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BRIEF REPORT

Attention to Emotional Images in Previously Depressed Individuals: An Eye-Tracking Study

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Abstract Depression and dysphoria are associated with attention and memory biases for emotional information (Williams et al. 1997; Yiend in Cogn Emot 24:3–47, 2010), which are postulated to reflect stable vulnerability factors for the development and recurrence of depression (Gotlib and Joormann in Annu Rev Clin Psychol 6:285–312, 2010). The present study looked for evidence of attention and memory biases in individuals with a self-reported history of depression, compared to individuals with dysphoria and individuals with no history of depression. Participants viewed sets of depression-related, anxiety-related, positive, and neutral images while their eye fixations were tracked and recorded. Incidental recognition of the images was assessed 7 days later. Consistent with previous studies (Kellough et al. in Behav Res Therapy 46:1238–1243, 2008; Sears et al. in Cogn Emot 24:1349–1368, 2010), dysphoric individuals spent significantly less time attending to positive images than never depressed individuals, and it was also found that previously depressed individuals exhibited the same attentional bias. Previously depressed individuals also attended to anxiety-related images more than never depressed individuals. A bias in the initial orienting of attention was observed, with previously depressed and dysphoric individuals orienting to depression-images more frequently than never depressed participants. The recognition memory data showed that previously depressed and dysphoric individuals had poorer memory than never depressed individuals, but there was no evidence of a memory bias for either group. Implications for cognitive models of depression and depression vulnerability are discussed.

Keywords Depression · Attention · Depression vulnerability · Eye movements · Recognition memory

Introduction

Much of the research examining cognition in depression has been motivated by cognitive schema models (Beck 1976; Beck and Clark 1988) and cognitive theories of depression vulnerability (e.g., Ingram et al. 1998; Teasdale 1988). According to these models, biases in the processing of emotional information underlie the disorder and contribute to the development, maintenance, and recurrence of depressive episodes. A key prediction is that depressed individuals will selectively attend to and remember negative stimuli and will ignore or reduce their attention to positive stimuli. Consistent with this prediction, three decades of research has established that both depression and dysphoria are associated with biased attention and memory for negative and positive information (for reviews, see Gotlib and Joormann 2010; Mogg and Bradley 2005; Williams et al. 1997; Yiend 2010). An equally important prediction of cognitive models is that individuals who have recovered from depression will continue to exhibit attention and memory biases. These models assume that attentional biases are trait-like characteristics of individuals vulnerable to depression, and should therefore be present in recovered

Portions of these data were presented at the 20th annual meeting of the Canadian Society for Brain, Behavior, and Cognitive Science (Halifax, Nova Scotia, June 2010) and at the 72nd annual meeting of the Canadian Psychological Association (Toronto, Ontario, June 2011). The materials used in the study are available from the authors upon request.

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individuals not experiencing a depressive episode. For many researchers, attentional biases are thought to play a crucial role in maintaining a vulnerability to depressive episodes (e.g., De Raedt and Koster 2010; Gotlib and Joormann 2010; Koster et al. 2011). The alternative possibility—that attentional biases are state-like characteristics of depressed and dysphoric mood that do not persist beyond a depressive episode—would have important implications for all theoretical accounts of depression.

Researchers have used a variety of methods to study attention in depressed and dysphoric individuals, including the emotional Stroop task, spatial cueing tasks, visual search tasks, and the dot-probe task (see Yiend 2010). Several of these tasks have also been used to look for evidence of attentional biases in previously depressed individuals. Using a Stroop task, Gotlib and Cane (1987) found that a group of depressed patients had longer colour naming latencies to negative content words while they were experiencing depressive episodes but not when they had recovered. Similar results were reported by Gilboa and Gotlib (1997) and Hedlund and Rude (1995). Using a visual search task, Wenzlaff et al. (2001) found that previously depressed individuals performed similarly to non-depressed individuals, identifying more positive than negative words. However, when placed under a cognitive load with an additional task, previously depressed individuals performed similarly to depressed individuals and identified more negative than positive words. Wenzlaff et al. interpreted this finding as evidence of a latent attentional bias that emerged only when the processing demands of the task interfered with previously depressed individuals' ability to suppress negative thoughts.

The Wenzlaff et al. (2001) study highlights a complication for researchers looking for evidence of trait-like attentional biases in recovered depressed individuals. Although cognitive models presume that biases in attention and memory are stable vulnerability factors that endure beyond depressive episodes, researchers have argued that these biases cannot always be expected to be observed in recovered depressed individuals (Just et al. 2001; Mathews and MacLeod 2005). For one, it is possible that treatment for depression affects the depression itself as well as the biases that were etiologically important in precipitating and maintaining it. If so, recovered depressed individuals will likely be heterogeneous with respect to their attention and memory biases, making differences between recovered depressed and never depressed individuals potentially difficult to discern. In addition, as Scher et al. (2005) and others have pointed out, attentional biases may be latent and unexpressed until activated by stressors or negative moods, in which case they will be observed only under special conditions. In fact, in a number of studies differences between previously depressed and never depressed individuals were observed only when previously depressed individuals experienced a negative mood induction.

For example, Ingram et al. (1994) used a dichotic listening task to assess the automatic processing of emotional material by never depressed and remitted depressed participants. In this task, participants are instructed to attend to a target message presented in one ear while simultaneously ignoring distractor stimuli presented in the other, "unattended" ear; when distractor stimuli capture attention, the tracking of the target message is interrupted and tracking errors result (a form of attentional interference). Ingram et al. (1994) found that for previously depressed and never depressed participants both positive and negative distractor words produced attentional interference, with no differences between the groups in the magnitude of the interference effects. When participants were exposed to a negative mood induction, however, previously depressed participants exhibited larger interference effects for both positive and negative distractors. A similar outcome was reported by McCabe et al. (2000) using the deployment of attention task, which measures the allocation of attention toward or away from positive and negative stimuli. McCabe et al. (2000) found that previously depressed participants, like never depressed participants, directed their attention away from negative words in a neutral mood induction condition. In contrast, in a negative mood induction condition, previously depressed participants did not exhibit this "protective bias" in their attentional allocation and instead attended equally to negative and neutral words, much like currently depressed individuals (McCabe and Gotlib 1995). These and other findings suggest that, at least for some tasks, a negative mood induction or other stressor may be necessary to elicit an attentional bias in vulnerable individuals (Scher et al. 2005).

One recent study, which did not employ a negative mood induction, did find that previously depressed individuals attended to emotional stimuli differently than never depressed individuals (Joormann and Gotlib 2007). Joormann and Gotlib used a dot-probe task to look for attentional biases in the processing of emotional faces in depressed and previously depressed individuals. On each trial a neutral face was paired with either a happy or sad face and the pair was presented for 1,000 ms. Participants responded to probes that were presented in the location of the emotional or neutral face following the offset of the faces; faster responding to probes presented in the location of an emotional face was taken as evidence of an attentional bias. Joormann and Gotlib found that both depressed and previously depressed individuals selectively attended to sad faces, whereas never depressed individuals avoided sad faces and oriented to happy faces. The fact that depressed and previously depressed individuals exhibited similar attentional biases is consistent with cognitive

models that predict that these biases are not merely symptoms of depression but instead reflect stable individual differences in attention to emotional information. Of course, given the presentation duration used in their study (1,000 ms), Joormann and Gotlib's results may be most relevant to the ability of sad faces to capture the attention of depressed and previously depressed individuals.

Previous Eye-Tracking Studies

In the present study we looked for evidence of attentional biases in previously depressed individuals using an eye-tracking paradigm in which participants' gaze is continuously recorded while they view emotional images. A major advantage of this paradigm is that it can provide a continuous record of the allocation of attention over an extended interval of time while multiple stimuli compete for attention. Only a few studies have used eye gaze tracking to examine the allocation of attention to emotional images and none have compared depressed or dysphoric individuals to at-risk individuals with a history of depression. For example, Eizenman et al. (2003) tracked the eye movements of a small group of depressed individuals ($n = 8$) and a matched group of non-depressed individuals ($n = 9$) while they examined eight different slides, each slide consisting of four different images (an image with a neutral theme, an image with a dysphoric theme, an image with a threatening theme, and an image with a positive/social theme). The participants examined the images in any manner they wished throughout a 10.5-s presentation time. Kellough et al. (2008) conducted a similar study using the same image types; depressed and non-depressed individuals viewed sets of four images over a longer period (30 s) so that the researchers could examine changes in the allocation of attention over time.

The results of these previous eye-tracking studies have shown that depressed and dysphoric individuals attend to emotional images differently than non-depressed individuals. Two studies have found that depressed individuals spend significantly more time viewing negative images than non-depressed individuals (Eizenman et al. 2003; Kellough et al. 2008). For positive images the results have been mixed. Whereas Eizenman et al. reported that depressed and non-depressed individuals did not differ in their attention to positive images, Kellough et al. found that depressed individuals attended to positive images less than non-depressed individuals. For the studies comparing dysphoric and non-dysphoric individuals the results have also been somewhat inconsistent. Mathews and Antes (1992) found that dysphoric individuals attended more to "sad" regions of complex images composed of spatially separate "sad" and "happy" regions (e.g., a picture of a flower next to a skull), whereas Sears et al. (2010) found that dysphoric individuals did not attend to depression-related images any differently than non-dysphoric individuals. Sears et al. also found that dysphoric individuals attended to positive images less than non-dysphoric individuals and Mathews and Antes reported a similar result. A recent study by Ellis et al. (2010) examined dysphoria-related differences in the distribution of attention to a 2×2 matrix of dysphoric, aversive, positive, and neutral words over a 10 s interval. Ellis et al. found that dysphoric and non-dysphoric individuals differed only in their attention to positive words: dysphoric individuals spent significantly less time viewing positive words than non-dysphoric individuals. Similarly, in another recent eye-tracking study that presented sets of sad, happy, angry, and neutral faces, it was also found that dysphoric and non-dysphoric individuals differed only in their attention to happy faces (Leyman et al. 2011). Taken together, the results of these studies support the conclusion that positive stimuli do not engage the attention of depressed and dysphoric individuals as strongly as they do for non-dysphoric individuals, consistent with one of the predictions of cognitive models of depression.

The Present Study

Eye gaze tracking has proved to be an important tool for the study of attentional biases in depressed and dysphoric individuals, but researchers have yet to use it to look for attentional biases in previously depressed individuals. The key question is whether those who have recovered from depression exhibit attentional biases like depressed/dysphoric individuals or whether these biases are present only for those currently experiencing a depressive episode. If attentional biases in previously depressed individuals are observed, then this would be consistent with the view that the biases are trait-like characteristics of individuals vulnerable to depression. In the present study, we used an eye-tracking paradigm similar to that of Kellough et al. (2008) and Sears et al. (2010) to compare attention to emotional images in previously depressed individuals, dysphoric individuals, and never depressed individuals. Like Joormann and Gotlib (2007), we did not use a negative mood induction or other stressor designed to activate a negative schemata, and therefore our study was likely a conservative test for attentional biases in the previously depressed. Participants viewed sets of emotional and neutral images while their eye fixations were tracked and recorded throughout a 10-s trial. We also looked for evidence of memory biases by assessing participants' subsequent recognition of the images. While a number of studies have reported mood-congruent memory biases for emotional material using recall tasks, the evidence for memory biases in recognition memory tasks is sparse and less convincing

(e.g., Ellis et al. 2010; Sears et al. 2010; White et al. 2009). Our study was unique in that we administered an incidental recognition memory test 7 days after participants viewed the images (i.e., participants were not asked to study the images and the memory test was not mentioned). Our specific research questions were as follows: (1) Would previously depressed individuals attend to depression-related images and positive images differently than never depressed individuals? (2) Would previously depressed individuals attend to depression-related images and positive images differently than dysphoric individuals? (3) Would there be differences between previously depressed, never depressed, and dysphoric individuals in their recognition memory for emotional images?

Method

There were three groups of participants in the study: a never depressed group, a previously depressed group, and a dysphoric group. Participants viewed four types of images on each trial (depression-related, anxiety-related, positive, and neutral), one of each type, similar to the procedure used by Kellough et al. (2008) and Sears et al. (2010). Throughout the 10-s trial the number of eye fixations to each image and the amount of time spent looking at each image were recorded.

Participants

Participants were recruited via an online research participation system for undergraduate students at the University of Calgary and through campus advertisements seeking individuals with a history of depression. To control for gender only females were recruited. Participants volunteered to participate in the study in exchange for extra course credit or a payment of $20.00 (CAN). A total of 169 individuals participated in the study, with the final sample consisting of 77 individuals: 38 in the never depressed group, 15 in the previously depressed group, and 24 in the dysphoric group.

Measures

Participants completed the Beck Depression Inventory (BDI-II; Beck et al. 1996), the Positive and Negative Affect Scale (PANAS; Watson et al. 1988), the Beck Anxiety Inventory (BAI; Beck and Steer 1993), the State-Trait Anxiety Inventory (STAI; Spielberger et al. 1983), and a demographics questionnaire that included questions about previous episodes of depression, experiences with psychotherapy and antidepressant use, and recent mood. The PANAS was used to provide additional information on participants' pleasant and unpleasant mood states. It consists of 20 words that describe different emotions (e.g., excited, proud, upset, guilty, distressed); participants read each word and indicate "to what extent you have felt this way", using a scale from 1 (*very slightly or not at all*) to 5 (*extremely*). These same 20 words were rated for two time frames: "during the past few days" and "during the past few weeks". For the 10 positive affect items and for the 10 negative affect items the minimum score is 10 and the maximum score is 50.

We created a self-report inventory using the criteria for major depressive episode (Axis I) listed in the Diagnostic and Statistical Manual for Mental Disorders IV (DSM-IV-TR; American Psychiatric Association 2000) to assess participants' prior depressive episodes. The inventory consisted of eight questions that inquired about past depressive symptomology. Each question was framed as follows: "Over the past 2 years, how many times have you experienced [DSM-IV criterion] for most of the day, nearly every day, for at least 2 weeks?". For example, item 1 read "Over the past 2 years, how many times have you experienced a depressed mood (feeling sad or empty, being tearful) for most of the day, nearly every day, for at least 2 weeks?"; item 2 read "Over the past 2 years, how many times have you experienced fatigue or loss of energy for most of the day, nearly every day, for at least 2 weeks?". For each item the response options were "*never*", "*once*", "*twice*", "*three times*", or "*more than three times*". To be classified as "previously depressed" a participant had to meet DSM-IV criteria for an episode of major depression during the past 2 years. More specifically, a participant had to meet one of the two required symptoms for depression (i.e., a depressed mood or diminished interest or pleasure in all or most activities) plus an additional three criteria (e.g., insomnia or hypersomnia).

Participants were assigned to groups based on their responses on the self-report inventory and their BDI scores (similar to the procedures used by Harkness et al. 2010; Wenzlaff et al. 2001). Participants in the previously depressed group met diagnostic criteria for at least one episode of major depression during the past 2 years and had a BDI score less than or equal to 6, which excluded participants experiencing depressive symptoms at the time of testing. Participants in the never depressed group had BDI scores less than or equal to 6 and did not meet diagnostic criteria for an episode of major depression during the past 2 years. None of these individuals reported previous episodes of depression. Participants in the dysphoric group had BDI scores greater than or equal to 20, the BDI cutoff score recommended by Dozois et al. (1998) for a "dysphoric-depressed" classification when using undergraduate samples. All of the participants in the dysphoric group could be classified as "previously depressed" based on

Table 1 Participant characteristics for the never depressed, previously depressed, and dysphoric groups

	Never depressed ($N = 38$)		Previously depressed ($N = 15$)		Dysphoric ($N = 24$)	
	M	SD	*M*	SD	*M*	SD
Age	20.7_a	3.4	21.3_a	4.1	22.6_a	3.2
BDI	2.5_a	2.1	3.6_a	2.1	28.8_b	6.6
PANAS negative	14.3_a	3.2	16.6_a	5.9	28.7_b	8.0
PANAS positive	35.1_a	6.7	28.7_b	6.2	21.6_c	7.1
BAI	8.4_a	6.0	9.3_a	5.4	29.0_b	10.0
STAI-S	30.3_a	7.2	37.4_b	11.8	58.2_c	10.5
STAI-T	32.8_a	6.6	36.4_a	8.2	62.2_b	7.4

BDI Beck Depression Inventory, *PANAS negative* PANAS negative affect score ("past few days" score), *PANAS positive* PANAS positive affect score ("past few days" score), *BAI* Beck Anxiety Inventory, *STAI-S* State-Trait Anxiety Inventory (state score), *STAI-T* State-Trait Anxiety Inventory (trait score). Means having the same subscript are not significantly different at $P < .05$

their responses on the self-report inventory. The participant characteristics are listed in Table 1. Note that the never depressed and previously depressed groups did not differ in terms of their BDI scores, BAI scores, or their scores on the STAI-T. The three groups did not differ significantly in terms of ethnicity, with 65.7, 53.3, and 58.3% of the participants in the never depressed, previously depressed, and dysphoric groups self-identifying as "Caucasian" on the demographics questionnaire and nearly all of the remaining participants self-identifying as "Asian".

Stimuli

The stimuli were 160 color images, divided equally between four categories: depression-related, anxiety-related, positive, and neutral. (These images are available from the authors upon request.) The distinction between depression-related and anxiety-related images was intended to differentiate between themes of sadness and threat. Most of the images were collected from the Internet; the remaining images were taken from the International Affective Picture System database (Lang et al. 2005). The depression-related images included scenes of people appearing sad and unhappy, neglected animals (e.g., a puppy in a small steel cage), scenes of poverty, and dark, gloomy landscapes. The anxiety-related images involved themes of threat and injury, and included scenes of people being threatened with weapons, people with physical injuries (e.g., an untreated burn on an arm), dangerous situations (a person walking along a cliff), motor vehicle accidents, and threatening animals. The positive images showed people smiling and laughing, children playing, puppies and kittens, and vacation activities or destinations (e.g., a beach at a tropical resort). The neutral images were selected to include people in various activities and to have no obvious positive or negative theme (e.g., a woman talking on the telephone, a group of people having a meeting). They also included pictures of objects (e.g., a bicycle, a computer) and a variety of neutral landscapes (e.g., office buildings). Care was taken to ensure that there were no obvious systematic differences between the image categories (e.g., more landscapes in the neutral category than in the other categories; more people in the depression-related category than in the positive category).

Prior to the study the 160 images were categorized by 152 female undergraduate students (none of whom participated in the eye-tracking procedure). A total of 200 images were presented on a computer display one image at a time. For each image participants were asked to choose one of four categories that best described the image: (1) positive/happy (2) sad/depressing/gloomy (3) anxiety-provoking/dangerous/fearful, and (4) neutral/no emotion. For each of the 160 images used in the present study, at least 90% of the raters agreed upon its category. A different group of 50 female undergraduates rated the valence of the 160 images using a scale from −5 (*very negative*) to +5 (*very positive*), with a midpoint of zero (*neutral*). The mean valence ratings for the positive, depression-related, anxiety-related, and neutral images were 3.43, −3.31, −3.61, and .12, respectively.

Apparatus

Eye movements were recorded by an Eyelink I eye-tracking system (SR Research Ltd., Mississauga, ON, Canada), which uses infrared video-based tracking technology. Participants wore a small, lightweight headband equipped with cameras positioned below their eyes that tracked the position of their pupils as they moved. The system has an average gaze error of less than .5 degrees of visual angle and a sampling rate of 250 Hz (allowing for a temporal resolution of 4 ms). The EyeLink system is designed to

compensate for small changes in head position during tracking so a head rest is not necessary. The eye-tracking system was connected to a Dell Dimension 8300 computer and a ViewSonic G225fb 21-inch flat screen monitor with a vertical retrace rate of 160 Hz. The computer controlled the visual display and recorded the horizontal and vertical coordinates corresponding to the position of the right eye every 4 ms.

Procedure

Participants were provided with written and spoken instructions at the beginning of the session. They were told that they would be viewing "a slide show" of positive, negative, and neutral images and that their eye movements would be recorded while they viewed the images. Participants were not informed of the recognition memory test and were not asked to study the images. Instead, they were told that the purpose of the study was to determine how pupil dilation varies as a function of image emotionality and that their pupil dilation would be measured while they examined the images.

Participants were shown four images on each trial: a depression-related image, an anxiety-related image, a positive image, and a neutral image. One image was placed in each of the four corners of the display. Images were randomly assigned to the four display locations; across all of the trials each image type was equally likely to appear in each corner. All the images were 325 × 243 pixels in size and were presented at a display resolution of 1,024 × 768 pixels on a white background. At the start of each trial participants fixated on a black dot in the centre of the display for 3 s. The four images were then presented for 10 s. There were 45 trials in total, the first five trials being practice trials to familiarize participants with the procedures before beginning data collection. Two trial sequences were created to control for order effects and these were alternated across participants.

After participants viewed the images they sat in a quiet, private room to complete the questionnaires. Before leaving the laboratory, participants were told to expect an email in 7 days that would invite them to complete an online survey (the recognition memory test was not mentioned). The e-mail sent to participants included detailed instructions and a hypertext link to the recognition memory test. The memory test was administered via the Internet using the Survey Monkey web site (www.surveymonkey.com) and could be completed from any computer with Internet access. Participants were asked to complete the memory test (in private) as soon as possible after receiving their e-mail notification.

For the recognition memory test participants were shown 320 images, one image at a time. The 320 images included the 160 previously viewed images and 160 "new" images that had not been presented (equally divided between the four categories of images). The sequence of "new" and "old" images was randomized. For each image they were asked to choose one of four responses: "sure old", "guess old", "sure new", or "guess new". This procedure provided information on both the accuracy and the confidence of participants' responses, unlike simple "yes" and "no" response options. The instructions were as follows: "If you are sure the image is one you saw before, choose Sure Old. If you are not sure but guess that the image is one you saw before, choose Guess Old. If you are sure the image is not one you saw before, choose Sure New. If you are not sure but guess the image is not one you saw before, choose Guess New. Try to spend only a few seconds looking at each image and go with your first impression". Participants were informed that 50% of the images were "old" images they had previously viewed and 50% were new images.

Results

The eye movement data were initially processed using the EyeLink Data Viewer analysis software (SR Research) to filter for blinks, missing data, and other recording artifacts (using the default settings). The data were checked for distributional anomalies and none were present. For the analyses the dependent measures were the type of image initially fixated on each trial (depression-related, anxiety-related, positive, or neutral), the number of fixations to each image type, and the amount of time spent looking at each image type (total fixation time, measured in milliseconds). These measures were computed for each image for each trial and then averaged over the 40 trials. The recognition memory data were analyzed using the signal detection measure d-prime, which provides a measure of recognition memory accuracy. The eye movement data is listed in Table 2; the d-prime data is listed in Table 3. These data were analyzed using a 3 (Group: never depressed, previously depressed, dysphoric) × 4 (Image Type: depression-related, anxiety-related, positive, neutral images) mixed-model analysis of variance (ANOVA). For all analyses, the critical statistical test was the interaction between Group and Image Type; follow-up tests were carried out only if this interaction was statistically significant. Statistically significant interactions were followed up with simple main effects, testing for differences between the three groups for each image type; statistically significant simple main effects were followed up with between-group t-tests and an alpha of 5% to maximize statistical power.

Table 2 Initially fixated image, number of fixations, and total fixation time (in milliseconds) for depression-related, anxiety-related, positive, and neutral images

Image type	Never depressed	Previously depressed	Dysphoric
Initially fixated image			
Depression-related	17.8% (.8)$_a$	22.3% (1.3)$_b$	21.9% (1.0)$_b$
Anxiety-related	31.5% (1.2)$_a$	28.5% (1.9)$_a$	31.4% (1.5)$_a$
Positive	28.4% (1.1)$_a$	28.7% (1.8)$_a$	23.2% (1.4)$_b$
Neutral	22.3% (.9)$_a$	20.5% (1.4)$_a$	23.5% (1.1)$_a$
Number of fixations			
Depression-related	8.1 (.2)$_a$	8.5 (.4)$_a$	8.3 (.3)$_a$
Anxiety-related	9.5 (.3)$_a$	11.1 (.5)$_b$	9.5 (.4)$_a$
Positive	9.7 (.3)$_a$	8.2 (.6)$_b$	7.5 (.4)$_b$
Neutral	4.9 (.2)$_a$	4.6 (.3)$_a$	4.3 (.2)$_a$
Total fixation time (ms)			
Depression-related	2,042 (70)$_a$	2,144 (112)$_a$	2,230 (89)$_a$
Anxiety-related	2,408 (87)$_a$	2,911 (139)$_b$	2,606 (110)$_{ab}$
Positive	2,536 (96)$_a$	2,064 (153)$_b$	2,021 (121)$_b$
Neutral	1,236 (49)$_a$	1,103 (78)$_a$	1,076 (62)$_a$

Standard errors in parenthesis. Means in the same row having the same subscript are not significantly different at $P < .05$

Type of Image Initially Fixated

Like other investigators (Caseras et al. 2007; Kellough et al. 2008), we considered the first shift of gaze to the images to be a good measure of the initial orienting of attention. If dysphoric individuals were more likely to look at depression-related images first, for example, then this would be evidence of a bias in the initial orienting of attention. The percentage of first fixations to the four images types is listed in Table 2. An analysis of these data produced an effect of Image Type, $F(3, 222) = 24.98$, $MSE = 53.56$, $P < .001$, partial $\eta^2 = .25$, no effect of Group, $F(2, 74) = 1.10$, $MSE = .18$, $P > .10$, and an interaction between Group and Image Type, $F(6, 222) = 3.06$, $MSE = 53.56$, $P < .01$, partial $\eta^2 = .08$. Simple main effects revealed significant differences between the groups for depression-related images, $F(2, 74) = 6.62$, $MSE = 25.83$, $P < .01$, $\eta^2 = .15$, and positive images, $F(2, 74) = 4.62$, $MSE = 48.24$, $P < .05$, $\eta^2 = .11$, but not for neutral or anxiety-related images, $F(2, 74) = 1.42$, $MSE = 30.88$, $P > .10$; $F < 1$, respectively. Follow-up comparisons revealed that previously depressed participants and dysphoric participants looked at depression-related images first more frequently than never depressed participants (22.3% and 21.9% vs. 17.8%), $t(51) = 3.08$, $P < .01$, $t(60) = 2.92$, $P < .01$, respectively. Dysphoric and previously depressed participants did not differ, $t(37) = .22$, $P > .10$. For positive images there was a different pattern of group differences. Dysphoric participants looked at positive images first less frequently (23.2%) than never depressed participants (28.4%) and previously depressed participants (28.7%), $t(60) = 2.80$, $P < .01$; $t(37) = 2.52$, $P < .05$, respectively. Previously depressed participants and never depressed participants did not differ, $t(51) = .14$, $P > .10$. Thus, for depression-related images, both previously depressed and dysphoric participants exhibited a similar bias in the initial orientation of attention relative to never depressed participants, whereas for positive images only dysphoric participants exhibited a bias.

Number of Fixations

There was an effect of Image Type, $F(3, 222) = 108.72$, $P < .001$, partial $\eta^2 = .59$, an effect of Group, $F(2, 74) = 4.19$, $P < .05$, partial $\eta^2 = .10$, and an interaction between Group and Image Type, $F(3, 222) = 4.26$, $P < .001$, partial $\eta^2 = .10$. Simple main effects revealed significant differences between the groups for positive images, $F(2, 74) = 7.18$, $MSE = 5.43$, $P < .01$, $\eta^2 = .16$, and anxiety-related images, $F(2, 74) = 3.56$, $MSE = 4.04$, $P < .05$, $\eta^2 = .09$, but not for depression-related or neutral images, $F < 1$; $F(2, 74) = 1.99$, $MSE = 1.49$, $P > .10$, respectively. Follow-up comparisons revealed that both previously depressed and dysphoric participants made significantly fewer fixations to positive images than never depressed participants (8.2, 7.5, and 9.7, respectively), $t(60) = 3.39$, $P < .01$; $t(51) = 2.69$, $P < .05$, respectively. Dysphoric and previously depressed participants did not differ, $t(37) = 1.20$, $P > .10$. For anxiety-related images, previously depressed participants made significantly more fixations to these images than never depressed participants and dysphoric participants (11.1, 9.5, and 9.5, respectively), $t(51) = 2.41$, $P < .05$; $t(37) = 2.61$, $P < .05$, respectively, whereas dysphoric and never depressed participants did not differ, $t(60) = .03$, $P > .10$. Thus, the fixation data indicate that previously depressed participants and dysphoric participants were similar in that they

attended to positive images less than never depressed participants, whereas previously depressed participants were unique in attending to anxiety-related images more than never depressed participants.

Total Fixation Time

The total fixation time data is shown in Fig. 1. The total fixation time data mirrored the patterns observed in the fixation data. Specifically, there was an effect of Image Type, $F(3, 222) = 94.89$, $MSE = 284{,}493.69$, $P < .001$, partial $\eta^2 = .56$, no effect of Group, $F(1, 74) = 2.23$, $MSE = 76{,}509.14$, $P > .10$, and an interaction between Group and Image Type, $F(6, 222) = 4.79$, $MSE = 284{,}493.69$, $P < .001$, partial $\eta^2 = .12$. Simple main effects revealed that the three groups differed in their total fixation times to positive images, $F(2, 74) = 6.78$, $MSE = 353{,}448.35$, $P < .01$, and anxiety-related images, $F(2, 74) = 4.71$, $MSE = 293{,}568.93$, $P < .05$, $\eta^2 = .11$. Consistent with the fixation data, previously depressed participants and dysphoric participants had shorter total fixation times to positive images than never depressed participants, $t(50) = 3.57$, $P < .01$; $t(51) = 2.37$, $P < .05$, respectively. The total fixation times of previously depressed participants and dysphoric participants did not differ, $t(37) = .27$, $P > .10$. For anxiety-related images, the only significant difference was between the previously depressed and never depressed groups, with previously depressed participants fixating anxiety-related images 503 ms longer than never depressed participants (2,911 ms vs. 2,408 ms), $t(51) = 2.98$, $P < .01$. Previously depressed participants also had longer total fixation times for anxiety-related images than dysphoric participants (305 ms longer), but this difference was not statistically significant, $t(37) = 1.95$, $P = .06$. For depression-related images, dysphoric participants and previously depressed participants had longer total fixation times than never depressed participants, but these differences were not statistically significant, $F(2, 74) = 1.40$, $MSE = 189670.87$, $P > .10$. There were also no group differences for neutral images, $F(2, 74) = 2.34$, $MSE = 93{,}302.06$, $P > .10$. Taken together, the fixation data and total fixation time data show that both previously depressed and dysphoric participants attended to positive images less than never depressed participants and that previously depressed participants attended to anxiety-related images more than never depressed participants and dysphoric participants.[1]

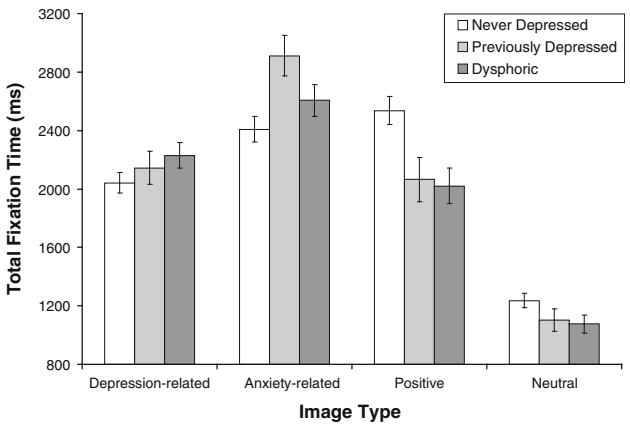

Fig. 1 Mean total fixation time for depression-related, anxiety-related, positive, and neutral images

Recognition Memory

Most of the participants completed the memory test; 36 of the 38 participants in the never depressed group (94.7%), 12 of the 15 participants in the previously depressed group (80.0%), and 20 of the 24 participants in the dysphoric group (83.3%) completed it. Note that the percentage of participants completing the memory test was lower for the previously depressed and dysphoric groups and that it is unclear how this could have biased the recognition data. The data was analyzed using the signal detection measure d-prime, which provides a measure of recognition memory accuracy independent of decision criteria and response bias. D-prime is calculated using hit and false alarm rates; hit rates were created by summing the "sure old" and "guess old" responses to the presented images; false alarm rates were created by summing the "sure old" and "guess old" responses to the non-presented foil images. The d-prime data are shown in Table 3; higher values of d-prime reflect better recognition memory. There was a main effect of Group in the analysis, $F(2, 65) = 3.31$, $MSE = 1.28$, $P < .05$, $\eta^2 = .09$. Previously depressed participants and dysphoric participants had poorer recognition memory than never depressed participants (.99, 1.15, and 1.43, respectively), $t(46) = 2.31$, $P < .05$; $t(54) =$

[1] A complementary approach is to analyze the percentage of time participants spent viewing each image type (e.g., Kellough et al. 2008). This analysis produced equivalent results, with an interaction between Group and Image Type, $F(6, 222) = 4.85$, $MSE = .021$, $P < .001$, partial $\eta^2 = .12$, and significant between-group differences for positive images, $F(2, 74) = 5.32$, $MSE = .005$, $P < .01$, $\eta^2 = .13$, and anxiety-related images, $F(2, 74) = 6.45$, $MSE = .004$, $P < .01$, $\eta^2 = .15$. Never depressed participants spent a significantly greater percentage of time attending to positive images (30.9%) than previously depressed participants (24.9%) and dysphoric participants (25.7%). For anxiety-related images, previously depressed participants and dysphoric participants spent a significantly greater percentage of time attending to these images (35.4 and 32.7%, respectively) than never depressed participants (29.2%). There was also a significant group difference for depression-related images, $F(2, 74) = 3.19$, $MSE = .002$, $P < .05$, $\eta^2 = .08$, with dysphoric participants and previously depressed participants having higher viewing percentages for depression-related images than never depressed participants (27.9, 26.1, and 24.8%, respectively).

Table 3 D-prime measures of recognition memory for depression-related, anxiety-related, positive, and neutral images

Image type	Never depressed	Previously depressed	Dysphoric
Depression-related	1.37 (.11)	.99 (.19)	1.10 (.15)
Anxiety-related	2.06 (.14)	1.48 (.24)	1.66 (.19)
Positive	1.26 (.08)	.92 (.14)	1.03 (.11)
Neutral	1.03 (.09)	.58 (.17)	.82 (.13)

Standard errors in parenthesis

2.02, $P < .05$, respectively, whereas the previously depressed participants and the dysphoric participants did not differ, $t(30) = .35$, $P > .10$. There was also a main effect of Image Type, $F(3, 195) = 50.38$, $MSE = .16$, $P < .001$, $\eta^2 = .43$, with significantly higher d-primes for emotional images (anxiety-related images = 1.73, depression-related images = 1.15, positive images = 1.07) than neutral images (.81), all $ps < .05$. Most important was the absence of an interaction between Group and Image Type ($F < 1$). Recognition memory was superior for emotional images for all three groups and there was no evidence that this emotional enhancement of memory was different for previously depressed or dysphoric participants.

Discussion

The purpose of our study was to look for evidence of attention and memory biases in individuals with a history of depression. To do so, we tracked and recorded the eye gaze of previously depressed, never depressed, and dysphoric participants while they viewed depression-related, anxiety-related, positive, and neutral images, and tested their recognition of these images 7 days later. According to cognitive models of depression, attentional biases are trait-like characteristics of depressed individuals and should therefore be present in recovered individuals not experiencing a depressive episode. Several of our findings are consistent with this prediction.

First, we found that previously depressed and dysphoric participants oriented to depression-related images more frequently than never depressed participants. This finding suggests that depression-related images were more likely to capture the attention of both dysphoric and previously depressed individuals, consistent with Joormann and Gotlib's (2007) finding that both depressed and previously depressed individuals selectively attended to sad faces in a dot-probe task. In addition, we found that dysphoric participants oriented to positive images less frequently than never depressed participants, whereas there was no difference between previously depressed and never depressed participants in their orienting to positive images. Thus, for previously depressed participants the bias in the initial orienting of attention was restricted to depression-related images, whereas for dysphoric participants there was evidence of a bias for both depression-related and positive images.

Second, we found that both previously depressed and dysphoric participants made significantly fewer fixations to positive images than never depressed participants and had shorter total fixation times to positive images than never depressed participants. The finding that dysphoric participants attended to positive images less than never depressed participants is consistent with the results of several previous eye-tracking studies, including Ellis et al. (2010), Kellough et al. (2008), Leyman et al. (2011), Mathews and Antes (1992), and Sears et al. (2010), and provides further evidence that reduced attention to positive stimuli is a common characteristic of individuals experiencing depression and dysphoria. The fact that the same attentional bias was observed for previously depressed individuals provides support for one of the more important predictions of cognitive models of depression—that attentional biases are stable trait-like characteristics of individuals vulnerable to depression.

We also found that previously depressed participants, like dysphoric participants, did not significantly differ from never depressed participants in terms of their total fixation times or their number of fixations to depression-related images (although for both groups total fixation times to these images were slightly longer than those of the never depressed group). These results indicate that both previously depressed and dysphoric participants attended to depression-related images similarly to never depressed participants. The fact that dysphoric participants did not differ from never depressed individuals in their attention to depression-related images is consistent with the findings of several other eye-tracking studies that have examined attentional biases in dysphoric individuals (Ellis et al. 2010; Leyman et al. 2011; Mathews and Antes 1992; Sears et al. 2010). On the other hand, Eizenman et al. (2003) and Kellough et al. (2008) found that clinically depressed individuals spent more time attending to depression-related images than never depressed individuals. Taken together, the literature to date suggests that a pronounced attentional bias for depression-related images is present only when depressive symptoms are severe or chronic (although the small number of eye-tracking studies in the literature precludes any strong conclusions). For dysphoric individuals, the lack of a positive or protective attentional bias appears to be the distinguishing trait.

One other potentially important finding was that previously depressed participants had longer total fixations times and made more fixations to anxiety-related images than

never depressed participants. This result was unexpected, but could be another manifestation of a latent attentional bias in at-risk individuals. That is, images with themes of threat and danger may be more potent emotional stimuli for previously depressed individuals (perhaps because of prolonged activation of the amygdala in response to stressful images; De Raedt and Koster 2010), and, if so, their increased salience may attract additional attention. This possibility will be an interesting question for future research and may be especially relevant to newer models of attentional processing in depression (e.g., Mogg and Bradley 1998; Koster et al. 2011). For example, in Mogg and Bradley's cognitive motivational analysis model, a "valance evaluation system" (VES) functions to assess stimulus threat value in order to prioritize the allocation of attention by a "goal engagement system" (GES). According to the model, the VES has a lower threshold for appraising threat in individuals vulnerable to emotional disorders (especially anxiety disorders), leading to higher threat evaluations and increased engagement of the GES relative to non-vulnerable individuals. The depression-specific impairment is postulated to be a difficulty disengaging attention from negative stimuli once attended. Similarly, Koster et al.'s (2011) impaired disengagement hypothesis maintains that impaired attentional disengagement from negative self-referent information is the key vulnerability in depressed and at-risk individuals. Both of these models offer ways of explaining why anxiety-related images would be more potent emotional stimuli for previously depressed individuals and why previously depressed individuals would attend to these images more than never depressed individuals.

Lastly, our attempt to observe mood-congruent memory biases using an incidental recognition memory test was not successful. Although we replicated the standard finding that images with emotional content tend to be better remembered than neutral images (e.g., Ochsner 2000), we did not find that previously depressed participants or dysphoric participants had better or worse memory for emotional images than never depressed participants. Our results are consistent with those of a number of investigators who have also reported no evidence of a mood-congruent memory bias for dysphoric individuals when using a recognition memory task (e.g., Ellis et al. 2010; Koster et al. 2009; Sears et al. 2010). On the other hand, Hamilton and Gotlib (2008) found that depressed individuals tended to have better recognition for negative images than positive images when memory for the images was tested 7 days later, whereas for non-depressed individuals this difference was reversed. If replicated, this finding will point to important differences in the memory biases of depressed and dysphoric individuals that warrant further study.

We should note a few limitations of our study. Perhaps the most important is that the measure we used to assess participants' history of depression, although based on the DSM-IV criteria for major depressive episode, was a self-report measure, and like all self-report measures was potentially subject to response biases (e.g., socially desirable responding) and other measurement issues (e.g., individual differences in the evaluation and report of similar experiences; e.g., feelings of sadness, fatigue, etc.). Ideally, future research should use structured clinical interviews to assess participants' history of depression in addition to self-report measures (e.g., Dearing and Gotlib 2009). The generalizability of our results is limited by the fact that the majority of our participants were younger women and because we created a potentially heterogeneous sample of previously depressed individuals through the use of two different recruitment methods (an online participant pool and campus advertisements). In addition, because our study did not include a clinically depressed group of participants, we were not able to assess the attentional biases of more severely depressed individuals. As a result, we were not able to compare the attentional biases of previously depressed individuals to those with clinical depression. It is possible that the biases of previously depressed individuals are more similar to the biases of dysphoric individuals, and if so, this would have implications for our understanding of attentional functioning in vulnerable individuals. Lastly, researchers should keep in mind that our results are based on the viewing times to a heterogeneous collection of images (landscapes, people, body parts, animals) and that it is unclear if this was a strength or weakness of our study. On the one hand, because there were clear differences between the never depressed, previously depressed, and dysphoric groups in their attention to positive and anxiety-related images, the implication is that these differences are not restricted to a specific type of image (e.g., faces). On the other hand, it will remain a question for future research whether the attentional biases we have observed are more or less pronounced for different types of images.

Conclusions

The results of the present study compliment and extend the findings of other investigators who have observed attentional biases in previously depressed individuals (Ingram et al. 1994; Joormann and Gotlib 2007; McCabe et al. 2000; Wenzlaff et al. 2001). The novel findings are that previously depressed individuals exhibited attentional biases similar to those of dysphoric individuals, in terms of the initial orienting of attention to depression-related images and in terms of the reduction of attention to positive images. The fact that these differences were observed without the use of a negative mood induction suggests that the

eye-tracking paradigm we used may be an especially sensitive measure of attentional biases. Our study contributes to a growing body of research documenting important differences in the way that individuals vulnerable to depression process emotional information. Researchers have shown that vulnerable individuals exhibit more sustained pupil dilation to emotional words (Steidmann et al. 2010), exhibit biased visual search (Wenzlaff et al. 2001), attend to positive and negative faces differently (Joormann and Gotlib 2007), and are more likely to interpret emotionally ambiguous stimuli in a negative manner (Dearing and Gotlib 2009). Taken together, this research converges on the conclusion that information processing biases are not merely transient symptoms of depression but are instead an important vulnerability factor, one of the key claims of cognitive models of depression.

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