi, 2007). Because of the complex association of pupil dilation with anxiety and the loose connection of pupil dilation with visual attentional bias, these hypotheses were exploratory. It was hypothesized that pupil diameter would be associated with body region ranked by dissatisfaction, and that pupil diameter would decrease from baseline to

post-intervention. Notably, pupil diameter is sensitive to the amount of interest stimuli hold, so this outcome is likely to be more biased by habituation effects than other eye movement outcomes, and thus, would particularly benefit from comparison with the effects of a control intervention.

The intervention in this study had participants rank body regions according to the amount of dissatisfaction they felt towards them. Dissatisfaction is conceptually similar to unease felt in anxiety, and has an affective component; therefore, pupil diameter was hypothesized to have a direct relation with ranked body region. In self images, there was a main effect of more dissatisfying regions having greater average pupil diameters (i.e., more dilated), confirming this hypothesis. Pupil diameter and image were also evaluated, and participants had larger pupil diameter when looking at images of themselves compared with confederate images pre-intervention. This suggests that looking at images of themselves, rather than images of confederates, was associated with stronger emotional affect and was potentially more threatening before the intervention, but this effect was not present after the intervention. There was a time effect on the body regions such that pupil diameter was smaller, suggesting less strong emotional affect, for all levels of the body region hierarchy post-intervention compared with pre-intervention, in line with the function of an anxiety hierarchy.

Physical Appearance Anxiety

In addition to eye movement outcomes, participants also completed self-report measures of their physical appearance anxiety related to specific body parts. It was hypothesized that physical appearance anxiety would be lower after the intervention. Participants reported less appearance anxiety overall after the intervention, and significantly less anxiety for the most dissatisfying region. It is interesting that these results were less robust than the eye movement

outcomes. Because there is some automaticity inherent in attentional biases, it was expected that eye movement behaviors would show less change than the emotional measure. However, it is possible that people want to change attentional biases, and this study shows that it is feasible to change them, even with a brief intervention. Despite the successful attention training, it is notable that the changes were small, and might not have been sufficient to produce psychological improvement after one attention training session. Nonetheless, the significant improvement in anxiety related to the most dissatisfying body region, suggests preliminary successful results.

This is the first attention training study to use eye tracking technology; however, previous studies using dot-probe methodology have attempted to modify attention biases. The current study suggests further evidence that attention can be modified, consistent with results that attentional biases could be induced (Smith & Rieger, 2006). Dot-probe attention modification studies have not shown changes in symptomatology even though changes in attention patterns occurred for some participants (Baert et al., 2010; Smith & Rieger, 2006, 2010). The current study adds to this literature by showing a less robust but nonetheless significant improvement in body image anxiety compared with eye movements, and supports theory that the relation between body dissatisfaction and attentional biases might have bidirectional influence (Smith & Rieger, 2010).

Contributions to Literature

Attention and Eating Disorders. As discussed in the introduction, patterns of attention associated with anxiety and other forms of distress are informed by behavior theory. Behavior theory posits that in phobias in particular, avoidance is an initial response to an intrinsically threatening stimulus, and both avoidance and overattention work together to maintain fear or distress through operant conditioning and the reinforcing experience of escaping the threatening

stimulus (McAllister & McAllister, 1995). In this study, overattention was associated with participants' self-reported ranked body region dissatisfaction, as was larger pupil size. Taken together, this suggests that an anxiety or affective process underlies the observed eye movement behavior and is characteristic of overattention rather than avoidance.

Given the role of avoidance in establishing anxiety responses (McAllister & McAllister, 1995), it appears that the tasks involved in this study might not have assessed this early anxiety formation phase, but rather, been part of a more established pattern that biased individuals to look towards dissatisfying and emotionally-laden regions. Eating disorders have features similar to those in obsessive-compulsive disorder, particularly related to food and body image (American Psychiatric Association, 2004; Shafran, 2002). Body checking and overattention towards dissatisfying body regions might serve to reassure participants similar to how checking behaviors in obsessive compulsive disorder help individuals regulate their emotions, albeit maladaptively (Shafran et al., 2004). It is possible that the observed overattention was a form of this anxiety response rather than a body-phobic avoidance response.

In the literature, overattention to dissatisfying body regions has been shown in subthreshold populations. This, taken together with the overall effect of the intervention and lack of effect of shape concern, suggest that the study population might not include the most severe forms of eating disorders. Although clinicians did refer patients for this study who were in treatment for body image concerns, all patients were concurrently enrolled at the university, and therefore, maintained a level of functioning that patients who require hospitalization or residential treatment cannot maintain. Assessing eye movement behavior in these more impaired individuals might produce different attention patterns or impact the feasibility of modifying

attentional biases, and would allow for assessment of the joint utility of this attention modification intervention with existing protocols.

The alerting attentional ability, achieving and maintaining high awareness of the environment and sensitivity to threatening stimuli, biases individuals to scan for threats preconsciously. This equipment and software sample eye position frequently; however, to protect against spurious eye movement data, minimum thresholds collapse these samples into fixations and then sum gaze duration. Alerting attention is by definition preconscious, and thus, would not meet the minimum threshold required of a fixation. As equipment develops and becomes more sensitive and sampling rates become higher, preconscious fixations may become a reliable outcome. As with studies described previously, combining a dot-probe task with eye tracking technology can provide evidence of eye movements associated with alerting attention, and are warranted in future research. Additionally, the assessment and intervention designs discouraged avoidance. Participants were aware that their eye movements were being tracked and were visible to the investigator in real time. They might have felt pressure to look at images rather than avoid them because of these demand characteristics.

The level of threat that the images produced is relative only to the other body regions. Although there is a progressive decline in threat as regions decline in how dissatisfying participants ranked them, it is not known how strong this relative threat is. Associated decline in PASTAS ratings suggest that participants are aware of and can perceive their anxiety about these different regions, and are aware of change in these levels of anxiety. However, looking at images on a computer screen as part of a study is likely not nearly as threatening as real-world body image threats such as clothes shopping, wearing a swimsuit, or being in social situations when others compare or judge an individual's appearance (e.g., Tiggemann & Boundy, 2008).

The level of threat and the potential efficacy of this study's intervention have implications for therapy. Psychotherapy traditionally also lacks real-world body image threat. However, when staging an experiential body image anxiety hierarchy, exposures such as the intervention for this study can be an initial foundation upon which more threatening experiences can build. The promising results of this pilot study, even though it involved a potentially low-threat exposure, warrant replication and potential application because self-reported body anxiety and observed eye movement overattention to dissatisfying body regions were successfully reduced.

Previous research on attentional biases that used Stroop and dot-probe tasks showed bias towards longer reaction time for eating disorder-related stimuli compared with neutral stimuli. Although the current study did not include a task assessing reaction time, previous findings might still apply to eye movement behavior. In particular, executive attention is known to be affected by emotionally-laden stimuli because they produce cognitive interference. Because of the affective dimension of body image dissatisfaction, interpretation of the current study's results have focused on stimuli in terms of overattention. It is also important to note that cognitive interference and executive attention bias might be driving the increased time on dissatisfying body regions. Eye tracking cannot determine motivation behind gaze; therefore, additional tasks might be layered onto the assessment used in the present study to parse whether there is a reassurance aspect to prolonged gaze, whether there is a cognitive load associated with conflicting attention, or whether cognition and point of gaze disengaged. Eye tracking researchers differentiate between the "point of gaze," which eye tracking technology measures as the eye position and time, and the "point of regard," which eye tracking cannot assess because it is point of gaze together with involvement with the stimulus (Duchowski, 2007).

95

Body Image and Eye Movement Behavior. Few studies have examined attention and body image by assessing eye movement behavior. Results of existing studies are inconsistent. Those that assess eating disordered attitudes along continuous measures, such as drive for thinness and eating concern, found an attention bias for gaze time (Hewig et al., 2008; Janelle et al., 2003; Jansen et al., 2005). The current study supports those findings in that eye movement behaviors did show bias for increased time on the most dissatisfying region. However, shape concern did not appear to influence the effect of the intervention. Other studies varied stimuli to include overweight, underweight, and normal weight individuals and failed to find a dissatisfaction bias in normal weight individuals, although they did show longer gaze time on satisfying regions (Gardner et al., 1990; Roefs et al., 2008). This suggests that attention bias might be changeable, which could explain why it was feasible to modify attention bias towards dissatisfying body regions. Future research should examine the trait and state-based components of visual attentional biases.

Modifying Attention. Protocols aiming to modify attentional biases have been evaluated for addictions and cravings (Field et al., 2009; Schoenmakers et al., 2010), including food cravings (Kemps & Tiggemann, 2009), and for depression (Baert et al., 2010). However, to the investigator's knowledge, this is the first attention modification intervention for body image that aimed to improve attentional abilities. The intervention by Baert and colleagues (2010) trained attention using the dot-probe task with an aim to improve depressive symptoms; their intervention taught students to associate positive words with the warning signal that appeared prior to the stimulus. Their results showed improvement in mildly depressed students, but worsened symptoms in moderately and severely depressed individuals. Building off these results, the results of the current study suggest the superiority of eye movement assessment because it

allows for any stimulus to be presented, and therefore yields greater ecological validity,
compared with learning in the context of a task that does not occur outside the research setting.
Nonetheless, results of the current study primarily show that participants can learn to modify
attentional biases and experience decreased anxiety with that modification; it does not show
whether the exposure would generalize beyond the setting. Of note, body image dissatisfaction
did not worsen as a result of the current intervention, potentially because exposure to the
threatening stimuli was paired with relaxation.

One study experimentally manipulated body checking by asking participants to scrutinize
and criticize their body, or to examine their body neutrally (Shafran et al., 2007). These
researchers found that participants who did not scrutinize their body felt less fat after the
intervention, although body dissatisfaction did not change. The current study differs from that
experiment because all participants described their bodies nonjudgmentally, paralleled to the
prior study's neutral condition. Interestingly, there was an overall effect of reduced body anxiety
in the current study, which might have been due to the paired relaxation and the graduated,
hierarchy-based exposure.

Another relevant study induced attention bias for body dissatisfaction using a dot-probe
task (Smith & Rieger, 2006). This investigation demonstrated the feasibility of modifying
attention so that biases occurred, which shows how vulnerable individuals can be to developing
negative biases. The current study extends this work by showing that it is possible to reverse
established attention biases so that they are more positive. Other studies have shown reduced
biases in attention using the dot-probe task, without concurrent reduced eating disordered
thoughts or associated affect (Shafran et al., 2008; Wilson et al., 2002). The current study
showed some drop in physical appearance anxiety, but did not assess other forms of eating

disordered thoughts or affect. It is possible that these outcomes would have been more difficult to change, and the eye movement behavior change and the intervention behind the attention training are more strongly tied to anxiety than other forms of eating disorder-related symptomatology.

Current Eating Disorders Treatment. Cognitive-behavioral theory proposes that distorted cognitions maintain eating disordered thoughts, feelings and behaviors, and emphasizes altering maladaptive and distorted thought patterns to improve eating disordered thoughts, behaviors and associated emotions (Wilson et al., 1997). More recent research has described impaired cognitive processes in women with threshold eating disorders (Shafran et al., 2008), and has sought to address these processes directly to improve concurrent psychotherapy by increasing individuals' capacity to engage in cognitive treatment (Tchanturia et al., 2004). CRT has shown efficacy addressing cognitive flexibility in particular (Tchanturia et al., 2007). The current study suggests that modifying visual attention biases is feasible, and might have utility as a supplement to treatment.

Treatments for body image and extreme shape concern involve exposures similar to the one in the current study. Patients will look at themselves in a mirror and follow a directed attention task so that they look at each body region in the mirror while practicing relaxation, and also learn to describe themselves nonjudgmentally (Shafran et al., 2009). The current study shows that body image anxiety and dissatisfaction have attentional correlates measured by eye movement behavior. Further, findings from the current study provide initial evidence of the effectiveness of this form of intervention from a behavioral perspective.

Strengths

This study has several strengths in its design and approach and presents novel information about visual attentional biases and body image, and the feasibility of modifying these biases. This study also adds to the current literature on attentional bias in eating disorders by assessing visual attention bias using continuous, behavioral outcomes as well as self-report items. These strengths will be discussed, as will limitations of this study and directions for future research to build upon findings and address these limitations.

Participants were a strength of this study because they were screened to ensure varied levels of body dissatisfaction were represented in the sample that completed eye tracking assessment and the attention modification intervention. Some participants were referred by clinicians because they were in treatment for threshold shape concern. Results that suggested the intervention modified all participants' attention abilities, not only those who met threshold eating disorder criteria, contradict existing findings that suggest attention modification would only be effective in threshold populations (Jansen et al., 2005). This extends potential areas for future research and application to include community-based outreach, which generally addresses subthreshold eating disorders, as well as clinical treatment.

Demographic representativeness was also a strength of this study. Participants who completed the screening study, as well as those who completed the in-person study, were racially and ethnically diverse, and represented a range of ages within the emerging adult developmental period. In anticipation of this diversity, the intervention was designed to be culturally sensitive by the inclusion of one African American confederate image, one Hispanic confederate image, two White confederate images, and participant-specific images. Eye movement behavior did not appear to be influenced by the race or ethnicity of the confederates; however, it is possible that

African American and Latina participants would not have responded similarly had the intervention only included White other images.

The manner in which eating disorder attitudes and behaviors were assessed was an additional strength of this study. All participants who self-referred to the study completed the EDEQ, a self-report measure of eating disorder symptomatology. Self-report was chosen as a gateway response format because it has a better ratio of costs to benefits of participation and might elicit more honest responses about sensitive material such as body image attitudes, cognitions and behaviors (Fairburn & Beglin, 1994). All participants who completed the in-person component of the study, whether referred by a clinician or self-referred through SONA systems, completed the EDE, an investigator-based structured interview that assesses the same symptomatology as the EDEQ. This allowed for more objective assessment of symptomatology, and decreased some potential self-report bias. In addition, eye movement behavior outcomes were assessed by objectively observed behaviors, further diversifying the forms of measurement used in this study. Methodologically, reliance on multiple forms of data, particularly moving beyond self-report, increases confidence in the validity of the results (Tabachnick & Fidell, 2007).

Most notably, this is the first eye tracking study on body image to include an intervention that positively modifies attention. The feasibility of attention modification and associated decrease in body image anxiety suggest that attentional biases are a potential target of therapeutic interventions for eating disorders. Similar to applications of CRT that have been discussed, visual attention modification has the potential to improve the effects of traditional psychotherapy for a complex and difficult to treat set of disorders.

Limitations

Despite the enumerated strengths, there are also several limitations that apply to the study's design and analysis. First, this intervention was a pilot undertaken to determine whether modifying visual attention biases was feasible. The intervention was brief and did not have a control arm. Further, only pre and post data were collected; there are no follow up data. Because there was not a control intervention, it is possible that the effects described, although they show modified attention, might have been due to habituation to the task over time, and are not an effect of the intervention. Behavior theory and clinical experience would suggest that body dissatisfaction and patterns cannot simply be reduced by time; however, future research with a control group is warranted to explore whether the intervention itself is effective.

As discussed previously, avoidance is a core feature of anxiety that can affect attentional biases through the executive attention ability. However, eye tracking was not able to assess avoidance with the current technology because of unevaluated differences between "point of gaze" and "point of regard." Avoidance and alerting ability were addressed in the intervention to alter attentional biases in these subprocesses; however, outcome data do not assess directly whether they changed. "Point of gaze" can be assessed with eye tracking, but "point of regard" requires additional layers of cognitive tasks to directly and indirectly assess whether participants are engaged with the visual stimulus at which their focus is directed.

Although the overall sample size in the screening study is a strength, the opt-in rate for the in-person study might indicate a response bias. As noted in the results, approximately 50% of participants who completed the online screening study chose to be considered for the in-person study. Online and in-person studies might attract different types of students; students at this university have their choice of research studies they can complete to fulfill course requirements,

as well as non-research options. Although *t*-tests did not reveal differences on the administered measures, it is still possible that unmeasured differences influenced this decision. Given the sensitive nature of some of the survey material, it is possible that those who provided online responses did not want the accountability that might come with in-person interaction. Further, it is notable that several of the participants who responded in the high subthreshold range of symptomatology online endorsed threshold levels of symptomatology during the investigator-based interview and were referred to the university's counseling services. Those participants might have been motivated to come to the in-person session to explore their own experiences and distress, or to seek a form of treatment that they perceived to be less stigmatizing than making an appointment at the university counseling center or student health services.

As discussed previously, although eye tracking improves on dot-probe and Stroop tasks in terms of the ecological validity of the attention bias assessment, it is still a contrived environment. The eye tracking technology used did not require any interaction with the investigator beyond the initial calibration that participants completed by directing their gaze according to instructions. However, participants knew that the investigator was observing their gaze location. In addition, self and other images were staged so that figure position and appearance were as standardized as possible. This was necessary to control for the stimulus value of the images, because differing features can bias attention independent of affect or cognitive involvement (Duchowski, 2007). Despite its necessity, the staging likely distanced participants from feeling as though they were in a natural setting and therefore limits generalizability to real-world body image exposures. The limitations in this feasibility study can be addressed in future research that adds different levels of controls and enhances generalizability.

Future Directions

The current study assessed eye movement in the context of a dissatisfaction hierarchy and piloted an attention modification intervention to determine feasibility. This research has several possible future extensions to develop knowledge about visual attentional biases and the effect of the intervention on modifying these biases. The following paragraphs discuss future directions research in this area could explore.

Most importantly, as has been noted previously, the natural next step in evaluating attention modification is to have a control arm. All participants completed pre- and post-testing, and all received the same intervention. In future studies, an intervention that takes the same amount of time and has the same exposure to eye tracking technology but does not address attentional abilities or body image could investigate whether the noted effects are caused by the intervention, by habituation to the stimuli, by habituation to the task, by attention received from the investigator, or by some other factor. Future studies could also lengthen the intervention to allow for more practice of the attention skills to determine what dosage is needed. Similarly, a study could evaluate the three attention skills that were part of the intervention to assess their relative effectiveness in modifying attention.

Immediate post-intervention results are promising; however, modified attention is only clinically useful if the effects endure. Follow-up assessment of eye movement and self-reported anxiety and body dissatisfaction symptoms could occur five minutes after the task with an interference activity, and could also occur on different days or months. Longer intervals between intervention and follow-up can show the trajectory of modified attention, and identify when the effect of the intervention might begin to extinguish. As with the depression modification study (Baert et al., 2010), future research could investigate the effect of multiple online attention

training sessions in addition to the initial, in-person intervention. Participants could complete the same intervention on their own to practice training their gaze to look at each body region for the same amount of time, nonjudgmentally describing images of themselves and others, and relaxing while looking at images. This could occur at a time and place of the participants' choosing, and would not require eye tracking because eye movement behavior could be assessed at follow-up appointments. Feasibility for these practice sessions would likely be high because the intervention is brief, and looking at images while remembering the attention modification skills does not appear to be difficult.

As has been discussed previously, future research could also evaluate the efficacy of this intervention in the context of existing therapy protocols, and could compare therapy with this intervention to treatment as usual. Eye movement behaviors could inform therapy and track body image intervention outcomes independent of the attention modification intervention developed as part of the current study. However, it is also possible that addressing attention bias and modification directly could improve other therapeutic efforts, much like CRT has enhanced concurrent psychotherapy in anorexia nervosa (e.g., Tchanturia et al., 2007).

Future research could also vary the stimuli presented when assessing eye movement behavior. Although this study had more ecological validity than those using dot-probe methodology, it still differs from typical experiences. Eye tracking technology has developed to the point that participants could wear eye tracking "glasses" and look at real-world objects such as a magazine, billboards, people on the street, or attention bias when trying on clothes in a mirror. Similarly, webpages can present more realistic images than still photographs of people in uniform clothing and position. Varied images complicate analyses, and would require additional

controls and more frequent machine calibration; however, given the initial promising results of

this pilot, it appears feasible to add additional parameters to the stimuli presented.

Another direction for future research, which might be warranted after the efficacy of the

intervention and methodology are tested further, is the way in which the attention modification

skills and eye movement assessment could be applied in treatment and outreach settings. The

attention modification skill on its own could easily be incorporated into talk therapy sessions and

outreach presentations. However, as eye tracking technology continues to develop, it could also

become a form of therapeutic biofeedback that psychologists could use to assist patients in

becoming more self-aware of their attentional patterns and their level of success in modifying

them. Eye movement behaviors could also be an objective outcome that health providers could

use to assess the efficacy of their treatment and the patient's progress. With longer follow-up and

longitudinal studies, it is possible that eye movement behaviors could help tailor treatment or

predict which individuals might be susceptible to developing threshold eating disorders or

relapsing after treatment given that residual levels of weight and shape concerns are the cognitive

variables most strongly associated with relapse (Farrell et al., 2006).

Conclusion

Threshold and subthreshold eating disorders involve complex profiles of behavioral,

biological, psychosocial, and cognitive factors. Women with eating disorders have attentional

biases associated with subprocesses of attention: alerting, orienting, executive attention abilities.

(Posner & Rothbart, 2007). Eye tracking provides direction for developers of interventions

addressing these biases by assessing continuous, behavioral outcomes. Identification of

attentional biases among individuals with eating disorders, and exploration of the feasibility of

changing these biases might shed light on the etiology and maintenance of eating disorder

behaviors. Findings from the current project could lead to future research in treatment of threshold body image concern. Moreover, outcomes from the current study could inform subsequent basic research to detect underlying vulnerabilities and/or consequences of attentional biases. This study enhances the current literature on visual attention bias, eye movement behavior, and eating disorders by demonstrating the feasibility of modifying attention and influencing body image anxiety. Participants showed overattention to body regions they ranked as more dissatisfying, and this overattention reduced after the intervention. The effect of the intervention did not appear to be influenced by level of shape concern, which contradicts some studies in extant research.

Future research can build upon the current study. Very little is known regarding feasibility of altering visual attentional biases related to eating disorders. Thus, how attentional biases contribute to the etiology and/or maintenance of eating disorders is unclear. Outcomes from the current study have significant implications as they provide direction for the modification and enhancement of treatment options for individuals with threshold and subthreshold body image concern. This objective assessment approach might also be a useful means of evaluating symptom severity and prognosis, as well as identifying potential risk and/or maintenance factors. Despite the clear advantages of exploring attentional biases, the application of this idea to a body image attention modification intervention is nearly nonexistent. The potential benefits are significant, as body dissatisfaction is an enduring symptom in eating disorders, and thought by many to be related to the etiology and maintenance of AN and BN, as well as their subthreshold forms.

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