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INTRODUCTION

Major depressive disorder (MDD) is a debilitating disorder that affects an estimated 14.8 million Americans (6.7% of the population) each year (Kessler, Chui, Demler, & Walters, 2005) and 17% of Americans in their lifetime (Kessler, Bergland, Demler, Jin, & Walters, 2005). According to a study of 245,000 people in sixty nations, MDD is more damaging to everyday health than chronic diseases such as asthma, angina, arthritis, and diabetes (Moussavi et al., 2007). Furthermore, MDD is the leading cause of disability in the United States of America (World Health Organization, 2004). However, despite being a common and costly disorder facing Americans, MDD remains poorly understood and difficult to treat. For example, in a recent meta-analysis of ten treatment studies conducted between 1981 and 2005, the remission rate for MDD over the course of the 8 to 20 week studies was 38% for psychotherapy and 35% for psychopharmacotherapy (De Maat, Dekker, Schoevers, & DeJonghe, 2006). Furthermore, the six studies in this meta-analysis that included follow-up data provided evidence that over a follow-up period of 1 to 2 years the relapse rate was 56.56% for psychopharmacotherapy and 26.51% for psychotherapy (De Maat et al., 2006). These statistics highlight the need to gain a better understanding of the factors that contribute to the onset and maintenance of depression in order to develop more effective treatments for this debilitating disorder.
One prevailing psychological approach to understanding depression is in terms of cognitive factors. Cognitive theories of depression posit that people with depression, and people who are at risk of developing depression, tend to have a style of thinking that causes them to process information in a way that is different from people who are not depressed. This style of information processing is thought to contribute to the onset or maintenance of depression (e.g., Beck, 1976; Bradley, Mogg, & Lee, 1997; Rottenberg, Gross, & Gotlib, 2005). However, information processing is not a unitary construct. Instead, it involves a series of steps (Anderson, 2000). Early stages of information processing involve perceiving and attending to a stimulus. Then, once an individual is paying attention to a stimulus, she or he can elaborate upon its meaning and store the information about the stimulus in his or her memory. Furthermore, individuals may need to be able to recall this information later. Researchers generally believe that depression can be affected by all stages of information processing (Beck, 1976; Bower, 1981). However, the current research study focused on attention, one stage of information processing. Specifically, the goal of this research study was to examine whether depressed individuals attend to their environment differently from people who are not depressed.

Currently, three main cognitive theories provide an account for how people with and without symptoms of depression differ in the way they attend to emotional stimuli – Beck’s cognitive model of depression (1967, 1976), Bradley’s sticky mind theory (Bradley et al., 1997; Joormann, 2004), and the depressive evenhandedness hypothesis or
the emotion context insensitivity hypothesis (Rottenberg & Gotlib, 2004; Rottenberg et al., 2005).

*Beck’s cognitive model of depression*

Beck’s (1967, 1976) model is arguably the most influential cognitive model of depression. Beck posits that people who are depressed, or who are at risk of developing depression, possess negative cognitive schemas (i.e., negative beliefs about themselves, the world, and the future) that are believed to affect how they process information. Specifically, when people with negative cognitive schemas encounter stimuli in their environment, Beck posits that they will tend to process the information in a negative light. Negative interpretations of information are believed to play a role in the onset and maintenance of depression. To gain a better understanding of this theory, consider the following example. Imagine that Mary sees her friend, Sarah, walk past her in the hallway without making eye contact or saying hello. Mary needs to process this information to understand its meaning. If Mary has the negative core belief, “I am an unlikable person,” she may tend to process this event in keeping with her belief, and thus, may deduce that Sarah did not acknowledge her because she does not like her. This interpretation may put Mary in a sad mood, cause her to withdraw socially, and put her at risk for developing depression. On the other hand, if Mary has the positive core belief, “I am a likeable person,” she might deduce that Sarah did not say hello because she was in a rush and did not see her. If she makes this interpretation, her mood will not be affected and she will not be at increased risk for developing depression. Beck’s theory posits that
negative cognitive schemas affect all stages of information processing. Thus, with respect to attention, negative cognitive schemas are believed to cause individuals to attend selectively to the negative aspects of their environment.

Based on Beck’s (1967; 1976) theory, researchers have hypothesized that people with symptoms of depression would show an automatic negative attentional bias and people who are not depressed would show no attentional bias (i.e., they would look at negative, neutral, and positive stimuli equally). To test whether people with depression show this predicted negative attentional bias, researchers have used several different paradigms. Two paradigms commonly used to measure attentional biases are the dot-probe task (MacLeod, Mathews, & Tata, 1986) and the deployment-of-attention task (DOAT; Gotlib, McLachlan, & Katz, 1988). Eye-tracking is a third paradigm used to measure attention. However, given that it uses newer technology, few studies have used eye-tracking to examine attentional biases in depression.

In the dot-probe task (MacLeod et al., 1986), participants are shown two stimuli (pictures or words), one beside the other, on a computer screen and are asked to look at the stimuli. In some trials, a probe, usually either a circle or a cross, replaces one of the stimuli. Participants are asked to indicate, by pressing a button, when they see the probe. The theory behind this paradigm is that participants will respond to the probe more quickly when it replaces an attended, rather than unattended, region of the computer screen. Thus, based on the prediction that people with depression would attend more often to negative stimuli (thereby illustrating a negative attentional bias), people with
depression should respond more quickly to the probe when it replaces a negative stimulus than when it replaces a positive or neutral stimulus.

The DOAT (Gotlib et al., 1988) is similar to the dot-probe task in that participants are shown two words or images, one above the other, on a computer screen. However, when the stimuli disappear, each stimulus is replaced by a differently-colored line (one is red and one is green). Participants are misinformed that one line will appear slightly before the other and are asked to indicate which line appeared first. In reality, both lines appear at the same time, and the line that the participant selects is thought to reflect the location of the participant’s attention. Thus, based on the hypothesis that people with depression exhibit a negative attentional bias, depressed individuals should tend to select the colored bar that replaced the negative stimulus. Furthermore, because psychomotor retardation, a symptom of depression (American Psychiatric Association, 2000), may impair reaction time, relying on line selection, rather than reaction times, to measure attentional biases may give the DOAT an advantage over the dot-probe task.

However, the results of the dot-probe task and DOAT are somewhat limited because they only provide information about where participants were looking immediately before the probe or lines appear. The results offer no information about whether participants shift their attention during the course of the stimulus presentation. Eye-tracking is a technique that eliminates this methodological limitation. In eye-tracking studies, participants’ eye-movements are monitored as they look at differently valanced (e.g., depression-relevant and non-depression relevant) stimuli. The eye-tracker is able to continuously record the position of the participant’s gaze. Thus, eye-tracking has two
advantages over the other two paradigms. First, it provides information about where a participant is looking during the entire course of the experiment. Secondly, it is a more direct measure of attention than the dot-probe task or DOAT because researchers do not have to infer where participants were looking based upon their responses. Instead, researchers can examine exactly where on a screen participants were looking during the entire study.

Despite its advantages, eye-tracking has limits in the type of information that it can provide about attentional biases. There are two types of attention – covert and overt. Shifts in overt attention involve shifts in gaze, and shifts in covert attention occur before eye movements occur and involve shifting attention before moving the eyes toward a particular stimulus. Thus, covert attention involves the allocation of attention to a region of space that does not correspond to the current direction of gaze (Deubel & Schneider, 1996; Hoffman & Subramaniam, 1995; Kowler, Anderson, Docher, Blaser, 1995; Peterson, Kramer, & Irwin, 2004). However, under normal viewing conditions, shifts in overt attention closely follow, and are directed by, shifts in covert attention. (Klein, Kingstone, & Pontefract, 1992; Kowler et al., 1995). Additionally, although somewhat controversial, it seems that there is likely a common mechanism underlying these two types of attention and that the eye-movement system plays an important role in both types (Liversedge & Findley, 2000; Smith, Rorden, & Jackson, 2004). Thus, although these two types of attention seem to be closely related, eye-tracking only provides direct information about overt attention.
Support for Beck’s theory

Research has generally found mixed support for the hypothesis that people with depression show a negative attentional bias. Mogg and Bradley (2005) recently completed a review of research examining attention and depression. In their review paper, depressed participants showed a negative attentional bias that was significantly larger than the bias shown by the control participants in 6 out of 20 experiments that used a dot-probe or emotional Stroop task. However, a closer look at these data suggests that a somewhat more reliable attentional biases was present in the depressed participants when the stimuli were presented for longer (i.e., 500ms or longer) periods of time (e.g., Bradley et al., 1997; Mogg & Bradley, 2005). For example, Bradley and colleagues (1997) conducted a dot-probe study using emotionally-valenced words as stimuli to examine how dysphoric individuals attend to emotional stimuli differently than people who are not depressed. Based on Beck’s theory, they predicted that people with depression would show a bias for negative information. Surprisingly, they found that people with symptoms of depression did not show a negative attentional bias for stimuli that were presented for 14ms. However, they did show the predicted negative attentional bias for information that was presented for 500ms and 1000ms. Similar results have been found using images as stimuli. For example, Gotlib, Krasnoperova, Yue, and Joormann (2004) conducted a study using pictures of emotional faces, rather than words. Participants completed a dot-probe task in which the stimuli were presented for 1000ms. Consistent with previous results, the participants with depression showed a bias for the negative faces that was significantly larger than the bias shown by the control participants. Thus, people with
depression do not seem to automatically attend to negative information as predicted by Beck (1967, 1976). Yet, if the negative information is presented for a longer period of time, they may show a negative attentional bias.

This lack of an automatic negative attentional bias among depressed individuals is quite different from what is seen among individuals with anxiety disorders. A recent meta-analysis found that anxious individuals show a negative attentional bias for subliminally ($d=.48, 85\% \ C.I. = .42-.54$) and supraliminally ($d=.32, 85\% \ C.I. = .20-.44$) presented information (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007). Furthermore, Bar-Haim and colleagues found that participants with all types of anxiety disorders tend to show this negative attentional bias. Thus, unlike depressed individuals, anxious individuals tend to orient immediately towards the negative information.

*The Sticky Mind Theory* (Bradley et al., 1997)

Based on the finding that depressed individuals do not show an automatic negative attentional bias, Bradley et al. (1997) developed a hypothesis that depression is related to an inhibitory deficit for negative information. Specifically, they hypothesized that people with symptoms of depression do not automatically orient toward negative information. However, once depressed or dysphoric individuals attend to negative information they have difficulty disengaging from it. On the other hand, people who are not depressed have no difficulty disengaging from negative information. Thus, people who are depressed end up attending to negative information for longer periods of time.
than people who are not depressed. This increased attention to negative information may lead to increased symptoms of depression and/or may maintain an episode of depression.

As described previously, dot-probe research has shown some support for Bradley and colleagues’ (1997) theory. A recent meta-analysis found that, for the dot-probe task, the size of the bias shown by the participants with symptoms of depression is medium sized ($d = -.19$) and significant ($p < .05$) for stimuli that are presented supraliminally. Control participants showed no significant attentional bias ($d = .06, p > .05$) (Rytwinski & Fresco, 2009a). However, although researchers have used the dot-probe task to test Bradley’s theory, Bradley et al. (1997) hypothesized that depressed individuals would not orient towards negative stimuli. Instead, they would have difficulty disengaging from them. Thus, at a particular point in time, depressed and euthymic participants may not differ with respect to location of gaze. Given that the dot-probe task can only measure attention at one point in time, it is not surprising that some researchers (e.g., MacLeod et al., 1986; Neshat-Doost, Moradi, Taghavi, Yule, & Dalgleish, 2000; Taghavi, Neshat-Doost, Moradi, Yule, & Dalgleish, 1999) have failed to find a negative attentional bias among depressed individuals when using the dot-probe task. To more directly test Bradley et al.’s theory, a task that can provide information about gaze length, such as eye-tracking, is needed.

The few published eye-tracking studies that have examined attention and depression provide more consistent support for Bradley et al.’s (1997) theory. For example, Mogg, Millar, and Bradley (2000) examined eye movements to angry, sad, and neutral faces that were each presented for 1 second each. People with depression did not
show a bias in initial orienting as they did not differ from the group with generalized anxiety disorder or the control group in direction or latency of initial shifts in gaze. Thus, people with depression do not appear to automatically orient toward negative stimuli as predicted by Beck (1967, 1976). Furthermore, Eizenman and colleagues (2003) conducted an eye-tracking study in which participants were shown 4 images (one neutral, one social, one threatening, and one sad) on a slide. The participants were simply instructed to look at the stimuli. These researchers found that average gaze duration on images with dysphoric themes was significantly longer for participants with depression as compared to that of participants in the control group. Kellough, Beever, Ellis, and Wells (2008) replicated Eizenman et al.’s (2003) study with a larger sample and longer stimulus exposure times (30 seconds each). They found that the depressed participants showed a bias for the negative stimuli and the control participants showed a bias for the positive stimuli. Furthermore, Caseras, Garner, Bradley, and Mogg (2007) found similar results. In their study, participants were presented with a central-fixation point and then they were shown a pair of images (either negative-neutral images or positive-neutral images) for 3000ms. The dysphoric and control participants did not differ in their initial allocation of attention. When participants were shown negative-neutral image pairs, both groups of participants tended to look at the negative images for a longer period of time than the neutral images. However, this negative attentional bias was significantly larger for the dysphoric group than the control group. When participants were shown positive-neutral picture pairs there were no significant differences between the groups in their average time spent looking at the different types of images. Thus, eye-tracking, provides fairly
consistent support for Bradley and colleagues (1997) theory that people with symptoms of depression do not automatically orient towards negative stimuli. Yet, when people with depression come into contact with a negative stimulus, they may have difficulty disengaging from that stimulus. However, the picture gets more complicated when one considers the results from studies using the DOAT.

Research using the DOAT has not supported Bradley et al.’s (1997) hypothesis. DOAT research has revealed that people with depression do not show a negative attentional bias. Instead, they show no attentional bias (i.e., they attend to negative, neutral, and positive information equally). On the other hand, people who are not depressed show a protective bias and avoid negative information (Gotlib et al., 1988; McCabe & Gotlib, 1995; McCabe & Toman, 2000; Rytwinski & Fresco, 2009b). In a meta-analysis looking at attentional biases using the DOAT, participants with symptoms of depression showed no significant attentional bias ($d = -0.06$, $p > 0.05$). Control participants showed a significant protective bias ($d = 0.61$, $p < 0.05$; Rytwinski & Fresco, 2009a). Thus, this body of research suggests that depression is characterized by the loss of a protective bias, rather than by problems disengaging from negative stimuli as predicted by Bradley and colleagues (1997). The depressive evenhandedness hypothesis could explain the results of the DOAT studies.

**Depressive Evenhandedness Hypothesis**

The depressive evenhandedness hypothesis posits that people who are depressed experience diminished emotional reactivity to both positive and negative stimuli.
Thus, it predicts that people who are depressed will report less intense emotions, show less of a behavioral response, and have less of a physiological response than people who are not depressed when confronted with emotional stimuli (either positive or negative). This hypothesis is derived from the evolutionary viewpoint that depression can be adaptive when it is a defensive response to aversive stimuli (e.g., famine) in which continued activity might be dangerous or ineffective (Nesse, 2000). Thus, symptoms of depression cause people to see all stimuli in the environment as dull and similar, causing people to feel pessimistic and lose interest in their environment, which reduces motivated activity, and in turn, keeps people safe during times of stress.

Experimental studies provide some support for this theory. For example, people with depression report less sadness to sad films and less amusement to amusing films as compared to control participants (Rottenberg, Kasch, Gross, & Gotlib, 2002). Gotlib, Sivers, Canli, Kasch, and Gabrieli (2001) found less differential neural of depressed participants responding to different valences of facial emotions. Furthermore, Rottenberg and colleagues (2005) found that depressed participants showed less sympathetic arousal to sad and happy videos as compared to control participants. Thus, based on the depressive evenhandedness hypothesis, people who are depressed will not show an attentional bias. Instead, people who are not depressed will show a protective bias and avoid the negative stimuli. This pattern of results is exactly what has been found in the DOAT studies that have examined attentional biases shown by people with depression.
(Gotlib et al., 1988; McCabe & Gotlib, 1995; McCabe & Toman, 2000; Rytwinski & Fresco, 2009b).

Summary, Research Goals, and Hypotheses

In summary, when considering whether people with depression attend to their environment differently than people who are not depressed, Beck’s cognitive theory of depression (1967, 1976) appears to be inadequate. People who are depressed do not appear to automatically orient toward negative information as predicted by Beck (e.g., Mogg & Bradley, 2005). Rather, two competing, and partially supported, theories provide an explanation for how people who are depressed attend to their environment differently from people who are not depressed. Bradley et al.’s (1997) theory posits that people with depression do not show an automatic bias for negative information. However, once they come into contact with a negative stimulus, they have difficulty disengaging from the stimulus. People who are not depressed do not appear to have this difficulty. Research using eye-tracking (Caseras et al., 2007; Eizenman et al., 2003; Kellough et al., 2008), and, to a lesser extent, research using the dot-probe task (Bradley, et al, 1997; Gotlib et al., 2004) provide support for this hypothesis. Conversely, the depressive evenhandedness hypothesis (Rottenberg, & Gotlib, 2004; Rottenberg et al., 2005) predicts that people who are depressed will not show an attentional bias; they will look at all types of stimuli (positive, negative, neutral) equally. People who are not depressed will show a protective bias and avoid negative information. Research using the DOAT supports this hypothesis (Gotlib et al., 1988; McCabe & Gotlib, 1995; McCabe & Toman, 2000; Rytwinski &
Fresco, 2009b). Thus, the overarching goal of this research project is to gain a better understand of how people with depression attend to their environment differently from people who are not depressed, and to gain some insight into why there appears to be support for these two competing theories.

One possible explanation for these contradictory findings is that the dot-probe task or DOAT do not work the way they are assumed to work. The DOAT assumes that the line that seems to appear first provides information about the location of the participants’ attention immediately before the lines appeared. Similarly, the underlying assumption of the dot-probe task is that the speed of responding to the probe provides information about the location of attention immediately before the probe appeared. However, little research has examined whether these assumptions are correct. The conflicting results about the way in which people with depression attend to their environment may be due to the fact that one, or both, of these tasks do not accurately measure gaze location. Alternatively, one or both of these paradigms may accurately measure location of attention for people who are not currently depressed but for not people who have symptoms of depression. For example, people who have symptoms of depression may have reduced motivation to participate in the task and/or psychomotor retardation (American Psychiatric Association, 2000). Thus, they may respond to the probe, in the dot-probe task, so slowly that it is no longer an accurate measure of attention. Alternatively, they may be so unmotivated to participate in the study that they just randomly select lines in the DOAT rather than attempting to accurately determine which line appeared first. Thus, the proposed study sets out to evaluate the dot-probe and
DOAT paradigms to ensure that they measure attention for people with and without symptoms of depression.

One way to evaluate these paradigms is to have the participants complete these two tasks while monitoring their eye-movements with an eye-tracker. As previously described, eye-tracking is a technique that allows researchers to directly and continuously examine a participant’s point-of-gaze, which would provide information about whether the dot-probe task and DOAT work in the ways they are hypothesized to work. Specifically, for the dot-probe task, eye-tracking could provide information about whether participants respond to the probe more quickly when it replaces the stimulus that they were looking at than when it replaces the unattended stimulus. For the DOAT, eye-tracking could offer information about whether line selection is related to gaze location.

Research findings indicate that the dot-probe task may provide accurate information about gaze location. For example, Bradley, Mogg, and Millar (2000) conducted a study in which participants completed a dot-probe task while having their eye-movements monitored. They found that reaction times on the dot-probe task were correlated with eye-movements, which suggests that reaction time in the dot-probe task provides information about gaze location. However, Bradley et al. (2000) did not report whether this correlation existed for both dysphoric participants and control participants. They also presented the stimuli in the study for a relatively short period of time (500ms). Interestingly, in another study that presented stimuli for 1000ms, there was no significant relationship between the initial gaze direction and reaction times in a dot-probe task (Mogg, et al., 2000). Thus, examining how shifts in attention affect the dot-probe task
results could add to our understanding of how the dot-probe task works and to our understanding of the attentional biases shown by people with depression. No studies have yet examined the DOAT within an eye-tracking paradigm.

A second possible explanation for the inconsistent results in studies examining attentional biases and depression is that depressed individuals may follow the task’s directions for the first several trials, but quickly become unmotivated or frustrated due to feelings of worthlessness or poor concentration (American Psychiatric Association, 2000) and begin to respond in a random manner. On the other hand, control participants may be able to complete the entire study in an accurate manner without becoming too frustrated or losing motivation. Results indicating that depressed participants’ responses are only related to gaze location near the start of the study would provide support for this hypothesis.

Thus, assuming that the dot-probe task and DOAT function the way that they are believed to function, the first three hypotheses were:

1) In the dot-probe task, participants, irrespective of group, will respond to the probe more quickly when it replaces an attended region of the screen than an unattended region of the screen.

2) In the DOAT, participants, irrespective of group, will believe that the line that replaces the attended region of the screen appears before the line that replaces the unattended region of the screen.

3) Symptoms of depression will not interfere with the participants’ ability to provide accurate responses throughout the entire study. Thus, the
participants’ performance on the dot-probe task and DOAT will be unrelated to when in the study they completed these tasks.

If one (or more) of these hypotheses is not supported, it could provide information about why these two tasks have yielded contradictory results about whether people with symptoms of depression show a negative attentional bias. However, if eye-tracking provides evidence that the depressed and euthymic participants’ responses in both the DOAT and dot-probe task are related to gaze location, then the next step would be to examine the results from the dot-probe task, the DOAT task, and an eye-tracking task to see if they provide support for the depressive evenhandedness hypothesis (Rottenberg, & Gotlib, 2004; Rottenberg et al., 2005) or Bradley and colleagues’ (1997) sticky mind theory. To recapitulate, Bradley’s sticky mind theory predicts that dysphoric participants will have difficulty disengaging from negative stimuli. The depressive evenhandedness hypothesis predicts that depressed participants will show no attentional bias and control participants will show a protective bias.

Support for Bradley’s (1997) sticky mind theory would come from the following pattern of results:

4) In the dot-probe task and DOAT, depressed participants show a negative attentional bias and the euthymic participants show no attentional bias. Additionally, the negative attentional bias shown by the depressed group is significantly larger than the bias shown by the euthymic group.
In the eye-tracking task, the average length of gaze for the depressed group is significantly longer for the negative stimuli than the neutral stimuli. For the euthymic group, there is no significant difference between the average length of gaze for negative and neutral stimuli.

Furthermore, the negative attentional bias shown by the depressed group is larger than the bias shown by the euthymic group.

Support for the depressive evenhandedness hypothesis (Rottenberg, & Gotlib, 2004; Rottenberg et al., 2005) would come from the following pattern of results:

In the dot-probe task and DOAT, euthymic participants show a protective attentional bias. Depressed participants show no attentional bias. Moreover, the protective attentional bias shown by the euthymic group is significantly larger than the bias shown by the depressed group.

In the eye-tracking task, the average length of gaze for the euthymic group is significantly longer for the neutral stimuli than the negative stimuli. There is no difference between the average length of gaze for negative and neutral stimuli for the depressed group. Additionally, the protective bias shown by the euthymic group is significantly different from the bias shown by the depressed group.

Finally, assuming that Bradley’s sticky mind theory or the depressive evenhandedness hypothesis is correct and both the DOAT and dot-probe task accurately
measure gaze location, the participants’ performance on the three tasks (i.e., dot-probe, DOAT, and eye-tracking task) should be positively correlated.

The information gained from this study could provide information about whether the dot-probe task and DOAT work the way they are purported to work. Furthermore, the results provide information about the way people with depression may attend to their environment differently from people who are not depressed. This information could be used to screen for people who are at risk of developing depression and to create more effective treatments for depression.
METHOD

Participants

Participants were recruited from the introductory psychology courses at a large Midwestern university and compensated with course credit or money. The participants were selected from a larger sample who were screened using the Beck Depression Inventory – Second Edition (BDI-II; Beck, Steer, & Brown, 1996) at mass testing. In total 71 participants completed the study. However, five participants were excluded due to difficulties recording their eye movements with the eye-tracking equipment. Additionally, because the study was interested in how depressed and euthymic individuals differ in the way they attend to emotional stimuli, only participants who met the DSM-IV criteria for a current mood disorder or who had never met criteria for any DSM-IV disorder were included in the analyses (n = 44). The average age of the participants was 19.65 years (SD = 2.72, range = 18 to 33), and 78.8% of the sample was female. The majority of the sample was Caucasian (81.8%), 9.1% was African American, 4.5% was Hispanic, and 4.5% identified themselves as “other.”

Eye-tracker and Stimuli

The participants’ eye movements were recorded using a Tobii 1750 eye-tracker (www.tobii.se) which has an error rate of less than .05 degrees and a sampling rate of 50MHZ. Timestamps are accurate to ±5ms. Stimuli were presented on a 17 inch flat-
panel screen, and the Tobii 1750 eye-tracker does not require restraints such as wearing a headband/helmet or using a bite bar. Thus, participants were able to complete the task in a normal computer-operating environment.

In total, 180 pairs of images were included in the study. Images, rather than words, were used in this study because images have two important advantages over words. First, words tend to lack ecological validity as they are not representative of naturalistic emotion-provoking stimuli. Secondly, images tend to be stronger emotional stimuli than single-word stimuli (e.g., Kindt & Brosschot, 1997). There were 90 depression-relevant images paired with 90 neutral images and 90 positive images paired with 90 neutral images (henceforward referred to as the negative-neutral and positive-neutral stimuli pairs). Within each type of stimulus pair, there were 45 pairs in which a neutral face is paired with an emotional face (either sad or happy). Both images in a pair were pictures of the same person. Using the same person within each pair of stimuli ensures that the pictures in each pair are matched exactly with respect to age, gender, race, physical appearance, and attractiveness. The only difference between the two pictures was the emotional expression. These stimuli were selected from Karolinska Face Set and the NimStim Face Set. The other 45 pairs were images selected from the International Affective Picture System (IAPS), a standardized and validated set of images with affective ratings (Center for the Study of Emotion and Attention [CSEA-NIMH], 1999) and from images collected and validated by Baumgartner, Esslen, and Jancke (2006). The IAPS stimuli have been rated on three dimensions: valence (feelings of displeasure vs. pleasure), arousal (feelings of excitement vs. calm), and dominance.
(feelings of control in the situation). Each dimension was rated on a 1 to 9 Likert-type scale by individuals without a psychiatric diagnosis (Lang, Bradley, & Cuthbert, 1999). Baumgartner’s images have been validated in a similar manner for valence and arousal (Baumgartner et al., 2006). In this study, the stimuli were selected based on the valance ratings where 1 was a rating of displeasure and 9 was a rating of pleasure. Most of the stimuli pairs were created based on previous research (Caseras et al., 2007; Eizenman et al., 2003).

The 180 pairs of stimuli were divided into 3 sets of images. Each set of images included: 15 negative-neutral pairs of faces taken from the Karolinska Face Set and the NimStim Face Set, 15 negative-neutral pairs of images taken from the IAPS and Baumgartner’s images, 15 positive-neutral pairs of faces taken from the Karolinska Face Set and the NimStim Face Set, and 15 positive-neutral pairs of images taken from the IAPS and Baumgartner’s images (see the appendix for a list of the stimulus pairs). Participants were shown one set of stimuli during each of the three tasks (i.e., the eye-tracking task, the dot-probe task, and the DOAT). The image set that the participants viewed in each task was counterbalanced. Thus, all participants saw all of the image pairs once, but which task they saw them in was different. The order in which the stimuli were presented within each stimuli set was randomized for each participant.

Each stimulus was 4.5 inches wide and 3.25 inches high. For the eye-tracking task and DOAT, the stimuli were positioned one above the other. In the dot-probe task, the stimuli were positioned beside each other. In all trials, the stimuli were separated by 1.5 inches and centered on the screen.
Attentional Bias tasks

The Eye-tracking task: Participants were presented with one set of stimuli (i.e., 60 pairs of stimuli) in a random order. Each trial began with the presentation of a central fixation cross. Participants were told to look at the fixation cross and then press the space bar to begin a trial. Immediately following their keyboard response, a picture pair appeared for 5000ms with the images positioned one above the other. Participants were asked to look at the pictures while they were on the screen. After 5000ms, the pictures disappeared and the central fixation cross reappeared. This procedure was repeated until all 60 picture pairs had been presented.

Dot-Probe Task (based on a task developed by MacLeod et al., 1986): Participants were shown a central fixation cross for 1000ms, then the central fixation cross disappeared and a stimulus pair appeared (the stimuli were positioned so that one stimulus was on the left side of the screen and one was on the right). After 750ms the stimulus pair disappeared and one of the images was replaced by a grey dot. The participants were told that they are to indicate the location of the dot (left or right) as quickly as possible. They made their selection by pressing one of two keys (labeled left and right). Once the participants have made their selection, the dot disappeared, the central fixation cross reappeared, and the next trial began. This procedure was repeated until one set of stimulus pairs had been presented.

DOAT: Participants completed a DOAT, which was adapted from the DOAT used by Gotlib and colleagues (1988), McCabe and Gotlib (1995), and McCabe and Toman.
(2000). Participants were presented with a central fixation cross for 1000ms, and then two images (one emotional and one neutral) appeared, one above the other, for 750ms. Next, the images disappeared and were replaced by two lines (one line was red and one was green). In reality the lines will appeared at the same time. However, the participants were told that one line appeared slightly before the other line and they were asked to indicate which line appeared first by pressing a key that is labeled ‘top’ or ‘bottom’. Once they indicated which line they believed appeared first, the central fixation cross reappeared and the procedure was repeated until they had seen one set of stimulus pairs.

**Questionnaires**

* A demographics questionnaire – This questionnaire inquired about the participants’ gender, age, ethnicity, socioeconomic status, and education.

* The *Beck Depression Inventory - Second Edition* (BDI-II; Beck et al., 1996) is a 21-item self-report instrument that broadly assesses the symptoms of depression including the affective, cognitive, behavioral, somatic, and motivational components as well as suicidal wishes. Beck and colleagues (1996) reported internal consistency (coefficient $\alpha$) in a university population to be .93. The internal consistency in this sample was .96. They also found the BDI-II to possess adequate test-retest reliability of .93 for a one-week interval and convergent validity with the Hamilton Rating Scale for Depression ($r = .71$; Hamilton, 1967), the Beck Hopelessness Scale ($r = .68$; Beck & Steer, 1988), and a previous version of the BDI ($r = .93$; Beck & Steer, 1987).
The Mood and Anxiety Symptom Questionnaire – Short Form (MASQ; Watson & Clark, 1991) is a 62-item instrument designed to assess symptoms commonly occurring in the mood and anxiety disorders. Items are rated on a 1 (“not at all”) to 5 (“extremely”) Likert-type scale. These 62 items are subdivided into four subscales: General Distress Anxious Symptoms (GDA), General Distress Depressive Symptoms (GDD), Anxious Arousal (AA), and Anhedonic Depression (AD). The GDA subscale is comprised of 11 items indicative of anxious mood, but provides little discrimination from depressed mood (e.g. “Felt nervous”, “Had an upset stomach”). The GDD subscale is comprised of 12 items indicative of depressed mood, but provides little discrimination from anxious mood (e.g., “Felt sad”, “Felt like crying”). The AA subscale contains 17 items detailing symptoms of somatic tension and hyperarousal (e.g., “Startled easily”, “Was trembling or shaking”). The AD subscale contains 22 items specifically assessing symptoms related to depression such as a loss of interest in pleasurable activities and low energy (e.g., Felt like nothing was enjoyable”). The AD scale also contains a number of reverse coded items assessing positive emotional experiences (e.g., “Felt cheerful”). In this sample the internal consistency was .90 for the GDD scale, .90 for the AA scale, .96 for the GD scale, and .93 for the AD scale.

The Ruminative Response Scale (RRS; Nolen-Hoeksema and Morrow, 1991) is comprised of responses to a sad mood that are focused on self (e.g., “Think back to times I have been depressed”), on symptoms (e.g., “Think about how hard it is to concentrate”) and on possible causes or consequences of their mood (i.e., “Go away by myself and think about why I feel this way”). Each item is measured on a 4-point Likert-
type scale, with values ranging from 1 (“almost never”) to 4 (“almost always). The internal consistency in this sample was .95. The RRS has been shown to have good convergent and predictive validity (Nolen-Hoeksema & Morrow, 1991; Treynor, Gonzalez, & Nolen-Hoeksema, 2003).

Additionally, Treynor et al. (2003) and Armey et al. (in press) showed that the RRS is made up of two factors – brooding and pondering/reflection. Brooding involves thinking about personal shortcomings and life set-backs, whereas pondering/reflection involves efforts to analyze one’s self, feelings, thoughts, and events in an attempt to resolve the problem. Brooding has been found to be more strongly related to depression than pondering/reflection (Treynor et al., 2003). In this sample, the internal consistency was .83 for the brooding factor and .78 for the pondering factor.

Interview

The Structured Clinical Interview for DSM-IV Axis I Disorders – Patient Edition (SCID –I; First, Spitzer, Gibbon, & Williams, 1995) is a semi-structured interview for making the major DSM-IV Axis I diagnoses. The SCID-I interviewer had previous experience with administering structured clinical interviews and was trained specifically to administer the SCID-I interview prior to beginning work on this study. The inter-rater agreement of diagnosis on the SCID-I is generally very good. For example, Ventura, Liberman, Green, Shaner, and Mintz (1998) reported good agreement on symptoms (kappa = .76) and very good diagnostic accuracy (83%) over a period of 5 years in a
general clinical sample, when compared with trained diagnostic interviewers who viewed the interviews live or via videotape.

Procedure

After receiving approval from the Kent State University institutional review board to conduct the study, eligible participants from introductory psychology classes were contacted by phone or email to inquire if they would be interested in participating in an eye-tracking study. If a participant agreed to participate in the study, she or he was scheduled to come into the laboratory. Once a participant arrived in the laboratory and completed the necessary consent forms, she or he was seated approximately 25 inches from the eye-tracker, and the eye-tracking system was calibrated. After completing the set-up in the eye-tracker, the participant participated in 3 different tasks thought to measure attentional biases (an eye-tracking task, a dot-probe task and a DOAT) in a counterbalanced order. The stimuli that accompany each task were presented in a random order.

Before a participant started each task, he or she was given three practice trials to ensure that the task was understood. For the eye-tracking task and dot-probe task, the practice trials were identical to the actual test trials, except the participant was presented with two neutral stimuli rather than an emotional stimulus and a neutral stimulus. To increase the likelihood that participants believe that the lines actually appeared sequentially, the practice trials for the DOAT were slightly different than the actual test trials - the lines actually appeared one after another in the first two practice trials (i.e. the
appearance of the lines were separated by 200ms and 100ms). The final practice trial for the DOAT was identical to the actual test trials and the lines actually appeared at the same time.

After a participant completed the eye-tracking portion of the study, he or she completed a packet of self-report questionnaires and an interview to assess psychopathology. The participant was then debriefed and compensated for his or her time.

**Analyses**

*Analyses used throughout the study.* Generalized estimating equations (GEE) (Liang & Zeger, 1986) were employed to assess most of the hypotheses. GEE represent a set of methods to model repeated measures with continuous or dichotomous outcomes. This method is superior to the generalized linear mixed model (GLMM) because it does not produce biased parameter estimates or standard errors (Hall et al., 2001). GEE is limited in that it does not allow for subject-specific effect estimation (Hall et al., 2001). However, the hypotheses in the current study focus on between group differences and do not require differences between individuals to be examined. Thus, it was an appropriate method to use in this study.

In the analyses, an autoregressive correlation matrix was used because it was predicted that trials that are closer together would be more correlated than trials that are further apart. Finally, subject ID number was entered as the subject variable and trial number was entered as the within-subjects variable.
Terms used throughout the study. Several variables are used repeatedly in the analyses. *Group* refers to the depressed versus euthymic participants. *Pair type* refers to a comparison between whether the stimuli are faces or images. *Pair valance* refers to a comparison between whether it is a negative stimulus paired with a neutral stimulus or a positive stimulus paired with a neutral stimulus. *Stimulus valance* refers to whether the stimulus is emotional (negative or positive) or neutral.
RESULTS

Group Differences

Participants were divided into two groups based upon the results of a clinician administered diagnostic interview of psychopathology. Participants with a current mood disorder were placed in the depressed group whereas participants with no history of psychopathology were placed in the euthymic group. There were 21 participants in the depressed group (18 women and 3 men) and 23 participants in the euthymic group (17 women and 6 men). All individuals in the depressed group had a primary diagnosis of Major Depressive Disorder \( n = 11 \), Dysthymic Disorder \( n = 4 \) or Depressive Disorder Not Otherwise Specified \( n = 6 \). Ten of the depressed participants had at least one other diagnosis. The most common comorbid disorders were generalized anxiety disorder \( n = 5 \), panic disorder \( n = 4 \), and social phobia \( n = 3 \). Six participants were taking an antidepressant medication.

\( T \)-tests and \( \chi^2 \) analyses were conducted to examine whether the groups differed on any demographic or mood-related variables. The two groups of participants did not differ in age \( [t(42) = -1.34, \text{ ns.}] \), gender \( [\chi^2 (1, N = 44) = 0.94, \text{ ns.}] \), ethnicity \( [\chi^2 (5, N = 44, \text{ df} = 3) = 4.83, \text{ ns.}] \) or family income \( [\chi^2 (10, N = 44) = 15.14, \text{ ns.}] \). As shown in Table 1, the depressed group scored significantly higher than the euthymic group on self-report measures of depression, anxiety, and rumination.
Table 1: Means, standard deviations, independent-samples t-tests and Cohen’s $d$ for the two groups on measures of depression, anxiety, and rumination.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Depressed Group Mean (SD)</th>
<th>Euthymic Group Mean (SD)</th>
<th>$t$-test</th>
<th>$D$</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI-II</td>
<td>32.33 (11.29)</td>
<td>5.35 (3.60)</td>
<td>$t(42)=10.88, p&lt;.001$</td>
<td>3.22</td>
</tr>
<tr>
<td>GDD</td>
<td>43.95 (9.32)</td>
<td>18.74 (6.74)</td>
<td>$t(42)=11.32, p&lt;.001$</td>
<td>3.40</td>
</tr>
<tr>
<td>AD</td>
<td>83.10 (9.12)</td>
<td>52.91 (7.63)</td>
<td>$t(42)=11.95, p&lt;.001$</td>
<td>3.59</td>
</tr>
<tr>
<td>GDA</td>
<td>30.81 (9.33)</td>
<td>17.91 (5.04)</td>
<td>$t(42)=5.77, p&lt;.001$</td>
<td>1.72</td>
</tr>
<tr>
<td>AA</td>
<td>30.95 (11.09)</td>
<td>20.91 (6.20)</td>
<td>$t(42)=3.75, p=.001$</td>
<td>1.11</td>
</tr>
<tr>
<td>RRS</td>
<td>67.67 (13.21)</td>
<td>37.30 (11.28)</td>
<td>$t(42)=8.22, p&lt;.001$</td>
<td>2.47</td>
</tr>
<tr>
<td>Brooding</td>
<td>9.24 (2.31)</td>
<td>5.30 (2.01)</td>
<td>$t(42)=5.93, p&lt;.001$</td>
<td>1.82</td>
</tr>
<tr>
<td>Pondering</td>
<td>6.57 (2.13)</td>
<td>4.17 (1.67)</td>
<td>$t(42)=4.17, p&lt;.001$</td>
<td>1.25</td>
</tr>
</tbody>
</table>

Note. BDI-II = Beck Depression inventory – II; GDD = General Distress Depressive Symptoms subscale of the MASQ; AD = Anhedonic Depression subscale of the MASQ; GDA = General Distress Anxious Symptoms subscale of the MASQ; AA = Anxious Arousal subscale of the MASQ; RRS = Ruminative Responses Questionnaire; Brooding = the Brooding subscale of the RRS; and Pondering = the Pondering subscale of the RRS.

Is the dot-probe task an accurate measure of attention?

The first hypothesis posited that in the dot-probe task, reaction time (i.e. the time from when the dot appeared on the screen to when the person made their response about the location of the dot) is related to gaze location. Thus, it was hypothesized that participants would respond to the probe more quickly when it replaced an attended region of the screen than an unattended region of the screen. However, before conducting analyses to examine this hypothesis, incorrect responses (0.05% of the trials; $n_{\text{depressed}} = 9$; $n_{\text{euthymic}} = 5$) were removed from the analysis. Furthermore, in keeping with previous dot-
probe research (e.g., Joormann & Gotlib, 2007), reaction times that were less than 100ms or greater than 1000ms (3.0% of the trials; $n_{\text{depressed}} = 74$; $n_{\text{euthymic}} = 7$) were considered outliers and removed from the analyses. These trials were removed because they were assumed to reflect anticipation errors and lapses in attention, respectively. Given that impaired concentration is a symptom of depression (American Psychiatric Association, 2000), it is not surprising that the depressed group had more invalid trials due to concentration difficulties than the euthymic group.

Then, GEE were conducted to assess the relationship between gaze location and reaction time. Reaction time was the continuous, normally distributed, dependent variable. Last gaze location before the dot appeared (i.e., looking at the image replaced by the dot versus not looking at the image replaced by the dot), participant group, pair type, pair valance and all interactions between these variables were also included as independent variables in the model. Based on the hypothesis, last gaze location was predicted to be the only significant effect. Participants were expected to respond more quickly when they were looking at the image replaced by the dot than when they were looking elsewhere on the screen.

As predicted there was a significant main effect for last gaze location, $X^2 (1) = 33.54, p < .001$. Participants, regardless of group, were faster to respond to the dot when they were looking at the image that was replaced by the dot ($M = 573.20, SD = 91.21$) than when they were looking elsewhere on the screen ($M = 590.21, SD = 94.19$). Thus, this finding supports the theory that, in the dot-probe task, reaction time can provide information about where on a screen an individual is looking. Findings also revealed a
main effect for pair type, $X^2 (1) = 64.60, p < .001$. Participants were faster to respond (regardless of their gaze location) to the faces ($M=567.80, SD =91.34$) than images ($M=596.06, SD = 94.52$). There were no other significant effects.

In 39.9% of the trials, participants’ gaze location changed from when the images disappeared to when the dot appeared (e.g., they were looking at the left image when the images disappeared and the location of the right image when the dot appeared or vice versa). This change of gaze location may have affected reaction times. Thus, the analyses were repeated with only the trials in which the participants were looking at the same place immediately before the dot appeared and immediately after the dot appeared (60.1% of the original trials). The pattern of results remained unchanged. Participants were faster to respond when they were looking at the dot ($M=576.82, SD =128.15$) than when they were looking elsewhere on the screen ($M=602.21, SD =122.58$), $p < .001$.

To examine whether performance was related to when in the study participants completed the dot-probe task (i.e., the third hypothesis), additional GEE analyses were conducted with task location (i.e. completed the dot-probe task first, completed the dot-probe task second, completed the dot-probe task third) entered as an additional independent variable. Assuming that task location did not affect the results, the relationship between reaction time and eye-location should be the only significant effect. As predicted, the pattern of results did not change, and there were no added main effect or interactions involving task location.
Is the DOAT an accurate measure of attention?

The second hypothesis posited that the DOAT is an accurate measure of attention. Thus, line selection (top or bottom) was predicted to be related to the location of the participants’ gaze (i.e., looking at the top or bottom of the screen) immediately before the lines appeared.

However, before conducting analyses to examine whether line selection is related to gaze location, invalid trials were removed from the data. In the DOAT, participants are forced to select the top line or bottom line as appearing first in each trial, and their selection is thought to be related to gaze location. There is no way for participants to indicate the location of their attention if they are not looking at one of the two images immediately before the lines appear (e.g., if they are looking between the images or at the white space surround the images, their line selection is meaningless). Thus, trials in which the participant was not looking at an image immediately before the lines appeared were removed from the analysis. In total, 10.68% \((N = 280)\) of the trials were invalidated for this reason.

Additionally, before conducting analyses to directly assess hypothesis 2, GEE analyses were conducted to examine whether participants tended to select a particular location of line (top or bottom) or a particular color of line (red or green). Line selection (top or bottom) was the dichotomous outcome variable. Location of the red line (top or bottom), group, pair type, and pair valance were the independent variables. Assuming that the participants did not show a bias for a particular line location (top or bottom) or a particular line color, there should be no significant main effects or interactions. As
predicted, there was no evidence for either of these biases. The participants selected the
top line in 49% of trials (95% C.I. = 46% to 52%). This finding did not vary based on
depression status, $X^2 (1) = 0.07, p = ns$. There was also no significant main effect for red
line location [$X^2 (1) = 3.07, p = ns$] or interaction between group and red line location [$X^2$
(1) = 0.02, $p = ns$]. Thus, line color and line location do not seem to have affected the
participants’ responses.

Additional GEE analyses were conducted to examine whether line location and
gaze location are related (hypothesis 2). Line selection was the dichotomous dependent
variable. Gaze location (looking at the top image versus looking at the bottom image),
group, pair type and pair valance, and the interactions between these variables were
entered as the independent variables. Based upon the hypothesis that line location and
gaze location would be related, a significant main effect for gaze location was expected.
Thus, when participants were looking at the top line they were expected to select the top
line as appearing first and when they were looking at the bottom line they were expected
to select the bottom line as appearing first. There were no significant main effects or
interactions. In trials in which the participants looked at the top image they selected the
top line 52% of the time (95% confidence interval 48% to 56%) and when they look at
the bottom image they selected the top line 48% of the time (95% confidence interval
44% to 52%). If the DOAT worked with way it is envisioned to work, participants should
have selected the top line when they were looking top in nearly 100% of the trials and the
top line when they were looking bottom in none of the trials. Thus, there was no evidence
that gaze location immediately before the lines appeared was related to line selection as
predicted. This finding provides no evidence that the DOAT provides accurate information about gaze location.

A plausible cause of these null effects is that location of the participants’ gaze changed between when the images disappeared and when the lines appeared. If this change in attention occurred, then participants may have selected the first line that they fixated upon as predicted by the DOAT. However, that line may not correspond to the image they were looking immediately before the lines appeared. Thus, the analyses were repeated with only the trials in which the last fixation on the images and first fixation on the lines were congruent (59.38% of the original trials). Again there were no significant main effects or interactions. Participants selected the top lines when looking top in 53% of trials (95% C.I. = 48% to 58%) and they selected the top line when looking bottom in 46% of the trials (95% C.I. = 41% to 51%). Thus, again there was no evidence that the line selection in the DOAT is an accurate representation of where an individual was looking immediately before the lines appear.

To examine whether performance on the DOAT was related to when in the study the participant completed the DOAT (i.e. hypothesis 3), the previous GEE was repeated with task location (i.e. DOAT first, DOAT second, DOAT third) entered as an additional independent variable. There were no significant findings. Thus, there was no evidence that task location affected the results.
Do the participants exhibit an attentional bias?

The remaining research questions dealt with whether the results support Bradley’s sticky mind theory (i.e., that dysphoric participants have difficulty disengaging from negative stimuli) or whether they support the depressive evenhandedness hypothesis (i.e., that control participants show a protective bias). To examine these research questions, each of the tasks was examined individually. Then, analyses were conducted to examine whether performance on the three tasks was correlated.

Traditional dot-probe task results. First, the reaction time results from the dot-probe task were analyzed. GEE analyses were conducted with reaction time (with outliers removed) as the dependent variable, and dot location (dot replaced emotional stimuli vs. dot replaced neutral stimuli), group, pair type and pair valance were entered as dependent variables. There were no significant findings involving group or dot location. Participants did not differ in how quickly they responded to the dot when it replaced an emotional stimulus ($M=581.37, SD=96.71$) versus when it replaced a neutral stimulus ($M=583.58, SE=96.45$), $X^2 (1) = .93, p = ns$. There was also no significant pair valance X dot location interaction [$X^2 (1) = .01, p = ns$] or group X pair valance X dot location interaction [$X^2 (1) = 2.56, p = ns$], which would be expected if either group showed an attentional bias. Thus, immediately before the dots appeared neither group was showing a bias for a particular type of stimulus. However, as described earlier in the discussion participants were faster to respond to the faces than images, $X^2 (1) = 42.67, p < .001$. 
Dot-probe task results with eye-tracking data. To examine whether the above dot-probe findings accurately reflect the location of participants’ attention, additional GEE analyses were conducted with location of gaze immediately before the dot appeared (emotional image vs. neutral image) entered as the dependent variable. Participant group, pair type, and pair valence were entered as independent variables. There were no significant main effects or interactions. Furthermore, examination of the estimated means revealed that none of the participant groups showed an attentional bias. They looked at the emotional image in 52% of the trials (95% C.I. = 50% to 54%).

Thus, the results from the dot-probe task using reaction time and gaze-location both suggest that participants were not showing an attentional bias. At least immediately before the dot appeared, participants, regardless of depression status, were equally likely to be looking at the emotional (both negative and positive) and neutral stimuli.

Traditional DOAT results. To examine group differences in line selection in the DOAT, GEE analyses were conducted with line selection (participant selected the line that replaced emotional stimulus vs. participant selected the line that replaces neutral stimulus) as the dichotomous dependent variable. Participant group, pair type, and pair valence were again entered as independent variables. Additionally, when participants in a DOAT select the line that replaced the emotional stimulus in more than 50% of the trials, it is evidence of an attentional bias. Thus, following the GEE analyses, the estimated means were examined to see if either group of participants showed an attentional bias.4

The GEE analyses revealed a trend toward a three-way interaction between group, pair type and pair valance, \( X^2 (1) = 3.00, p = .08 \). Follow-up GEE analyses were
conducted to better understand this interaction. The depressed group selected the line that replaced the negative stimulus more than the euthymic group for the negative-neutral image pairs, $X^2 (1) = 4.44, p < .05$. Furthermore, the depressed group selected the line that replaced the emotional stimulus in the negative-neutral image pairs significantly more than they selected the emotional stimulus in the positive-neutral image pairs, $X^2 (1) = 5.51, p < .05$. There were no other significant findings based upon the GEE analyses. As shown in table 2, the estimated means revealed that the depressed group selected the negative stimulus in the negative-neutral image pairs significantly more than chance, $p<.05$.

Table 2: Proportion of trials (and 95% confidence intervals) in which the depressed and euthymic participants selected the line that replaced the emotional stimulus in the DOAT.

<table>
<thead>
<tr>
<th></th>
<th>Negative-Neutral</th>
<th>Positive-Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Faces</td>
<td>Image</td>
</tr>
<tr>
<td>Depressed</td>
<td>.54 (.50-.58)</td>
<td>.58 (.53-.63)*</td>
</tr>
<tr>
<td>Euthymic</td>
<td>.52 (.47-.57)</td>
<td>.48 (.40-.56)</td>
</tr>
</tbody>
</table>

Note. * = the mean is significantly different from chance.

DOAT results with eye-tracking. GEE analyses were conducted to examine whether the gaze location immediately before the lines appeared revealed an attentional bias for either of the groups in the DOAT. Location of gaze immediately before the lines appeared (i.e., looking at the emotional stimulus or looking at the neutral stimulus) was entered as a dichotomous dependent variable. Group, pair type and pair valence were
entered as independent variables. Based upon the participants’ responses in the DOAT, it was predicted that the depressed group would tend to look toward the negative stimuli in the negative-neutral image pairs whereas the euthymic group would show no attentional bias.

Inconsistent with the DOAT responses, but consistent with the dot-probe findings, there were no main effects or interactions. Furthermore, participants, regardless of group, looked at the emotional stimulus in 53% of the trials (95% C.I. = 50%-56%). Thus, as shown in Table 3, participants were fairly evenlyhanded in their location of attention. In summary, although the depressed participants tended to select the line that replaced the negative stimulus in the negative-neutral image pairs, participants were equally likely to look at the emotional and neutral stimuli immediately before the lines appeared.

Table 3: Proportion of trials (and 95% confidence intervals) in which the participants were looking at an emotional stimulus immediately before the lines appeared in the DOAT.

<table>
<thead>
<tr>
<th></th>
<th>Negative-Neutral</th>
<th>Positive-Neutral</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Faces</td>
<td>Image</td>
</tr>
<tr>
<td>Depressed</td>
<td>.54 (.49-.68)</td>
<td>.55 (.49-.61)</td>
</tr>
<tr>
<td>Euthymic</td>
<td>.52 (.47-.59)</td>
<td>.57 (.50-.63)</td>
</tr>
</tbody>
</table>

*Note. * = the mean is significantly different from chance.

Eye-tracking Results - Location of first gaze. The next research question was interested in whether the participant groups tended to differ with respect to location of first gaze. GEE analyses were conducted with first gaze location on an image (top or
bottom) as the dichotomous outcome variable. Participant group, emotional stimulus location (top or bottom), pair type, and pair valance entered as the independent variables.

The only significant main effect was for pair type, $X^2 (1) = 4.30, p < .05$. The participants looked at the top image first in 95% (95% C.I. = 92% to 98%) of the face trials and 90% (95% C.I. = 85% to 95%) of the image trials. There were no other main effects or interactions. Overall, in 93% (95% C.I. = 89% to 97%) of the trials, participants, regardless of group, looked at the top image first. Thus, neither stimulus valance nor group membership appear to have affected the location of the first fixation.

_Eye-tracking Results - Average Fixation Duration._ To calculate average fixation length, which was defined as the length of time a participant looked at a particular point on the screen, the last fixation for each trial was removed from the analysis because it may have been truncated by the end of the trial. Then, the total time looking at a particular stimulus in a trial was divided by the total number of fixations on that stimulus. For each trial, two average fixation lengths were calculated for each participant (one for the emotional stimulus and one for the neutral stimulus).

GEE analyses were then conducted to examine whether the groups differed on average fixation duration. Average fixation duration was entered as the continuous predictor variable, and group, pair type, pair valance, and stimulus valance were entered as the independent variables. There was a significant main effect for stimulus type, $X^2 (1) = 49.48, p < .001$. Participants, regardless of group, tended to fixate upon one area of the faces ($M=337.67, SD=111.24$) for longer than the images ($M=246.63, SD=68.19$). There were no other significant effects.
Eye-tracking results - Average Gaze Duration. The next research question dealt with whether the groups differed in how long they spent looking at an image before averting their gaze. For each participant, the average gaze duration for the emotional stimulus and neutral stimulus was calculated for each trial. However, the last gaze location in each trial was not included in the analyses due to the fact that it was truncated by the end of the trial. See Table 6 for a summary of the average gaze durations. GEE analyses were conducted with average gaze time entered as a continuous dependent variable. Group, pair-type, stimulus valence, pair valance, and stimulus type were entered as independent variables.

There was a significant main effect for group, $X^2(1) = 5.54, p < .05$. The euthymic group had longer average gaze times ($M=1186.26, SD = 200.75$) than the depressed group ($M=1051.93, SD=177.67$). There were also significant main effects for pair type, $X^2(1) = 29.86, p < .001$, and stimulus valance, $X^2(1) = 49.85, p < .001$. Average gaze times were longer for the images ($M=1215.50, SD=210.14$) than faces ($M=1022.69, SD=234.22$), and for the emotional stimuli ($M=1119.30, SD=189.31$) than neutral stimuli ($M=977.12, SE=170.08$). Finally, there was a significant three-way interaction between group, pair valance and stimulus valance, $X^2(1) = 5.13, p < .05$. To interpret this interaction, bias scores were calculated for each trial by subtracting the average gaze duration for the emotional stimulus from the average gaze duration for the neutral stimulus. Thus, 60 bias scores were calculated for each participant. GEE analyses were conducted with bias score as the dependent variables, and group and pair valance as the independent variables.
The results of the GEE revealed that the participants showed a larger negative attentional bias than positive attentional bias, $X^2 (1) = 7.13, p < .01$. However, this effect was qualified by a two way interaction between group and pair valance, $X^2 (1) = 4.27, p < .05$. As shown in Figure 1, the depressed group showed less of a positive attentional bias than the euthymic group, $X^2 (1) = 8.47, p < .01$. The groups did not differ with respect to negative attentional biases, $X^2 (1) = .33, p < ns$.

Examination of the estimated means revealed that both the depressed group ($M = 222.48, 95\% C.I. = 121.87$ to $323.09$) and euthymic group ($M = 183.40, 95\% C.I. = 97.47$ to $269.34$) showed a significant negative attentional bias. The euthymic group ($M = 158.97, 95\% C.I. = 71.28$ to $246.67$), but not the depressed group ($M = 4.43, 95\% C.I. = -51.60$ to $60.47$), also showed a significant positive attentional bias.

*Figure 1.* Average positive and negative bias scores (and standard errors) for the depressed ($n=21$) and euthymic ($n=23$) participants.
Are the effects due to anxiety?

Given that the groups differed in anxiety, as well as depression, the analyses that examined attentional biases were repeated after dividing the depressed group into two groups based upon whether they had a comorbid anxiety disorder ($n=10$) or not ($n=11$). As shown in Table 4, the groups also differed on a self-report measure of anxiety. The comorbid group, but not the depressed-only group, scored higher than the euthymic group on the anxious arousal subscale of the MASQ, which measures symptoms of somatic tension and hyperarousal. The two depressed groups did not differ from each other on measures of rumination, and they both scored higher than the euthymic group on these measures. The comorbid group reported being more depressed than the depressed-only group. However, both depressed groups reported being significantly more depressed than the euthymic group. Furthermore, based on the BDI-II manual (Beck et al., 1996), all depressed participants endorsed at least moderate symptoms of depression.
Table 4: Means, standard deviations and one-way ANOVA results for the three groups on measures of depression, anxiety, and rumination.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Euthymic Group Mean (SD) (n=23)</th>
<th>Depressed Only Group Mean (SD) (n=11)</th>
<th>Depressed and Anxious Group Mean (SD) (n=10)</th>
<th>ANOVA results</th>
<th>Partial $\eta^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>BDI-II</td>
<td>5.35 (3.60)$^a$</td>
<td>27.00 (9.14)$^b$</td>
<td>38.20 (10.85)$^c$</td>
<td>$F(2,41)=81.32^{**}$</td>
<td>.80</td>
</tr>
<tr>
<td>GDD</td>
<td>18.74 (4.79)$^a$</td>
<td>41.36 (8.97)$^b$</td>
<td>46.80 (9.29)$^b$</td>
<td>$F(2,41)=70.08^{**}$</td>
<td>.77</td>
</tr>
<tr>
<td>AD</td>
<td>52.91 (7.63)$^a$</td>
<td>77.55 (8.30)$^b$</td>
<td>89.20 (5.39)$^c$</td>
<td>$F(2,41)=98.37^{**}$</td>
<td>.83</td>
</tr>
<tr>
<td>GDA</td>
<td>17.91 (5.04)$^a$</td>
<td>26.00 (8.93)$^b$</td>
<td>36.10 (9.74)$^c$</td>
<td>$F(2,41)=27.39^{**}$</td>
<td>.57</td>
</tr>
<tr>
<td>AA</td>
<td>20.91 (6.20)$^a$</td>
<td>26.82 (10.51)$^{a,b}$</td>
<td>35.50 (10.34)$^b$</td>
<td>$F(2,41)=10.57^{**}$</td>
<td>.34</td>
</tr>
<tr>
<td>RRS</td>
<td>37.30 (11.28)$^a$</td>
<td>62.09 (12.76)$^b$</td>
<td>73.80 (11.28)$^b$</td>
<td>$F(2,41)=39.89^{**}$</td>
<td>.66</td>
</tr>
<tr>
<td>Brooding</td>
<td>5.30 (2.01)$^a$</td>
<td>9.27 (2.65)$^b$</td>
<td>9.20 (2.20)$^b$</td>
<td>$F(2,41)=17.19^{**}$</td>
<td>.46</td>
</tr>
<tr>
<td>Pondering</td>
<td>4.17 (1.67)$^a$</td>
<td>6.27 (2.28)$^b$</td>
<td>6.90 (2.02)$^b$</td>
<td>$F(2,41)=8.88^{**}$</td>
<td>.30</td>
</tr>
</tbody>
</table>

Note. BDI-II = Beck Depression inventory – II; GDD = General Distress Depressive Symptoms subscale of the MASQ; AD = Anhedonic Depression subscale of the MASQ; GDA = General Distress Anxious Symptoms subscale of the MASQ; AA = Anxious Arousal subscale of the MASQ; RRS = Ruminative Responses Questionnaire; Brooding = the brooding subscale of the RRS; and Pondering = the pondering subscale of the RRS. $^{**} = p < .001$. Different superscripts within a row denote that Bonferroni post-hoc analyses revealed that the means were significantly different, $p<.05$.

To gain more confidence that depression, and not anxiety, was driving the results, the analyses described earlier in the results section were repeated with these three groups. However, given the small sample size, the results should be interpreted tentatively.

**Dot-probe results:** The results for the dot-probe task were unaffected by this additional group of participants. When looking at the reaction time results, there was no significant group X pair valance X dot location interaction [$X^2 (2) = 3.36, p < ns$], which would be expected if any of the groups showed an attentional bias. Additionally, there were no other significant effects involving participant group.

Similarly, the eye-tracking results from the dot-probe task failed to reveal any significant effects. The estimated means from the eye-tracking data indicated that the
euthymic group ($M=0.52$, 95% C.I. = 0.48 to 0.55), depressed-only group ($M=0.54$, 95% C.I. = 0.50 to 0.57), and comorbid depressed group ($M=0.53$, 95% C.I. = 0.49 to 0.56) looked at the emotional and neutral stimuli in an evenhanded manner. Thus, keeping with the dot-probe results described earlier in the discussion, none of the groups showed a bias for a particular type of stimulus in the dot-probe task.

**DOAT results:** For the DOAT task, there was a group X pair valance interaction when looking at line selection, $X^2 (2) = 22.37, p < .001$. As shown in Table 5, the depressed-only group showed a negative attentional bias that was significantly larger than the negative attentional biases shown by the other groups ($\beta = 0.43, p < .05$). The three-way interaction between group, pair type and pair valance was nonsignificant, $X^2 (2) = 3.01, p = ns$. The mean bias scores revealed that the depressed only group showed a significant attentional bias for the negative-neutral images ($M = 0.63$, 95% CI = 0.56 to 0.69) and faces ($M = 0.58$, 95% CI = 0.53 to 0.62). The comorbid and euthymic participants did not show an attentional bias for any of the stimuli types.

<table>
<thead>
<tr>
<th></th>
<th>Euthymic</th>
<th>Depressed Only</th>
<th>Depressed and Anxious</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative-Neutral</td>
<td>0.50 (.10)</td>
<td>0.60 (.07)*</td>
<td>0.51 (.06)</td>
</tr>
<tr>
<td>Positive-Neutral</td>
<td>0.50 (.09)</td>
<td>0.45 (.06)</td>
<td>0.53 (.09)</td>
</tr>
</tbody>
</table>

*Note.* * = a proportion that is significantly different from chance (.50).

Despite the group differences in line selection in the DOAT task, the eye-tracking results for the DOAT failed to show any attentional biases. In keeping with the original
analyses, there were no significant findings. All groups showed relative evenhandedness. Thus, although the depressed-only group tended to select the line that replaced the negative stimulus, there was no evidence that they were looking at the negative stimulus immediately before the lines appeared.

**Eye-tracking results:** The results for first gaze location were not associated with the presence of an anxiety diagnosis. There were no main effects or interactions involving group. The euthymic participants looked at the top image in 89% of the trial (95% C.I. = 81% to 97%), the depressed participants look at the top image in 94% of the trial (95% C.I. = 88% to 100%), and the depressed and anxious participants looked at the top image in 97% of the trials (95% C.I. = 94% to 99%).

Similarly, the results for average fixation length were unrelated to anxiety diagnosis. Participants, regardless of group, tended to fixate upon one spot on the faces for a longer time than the images, $X^2 (1) = 43.86, p < .001$. There were no other significant main effects or interactions.

The pattern of results for average gaze duration was largely unrelated to anxiety diagnosis. The average gaze durations are shown in Table 6. GEE analyses with gaze duration bias scores as the dependent measure, and group, pair type, and pair valance as the independent variables, revealed a trend toward a two-way interaction between group and pair valance, $X^2 (2) = 4.60, p = .10$. Examination of the estimated means revealed that all groups showed a negative attentional bias, but only the euthymic group showed a significant positive attentional bias (see figures 1 and 2).
Table 6: Means (and standard deviations) for the average gaze duration for each of the groups.

<table>
<thead>
<tr>
<th></th>
<th>Euthymic (n=23)</th>
<th>Depressed (n=21)</th>
<th>Depressed only (n=11)</th>
<th>Depressed and Anxious (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Negative-Neutral Faces</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>1081.48 (301.41)</td>
<td>988.37 (282.42)</td>
<td>1036.13 (285.13)</td>
<td>932.67 (284.19)</td>
</tr>
<tr>
<td>Neutral</td>
<td>977.07 (228.52)</td>
<td>884.95 (191.05)</td>
<td>905.22 (199.46)</td>
<td>882.02 (187.36)</td>
</tr>
<tr>
<td><strong>Images</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>1275.02 (284.32)</td>
<td>1235.93 (253.97)</td>
<td>1256.42 (234.85)</td>
<td>1220.74 (263.73)</td>
</tr>
<tr>
<td>Neutral</td>
<td>1006.69 (261.18)</td>
<td>892.11 (210.94)</td>
<td>931.60 (255.05)</td>
<td>836.69 (130.25)</td>
</tr>
<tr>
<td><strong>Positive-Neutral Faces</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>1102.60 (259.17)</td>
<td>913.31 (195.91)</td>
<td>954.40 (218.60)</td>
<td>869.97 (144.90)</td>
</tr>
<tr>
<td>Neutral</td>
<td>977.39 (236.10)</td>
<td>925.87 (225.60)</td>
<td>928.51 (220.12)</td>
<td>923.56 (244.70)</td>
</tr>
<tr>
<td><strong>Images</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional</td>
<td>1286.98 (250.44)</td>
<td>1071.45 (214.10)</td>
<td>1137.70 (208.32)</td>
<td>991.98 (227.32)</td>
</tr>
<tr>
<td>Neutral</td>
<td>1092.67 (214.66)</td>
<td>1049.05 (155.45)</td>
<td>1072.24 (105.52)</td>
<td>1037.48 (195.05)</td>
</tr>
</tbody>
</table>

Figure 2. Average positive and negative bias scores (and standard errors) for the depressed-only (n=11) and comorbid depressed and anxious (n=10) participants.
Are the tasks correlated?

Assuming that all three tasks provide information about gaze location, performance on the three tasks should be correlated. Thus, correlations between 1) bias scores on the dot-probe task (i.e., difference between reaction time when the probe replaces a emotional versus neutral image), 2) bias scores on the DOAT (i.e., the proportion of time that the participants select the line that replaces the emotional stimulus), 3) bias scores in average length of gaze in the eye-tracking task (i.e., the difference between the average fixation length on emotional and neutral stimuli) were calculated for the negative-neutral and positive-neutral trials. These scores were predicted to be significantly correlated for the negative-neutral and positive-neutral trials. However, as shown in Table 7, no significant correlations were found.

Table 7: Correlations above the diagonal are correlations between the negative-neutral bias scores and the correlations below the diagonal are correlations between the positive-neutral bias scores.

<table>
<thead>
<tr>
<th></th>
<th>Dot-Probe</th>
<th>DOAT</th>
<th>Eye-tracking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dot-Probe</td>
<td>--</td>
<td>.02</td>
<td>.16</td>
</tr>
<tr>
<td>DOAT</td>
<td>.03</td>
<td>--</td>
<td>.01</td>
</tr>
<tr>
<td>Eye-tracking</td>
<td>.15</td>
<td>.18</td>
<td>--</td>
</tr>
</tbody>
</table>

Note: * = p < .05.
DISCUSSION

*Do the dot-probe task and DOAT accurately measure attention?*

The first goal of the study was to examine whether the dot-probe task and DOAT work the way they are hypothesized to work and provide information about location of attention. Eye-tracking provided direct evidence that participants’ responses in the dot-probe task, but not the DOAT, are related to participants’ location of gaze.

*Dot-probe results.* In the dot-probe task, eye-tracking findings revealed that participants were significantly faster to respond to the dot when it replaced an attended region of the screen than an unattended region of the screen, which is how the dot-probe task is purported to work. Thus, in keeping with previous research (Bradley et al., 2000), this result suggests that reaction time in the dot-probe task can be used to infer where participants are looking immediately before the probe appears.

Although significant, this difference in reaction times is quite small (approximately 17ms), but similar in magnitude to other research projects which have investigated attentional biases using the dot-probe task. A recent meta-analysis looking at attentional biases in the dot-probe task indicated that negative bias shown by anxious participants averaged approximately 17 ms (approximately 15ms for faces and 14ms for images) (Frewen, Dozois, Joanisse, & Neufeld, 2008). Similarly, Joorman and Gotlib (2007) found significant negative bias scores in a dot-probe task with depressed individuals that were all less than 20ms. Thus, the difference between the time it took
participants in the current study to respond to the dot when it replaced an unattended versus attended region of the screen is comparable to other published research findings.

However, despite the evidence that reaction time in the dot-probe task is associated with gaze location, the dot-probe task has some potential limitations that may reduce its utility. First, in a sizable proportion of the trials, participants changed the location of their gaze between when the stimuli disappeared and the dot appeared. These trials may be invalid and likely create measurement error in the data. Additionally, Schmukle (2005) found the dot-probe to have poor internal consistency and test-retest reliability. In Schmukle’s study, participants’ bias scores on the first half of a dot-probe task were unrelated to their bias scores on the second half of the task ($r < .20, p = \text{ns}$). Similarly, time 1 and time 2 bias scores were uncorrelated when participants’ completed a dot-probe task twice, separated by 1 week. Furthermore, the dot-probe task is only able to provide information about where a participant is looking immediately before the dot-appears. It cannot provide information about where participants look over the course of a trial. Thus, although reaction time in the dot-probe task may provide information about gaze location, given these limitations, other methods of measuring attention, like eye-tracking, may be better suited to provide information about attentional biases in depression.

**DOAT results.** Unlike the dot-probe results, eye-tracking did not provide evidence that line selection in the DOAT reflects gaze location. If the DOAT worked the way it is hypothesized to work, participants should have selected the top line as appearing first
when they were looking at the top image immediately before the lines appeared. Similarly, they should have selected the bottom line as appearing first when they were looking at the bottom image immediately before the lines appeared. There was no evidence of this relationship. Participants selected the lines at chance no matter where they were looking immediately before the lines appeared.

Furthermore, in approximately 11% of the trials, participants were not looking at an image immediately before the lines appeared (e.g., they were looking at the center of the screen or the white space surrounding the images). Because the DOAT only allows participants to provide information about whether they were looking at the top image (i.e., by selecting the top line as appearing first) or the bottom image (i.e., by selecting the bottom line as appearing first), line selection in these trials is meaningless. Moreover, these invalid trials are impossible to detect without using eye-tracking. However, even the valid trials did not reveal a relationship between gaze location and line selection. Thus, based on the results of this study, there is no evidence that participants’ responses in the DOAT corresponded to gaze location.

However, the addition of eye-tracking to the DOAT and dot-probe task may have affected participants’ performance. Specifically, in the DOAT, knowledge that their eye-movements were being monitored may have allowed participants in the current study to infer that line selection was thought to be related to gaze location. This knowledge may have affected the line selection results. For example, rather than selecting which line they were looking at and truly believed appeared first, participants may have selected the line
they thought they should select as appearing first because it corresponded to the image that was most interesting to them. Research comparing DOAT performance when participants know their eye-movements are being monitored to performance when participants are unaware that their eye-movements are being monitored is required to understand whether the eye-tracking component of the study affected participants’ performance. However, if future research corroborates the finding that gaze location and line selection are unrelated, one might be better abandoning the DOAT and using a more reliable and sophisticated measure of attention to understand attentional biases in depression.

*Do depressed individuals show a negative attentional bias?*

The second part of the study examined whether depressed and euthymic individuals differ with respect to attention for emotional stimuli.

*Dot-probe task results.* In the dot-probe task, participants’ reaction times did not vary as a function of whether the dot replaced an emotional or neutral stimulus. Thus, participants did not show an attentional bias. This finding was further validated by the eye-tracking results in the dot-probe task. Immediately before the dot appeared, all participants were equally likely to be looking at the emotional and neutral stimuli. This finding is fairly consistent with the existing literature. Although a few studies have found a negative attentional bias using the dot-probe task when information was presented for greater than 500ms (e.g., Mogg, Bradley, & Williams, 1995; Mathews, Ridgeway, &
Williamson, 1996), others have not (e.g., MacLeod et al., 1986; Neshat-Doost et al., 2000; Taghavi et al., 1999). Furthermore, in keeping with Bradley’s sticky mind theory, eye-tracking research generally suggests that depressed and euthymic participants differ in average gaze duration on negative information, not location of attention at a particular point in time (e.g. Caseras et al., 2007; Eizenman et al., 2003). Thus, given that the dot-probe task can only provide a snap-shot of attention, one would not necessarily expect to find differences between the depressed and euthymic participants’ gaze location using the dot-probe task.

**DOAT results.** The line selection results from the DOAT were inconsistent with the dot-probe task results. In the DOAT, the depressed participants were more likely to select the line that replaced the negative image than the line that replaced the neutral image. Based upon the assumption that line selection is related to gaze location in the DOAT, this result suggests that immediately before the lines appeared, the depressed participants were more likely to look at the negative images than neutral images. However, the eye-tracking results failed to support this hypothesis. As described earlier, line selection was unrelated to gaze location. Furthermore, in keeping with the dot-probe results, eye-tracking results revealed that, in the DOAT, participants did not tend to look at a particular type of image immediately before the lines appeared. Thus, the bias for selecting the line associated with the negative stimulus shown by the depressed participants does not appear to reflect gaze location.
Future research is required to understand what caused the depressed group to tend to select the line that replaced the negative stimulus. However, during the debriefing several depressed participants indicated that they did not know which line was appearing first in the DOAT, so they selected the line that replaced the image that was “most interesting to them,” or “most like their mood.” Thus, this negative bias may have occurred at a later stage of information processing than attention. For example, compared to euthymic individuals, the depressed individuals may have a tendency to think about the negative stimuli even when they are not looking at them. This hypothesis fits with previous research findings which have indicated that depressed individuals tend to ruminate upon or brood about negative information more so than euthymic individuals (e.g., Nolen-Hoeksema, 1991; Joormann, Dkane, & Gotlib, 2006).

Interestingly, the line selection results from the DOAT did not replicate the findings in previous DOAT studies, which provided support for the depressive evenhandedness hypothesis in that depressed individuals generally show no attentional bias and the control participants show a protective bias away from the negative stimuli (Gotlib et al., 1988; McCabe & Gotlib, 1995; McCabe & Toman, 2000; Rytwinski & Fresco, 2009b). Again, the reason for the discrepancy between the current study and previous DOAT studies is unknown. However, as described earlier in the discussion, the knowledge that their eye-movements were being monitored may have affected the participants’ performance in the DOAT.
Eye-tracking task results: Consistent with previous research findings (Caseras et al., 2007; Kellough et al., 2008; Mogg et al., 2000), the eye-tracking task results revealed that the participants did not differ in the direction of their initial shift of gaze. Participants looked at the top image first in nearly all of the trials. Thus, unlike anxious participants (Bar-Haim et al., 2007), depressed participants do not appear to immediately orient toward a particular type of stimulus. Furthermore, in keeping with Kellough and colleagues’ (2008) findings, the groups did not differ in average fixation durations. Instead, the participants differed in how long they continued to look at a particular type of image (i.e., gaze duration).

In terms of gaze duration, in the positive-neutral pairs, the euthymic group, but not the depressed group, showed a bias for the positive stimuli. Previous eye-tracking research has found mixed for a positive bias amongst euthymic individuals. For example, Caseras et al. (2007) found that both the dysphoric participants and euthymic participants showed a significant positive attentional bias. However, Caseras et al. only looked at first gaze duration, not average gaze duration. Thus, the differences between groups may not arise until participants have looked at both stimuli. Other researchers have found evidence to support the finding that depressed and euthymic participants differ with respect to attention to positive information. Eizenman et al. (2003) and Kellough et al. (2008) found a positive bias amongst euthymic participants. The euthymic participants in their studies looked at the positive stimuli longer than the negative and neutral stimuli. In the current study, the euthymic participants looked at the negative and positive stimuli for
an equal amount of time, but more than the neutral stimuli. The difference between the current study and these previous research studies may again be due to methodological differences between the studies. For instance, in Eizenman et al.’s and Kellough et al.’s studies, participants saw four images (a negative, a neutral, a social, and a threatening image) at a time. In the current study participants either saw a negative image paired with a neutral image or a positive image paired with a neutral image. Participants were never shown a negative image paired with a positive image. Thus, the negative and positive gaze durations in the current study represent how long a participant continued to look at the stimulus when their other option was to look at a neutral stimulus. If they had been presented with positive-negative trials, the euthymic group may have looked at the positive stimuli longer than the negative stimuli. Thus, future research with negative-positive image pairs is needed to further understand how depressed and euthymic participants differ with respect to gaze duration. However, based on the previous research findings, euthymic participants are predicted to show a positive attentional bias relative to both negative and neutral stimuli.

Additionally, in the current study, both the depressed and euthymic participants showed a significant negative attentional bias. They looked at the negative stimuli longer than the neutral stimuli. Again this finding is somewhat discrepant from previous research findings. For example, both the dysphoric and euthymic participants in Caseras et al.’s (2007) study showed a negative attentional bias for the negative-neutral pairs. However, the dysphoric group in their study showed a negative attentional bias that was
significantly (88ms) larger than the negative attentional bias shown by the euthymic group. Similarly, in Eizenman and colleagues’ (2003) and Kellough and colleagues’ (2008) studies, the depressed and euthymic participants looked at the negative stimuli longer than the neutral stimuli. However, this effect was larger for the depressed than euthymic participants. Although nonsignificant, the results from the current study were in the same direction. The bias shown by the depressed group was on average approximately 40 ms larger than the bias shown by the euthymic group. In summary, based upon the existing literature and the results of the current study, it appears that both depressed and euthymic participants tend to look at negative stimuli longer than neutral stimuli. However, this effect may be more pronounced for the depressed relative to euthymic participants.

*Why do these group differences exist?* None of the three prevailing models that have been developed to predict attentional bias in depression (i.e., Beck’s theory, Bradley’s sticky mind theory, or the depressive evenhandedness hypothesis) can fully account for the findings in this study. Consistent with previous research (Mogg & Bradley, 2005), Beck’s theory does not appear to explain the attentional biases that were shown by the participants because neither group appeared to immediately orient towards one particular type of stimulus. Additionally, there was no evidence of depressive evenhandedness because the depressed participants showed a bias for the negative stimuli. Finally, Bradley et al.’s theory cannot account for the positive bias shown by the euthymic participants.
However, research on rumination and depression may be able to provide a parsimonious explanation for the results. As compared to euthymic individuals, depressed individuals tend to ruminate or brood upon negative information (e.g., Brinker & Dozios, 2009; Nolen-Hoeksema, 1991, Treynor et al., 2003). Furthermore, depressive rumination is associated with the onset (Just & Alloy, 1997), deteriorating course (Kuehner & Weber, 1999), chronicity (Nolen-Hoeksema, 1991), and duration of a depressed mood (Just & Alloy, 1997).

Recent research has also begun to investigate how depression is related to the processing of positive information. Depression is related to a decreased responsiveness to positive, but not negative stimuli (Sloan, Bradley, Dimoulas, & Lang 2002) and to reward, but not punishment (Henriques, & Davidson, 2000). Furthermore, dysphoric individuals tend to suppress positive emotions (Bryant, 2003; Min’er & Dejun, 2001). Finally, decreased positive rumination and increased dampening of positive emotions have been correlated with increased symptoms of depression (Feldman, Joormann, & Johnson, 2008).

Thus, if future research corroborates the prediction that euthymic individuals show a positive attentional bias when presented with positive-negative stimulus pairs and depressed individuals show a larger negative attentional bias than euthymic individuals, the combination of increased negative rumination and decreased positive rumination amongst depressed individuals could account for these results. Negative rumination may cause depressed individuals to favor the negative stimuli, and positive rumination may
cause euthymic individuals to favor the positive stimuli. Future research examining whether positive and negative rumination are related to attention to emotional stimuli might provide a better understanding of the psychological cause of these biases.

*Are the findings due to anxiety?*

Given that the depressed group endorsed higher levels of depression and anxiety symptoms as compared to the euthymic group, and that anxiety is related to a negative attentional bias (Bar-Haim et al., 2007), it was important to examine whether anxiety could account for any of the attentional biases that were found in this study. Thus, the depressed group was divided into two groups based upon whether or not they had a comorbid anxiety disorder. Although the results should be interpreted cautiously given the small sample sizes, anxiety does not appear to account for the results. With respect to average gaze duration, both depressed groups showed a significant negative attentional bias and neither group showed a significant positive attentional bias.

*Correlations between the paradigms*

If the dot-probe task, DOAT and eye-tracking were all measuring the same thing, bias scores on the three tasks (i.e., reaction time on the dot-probe task, line selection on the DOAT and gaze duration in eye-tracking) should be correlated. However, there were no significant correlations between the tasks. Based upon the eye-tracking results from the dot-probe task and DOAT, this result was not surprising. Line selection on the DOAT
was unrelated to gaze location. Thus, it was not expected to be correlated with the other two tasks which provide accurate information about gaze location. Furthermore, dot-probe reaction times were related to gaze location. However, they only provide a snapshot of attention. Given that depressed and euthymic participants appear to differ with respect to gaze duration and not gaze location at a particular point in time, it was not surprising that gaze duration was uncorrelated with dot-probe bias scores.

**Limitations and Future directions**

The results of this study provide information about the validity of the dot-probe task and DOAT and about how depressed individuals attend to emotional stimuli differently than euthymic individuals. Yet, much work is needed to fully understand attentional biases in depression. In addition to the ideas for future research mentioned in the discussion, the following areas of research may contribute to our understanding of attentional biases associated with depression:

First, the current study, as well as the four other published eye-tracking studies (Caseras et al., 2007; Eizenman et al., 2003; Kellough et al., 2008; Matthews & Antes, 1992) contained predominantly young, Caucasian, female participants. This lack of diversity may limit generalizability to other populations. Thus, replication with more diverse samples is needed.

Secondly, eye-tracking, although informative, only provides information about where a participant is looking at a particular point in time (i.e. overt attention). Generally,
shifts in overt attention follow shifts in covert attention (Klein et al., 1992; Kowler et al., 1995). However, covert attention can change without shifting overt attention (Hoffman, 1998). For example one can stare at this manuscript and be totally unaware of what one is seeing because thoughts about the weekend occupy one’s attention. Thus, future research is needed to investigate possible differences between depressed and euthymic individuals in terms of both covert and overt attention.

Thirdly, an understanding of the neural correlates associated with differences in gaze duration between depressed and euthymic individuals is needed. The amygdala, dorsolateral prefrontal cortex (DLPFC), and the subgenual or ventral anterior cingulate cortex (ACC), all parts of the limbic system, have been implicated in the emotional dysregulation seen amongst depressed individuals (Gotlib & Hamilton, 2008), and they may play a role in the attentional biases described in this study. The amygdala appears to play a role in identifying emotional aspects of information (Gallagher & Chiba, 1996; LeDous, 1993, 1996), and depressed participants evidence amygdala hyperactivation in response to negative stimuli (Abercrombie et al., 1998; Drevets, 1999). This hyperactivation has been hypothesized to be caused by decreased inhibition from the dorsolateral prefrontal cortex (DLPFC) (Davidson, 2000). Depressed individuals, particularly those participants with high levels of rumination, show decreased DLPFC and increased amygdala activation 30 seconds after being exposed to a negative stimulus and completing distraction task (Siegle, Steinhauer, Thase, Stenger, & Carter, 2002). Thus, amygdala hyperactivity and DLPFC hypoactivity may account for the difficulties
that depressed individuals experience in attempting to disengage from negative information and contribute to a negative attentional bias. In addition to the amygdala and DLPFC, the subgenual ACC may mediate reactions to negative stimuli. Gotlib et al. (2005) found depressed individuals to have greater subgenual ACC activation in response to emotional stimuli than healthy controls. Thus, all three of these systems may be involved in the negative attentional biases shown by depressed individuals. There is less research on whether these systems are related to the processing of positive information. One study found that depressed individuals have decreased amygdala activity, relative to euthymic individuals, when shown positive words (Canli et al., 2004). However, another study found increased amygdala activity amongst depressed individuals when shown positive faces (Sheline et al., 2001). Additionally, Schaefer, Putnam, Benca, and Davidson (2006) found that depressed individuals have diminished reactivity of the DLPFC in response to positive emotional faces. Thus, it is unclear how/if depressed individuals differ from euthymic individuals in the way they process positive information. Further research may provide information about which brain systems account for the attentional biases shown by depressed and euthymic individuals and how these brain systems may interact with each other to cause attentional biases in depression.

Finally, to date, all of the published eye-tracking studies examining attentional biases in dysphoric (Caseras et al., 2007; Matthews & Antes, 1992) and depressed (Eizenman et al., 2003; Kellough et al., 2008) individuals have been correlational in nature. Thus, prospective studies and studies using experimental manipulations are
needed to understand how attentional biases are related to depression. Once the attentional biases shown by depressed individuals are better understood, this knowledge could have some important practical implications. For example, if attentional biases are related to the onset of a depressive episode, then screening for attentional biases could detect which individuals are at risk of developing depression. Furthermore, attentional training could potentially reduce symptoms of depression. Studies of participants with generalized anxiety disorder (Amir, Beard, Burns, & Bomyea, 2009) and generalized social anxiety disorder (Schmidt, Richey, Buckner, Timpano, 2009) have demonstrated that teaching participants to look away from threat-related stimuli using a computer task can reduce negative attentional biases and symptoms of psychopathology. Although, no studies have examined attentional training for individuals with depression using visual stimuli, there is some evidence that attentional training can reduce symptoms of depression. Siegle, Ghinassi, and Thase (2007) taught depressed participants to perform two tasks which required attentional control (i.e., focusing on neutral sounds in the environment and doing a mental addition task). They found that the attentional training was associated with decreased symptoms of depression and changes in the physiological mechanisms underlying depression. Thus, it would be interesting to examine whether training depressed individuals to look away from negative and toward positive stimuli could also reduce symptoms of depression.
Conclusions

In summary, eye-tracking demonstrated that participants’ responses in the dot-probe task, but not the DOAT, are related to gaze location. However, given that depressed individuals do not automatically orient towards one type of stimulus and that the dot-probe task can only provide a snapshot of attention, eye-tracking may be a better technique to use to understand attentional biases in depression.

Eye-tracking revealed that depressed and euthymic participants differed with respect to average gaze duration. The euthymic participants showed an emotional attentional bias. They looked at both the negative and positive stimuli longer than the neutral stimuli. The depressed participants showed a negative attentional bias. They looked at the negative stimuli longer than the neutral stimuli. Future research is needed to understand the cause and time course of these differences. However, this area of research may have important implications in our understanding of the etiology and treatment of depression.
REFERENCES


presented at the Annual Meeting of the Society for Research in Psychopathology, Madison, WI.


The emotional Stroop task (MacLeod, 1991) is another paradigm that is commonly used to assess attentional biases in depression. Results from studies using the emotional Stroop task generally indicate that depressed individuals show a negative attentional bias and people who are not depressed do not show an attentional bias (e.g., Mogg and Bradley, 2005). However, it is not clear whether color-naming interference reflects competition at the input (attentional) stage or at the output or response selection stage (MacLeod, 1991). Thus, this task will not be discussed in this paper as the purpose of this paper is to examine attentional biases in depression.

The analyses were repeated with the participants divided into groups based upon BDI-II scores. Participants who scored less than 14 on the BDI-II ($n = 39$) were placed in the euthymic group and those who scored 14 or more on the BDI-II were placed in the dysphoric group ($n = 27$). Although somewhat attenuated, the results were similar to those presented in the document for the depressed and euthymic participants. For example, the results for gaze duration bias scores revealed a trend toward a 2-way interaction between group and pair valance, $X^2 (1) = 2.04$, $p < .15$. The euthymic group showed a significant bias for the negative-neutral ($M = 106.75$, 95% $C.I. = 132.03$ to 261.46) and positive-neutral ($M = 117.03$, 95% $C.I. = 47.98$ to 186.08) stimulus pairs. The depressed group showed a significant attentional bias for the negative-neutral stimulus pairs ($M = 211.23$, 95% $C.I. = 126.90$ to 295.55) but not the positive-neutral stimulus pairs ($M = 26.53$, 95% $C.I. = -20.53$ to 73.11). Please consult the author for further information.

Although GEE analyses have advantages over ANOVA-based analyses, ANOVAs have traditionally been used to analyze dot-probe data. Thus, this analysis was repeated using a repeated-measures ANOVA. Again, reaction time was the outcome variable, group was the between-subjects factor, and pair-type, pair valence, and dot location were the within-subjects variables. Consistent with the GEE findings, the only significant effect was a main effect for image type, $F(1,42) = 40.67$, $p > .001$, partial $\eta^2 = .49$. Again, participants were faster to respond to the dot when it replaced a face than when it replaced an image. Please consult the author for more information.
DOAT data has traditionally been analyzed using an ANOVA framework. Thus, the analyses were repeated using a repeated-measures ANOVA. The dependent variable was the percent of trials in which a participant selected the line that replaced an emotional stimulus. Thus, a percent significantly greater than 50% suggests that there is a bias toward emotional stimuli. A bias significantly less than 50% suggests a bias away from emotional stimuli. Group was the between subjects factor and pair type and pair valance were entered as within subjects variables. The results were equivalent to the GEE findings. There was a trend towards a significant 3-way interaction between group, pair type and pair valance, \( F(1,42) = 3.17, p=.08, \text{ partial } \eta^2 = .07 \). This interaction was examined and the pattern of findings was equivalent to the GEE findings. Please contact the author for further information.
APPENDIX: STIMULI
### Negative Stimuli

<table>
<thead>
<tr>
<th>Negative-Neutral Image Pairs</th>
<th>Stimulus Set 1</th>
<th>Stimulus Set 2</th>
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**Note.** Stimuli that are numbers (e.g., 2710) are from the IAPS stimuli set; Stimuli that begin with “B” (e.g., B8) are from Baumgartner’s (2006) stimuli set; Stimuli that begin with AF or BF (e.g., AF12SAS) are from the Karolinska Face set; the other stimuli (e.g., 01FSA_C) are from the NimStim Face set.
### Positive Stimuli

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