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Attentional Disengagement Predicts Stress Recovery in Depression: An Eye-Tracking Study

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Previous research has made significant progress elucidating the nature of cognitive biases in emotional disorders. However, less work has focused on the relation among cognitive biases and emotional responding in clinical samples. This study uses eye-tracking to examine difficulties disengaging attention from emotional material in depressed participants and to test its relation with mood reactivity and recovery during and after a stress induction. Participants diagnosed with Major Depressive Disorder (MDD) and never-disordered control participants (CTL) completed a novel eye-tracking paradigm in which participants had to disengage their attention from emotional material to attend to a neutral stimulus. Time to disengage attention was computed using a direct recording of eye movements. Participants then completed a stress induction and mood reactivity and recovery were assessed. MDD compared with CTL participants took significantly longer to disengage from depression-related stimuli (i.e., sad faces). Individual differences in disengagement predicted lower recovery from sad mood in response to the stress induction in the MDD group. These results suggest that difficulties in attentional disengagement may contribute to the sustained negative affect that characterizes depressive disorders.

Keywords: depression, selective attention, emotional processing, mood regulation, stress recovery

According to cognitive models (Beck, 1967; Bower, 1981; Teasdale, 1988), depression is caused and maintained by biases in the processing of emotional information. A key prediction of these models is that depressed individuals selectively attend to and remember emotion-congruent information. Beck's model (1967) postulates that existing memory representations, or schemas, lead individuals to filter stimuli from the environment such that their attention is directed toward information that is congruent with their schemas. Beck theorized that depressed persons' schemas include themes of loss, separation, failure, worthlessness, and rejection; consequently, depressed individuals will exhibit a systematic bias, selectively attending and processing negative stimuli in their environment.

Recent research using a variety of tasks has shown that depression is characterized by an attentional bias to negative information (for recent reviews see De Raedt & Koster, 2010; Gotlib & Joormann, 2010). Studies using attention allocation paradigms, such as the dot-probe task (MacLeod, Mathews, & Tata, 1986), have found attentional biases in depression, but only under conditions of long stimuli exposures. Bradley, Mogg, and Lee (1997), for example, found that dysphoric participants compared with nondysphoric participants showed a mood-congruent bias on the dot-probe task when negative stimuli were presented for 1,000 ms, but not when they were presented for brief durations (14 ms). Further research has replicated this finding in clinically diagnosed depressed participants, finding attentional biases to depression-related stimuli that were presented for 1,000 ms (Donaldson, Lam, & Mathews, 2007; Gotlib, Krasnoperova, Yue, & Joormann, 2004; Joormann & Gotlib, 2007). A recent meta-analytic review (Peckham, McHugh, & Otto, 2010) has examined the magnitude of this attentional bias in 12 dot-probe experiments, confirming a significant difference between depressed and control groups ($d = 0.52$).

Given these results, authors have speculated that depressed individuals may not direct their attention to negative information more quickly than do control participants, but once it captures their attention they may exhibit difficulties disengaging from it (e.g., Gotlib & Joormann, 2010). These difficulties in disengagement from negative material may result in sustained processing of negative material and interfere with the regulation of negative affect. Unfortunately, however, the dot probe task does not allow for a thorough examination of this hypothesis. This task assesses the focus of attention at only one point in time on each trial, at the offset of the cues. Thus, during longer stimulus presentation times, participants may shift attention repeatedly between the stimuli prior to their offset, which reduces the sensitivity of this measure to examine components of attention.

Recent research into attentional biases has, therefore, started to use eye movement recordings, which allow continuous monitoring of the focus of visual orienting and provide indicators of different components of attention (i.e., initial orientation or engagement of attention vs. maintenance of attention). Eizenman et al. (2003) used eye-tracking technology to continuously monitor point of gaze. Depressed individuals spent significantly more time looking

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at pictures featuring sadness and loss and had significantly longer average glance durations for these pictures than did nondepressed controls. Similarly, Caseras, Garner, Bradley, and Mogg (2007) found that depressed individuals were no more likely than controls to shift their attention toward negative stimuli, but once their attention was focused on negative stimuli they spent significantly more time looking at these stimuli than nondepressed controls. This bias in maintained attention to negative stimuli has been replicated in several subsequent eye-tracking studies (Ellis, Beevers, & Wells, 2010; Kellough, Beevers, Ellis, & Wells, 2008; Leyman, De Raedt, Vaeyens, & Philippaerts, 2011).

Despite these encouraging results, it should be noted that these studies focused on initial shift and subsequent maintenance of attention in a free viewing task. Thus, previous eye-tracking studies suggest that depression is characterized by prolonged processing of depression-related stimuli, but it remains unclear whether the prolonged processing is due to difficulties disengaging attention from negative material. To our knowledge only one recent eye-tracking study has directly tested this hypothesis, using a task that explicitly required participants to disengage their attention from depression-related stimuli (Sears, Thomas, LeHuquet, & Johnson, 2010). Sears et al. (2010) found that dysphoric compared with nondysphoric undergraduate students were slower to disengage their attention from depression-related images when prompted to look at a nonemotional stimulus. Additional eye-tracking research is needed to replicate this finding and to test if difficulties disengaging attention from depression-related stimuli are also exhibited by clinically depressed individuals. Moreover, eye-tracking tasks are needed that allow for a direct comparison of engagement and disengagement components in attention processing, to test the hypothesis that depression is characterized by difficulties in disengagement but not facilitated engagement with depression-related stimuli.

Furthermore, an important assumption of cognitive theories of depression is that cognitive biases in depression are, indeed, causally linked to sustained negative affect (Beck, 1967; De Raedt & Koster, 2010). Specifically, is has been argued that depressed participants' difficulty inhibiting attentional processing of negative information results in difficulty in mood and emotion regulation (Joormann & D'Avanzato, 2010). Indeed, a link between attention and emotional responding to stress has been reported in studies that have examined whether individual differences in attention biases are associated with mood changes in response to exposure to a stressor. Compton (2000), for example, demonstrated that a reduced ability to disengage attention was associated with increased reactivity to a distressing film clip. Likewise, Osinsky, Lösch, Henning, Alexander, and MacLeod (2012) have recently reported that college students who displayed the most pronounced bias toward negative information at the beginning of a semester reported the greatest amount of depressive symptoms during the final exams. Finally, Ellenbogen, Schwartzman, Stewart, and Walker (2006) showed that the ability to disengage from negative stimuli was associated with changes in negative mood ratings in response to a subsequent stress task.

Overall, these studies suggest that individual differences in attentional processing of negative stimuli are associated with emotional responding to stress. However, most studies have tested this hypothesis in undergraduate samples using reaction time (RT) assessments of biases that do not allow an assessment of the different components of attention processing. Furthermore, no studies using eye-tracking have directly monitored and registered attentional disengagement patterns in clinical depression to link individual differences in disengagement with stress reactivity and recovery in depression. Further research analyzing the role of attentional disengagement in stress reactivity and recovery in depression is clearly needed.

The present study examined if MDD participants exhibit difficulties disengaging attention from depression-related stimuli. To examine this hypothesis we developed a novel eye-tracking task that assessed individual differences in disengaging attention from emotional material and allowed us to differentiate attentional engagement and disengagement components. It was hypothesized that MDD compared with CTL participants take longer to disengage their attention from depression-related stimuli (i.e., sad faces) as opposed to other types of stimuli, such as negative stimuli not related to depression (i.e., angry faces) or positive stimuli (i.e., happy faces). No group differences were expected for attentional engagement.

We examined further whether difficulties disengaging attention from depression-related stimuli are associated with mood changes in response to an acute stressor in MDD participants. Previous studies analyzing the relation between difficulties in disengagement and mood changes in response to stress have typically used undergraduate samples, and the association of this bias with emotional responding in clinical depression remains unclear. It was hypothesized that difficulties disengaging attention from depression-related stimuli predict mood levels in response to a stress induction in MDD participants.

Method

Participants

Participants were recruited via newspaper advertisements and Internet postings. Adults between 18 and 60 years of age who were fluent in English were screened over the phone for initial exclusion/inclusion criteria. Individuals who had experienced severe head trauma, had learning disabilities, reported psychotic symptoms, or met *DSM–IV* criteria for bipolar disorder or for alcohol or substance abuse within the past 6 months were excluded. An abbreviated version of the Structured Clinical Interview for the *DSM–IV* (SCID; First, Spitzer, Gibbon, & Williams, 1996) was used during phone interviews to identify participants who were likely to meet criteria for inclusion into one of two groups: (a) individuals who met *DSM–IV* criteria for current Major Depression Disorder (MDD); or (b) individuals who did not meet criteria for any past or current Axis I disorder (CTL). Individuals in the CTL group were also required to not take any psychotropic medication. Individuals expected to meet inclusion criteria were invited to participate in the SCID (First et al., 1996), which was administered in the laboratory by trained and experienced graduate−student interviewers with an inter-rater reliability of .93. Based on the SCID, 35 individuals (16 MDD and 19 CTL) were deemed eligible and were included in the study.

Questionnaires

Depressive symptoms. Participants completed the Beck Depression-Inventory-II (BDI-II, Beck, Steer, & Brown, 1996), a

21-item self-report measure to assess depression severity. Respondents report on a 4-point scale how much they have been bothered by depression symptoms. This measure has shown excellent reliability and validity (Beck et al., 1996). In the current study, internal consistency was good ($\alpha = .96$).

Mood state. Three visual analogue scales (VASs) were used to evaluate mood state at different times across the experimental session. VASs were composed of three items each: happy mood (happy, optimistic, joyful), anxious mood (nervous, tense, anxious), and sad mood (depressed, upset, sad). Each scale consisted of a line with 11 labeled anchor points, ranging from 0 (*not at all*) to 10 (*very much*), on which participants indicated how they felt "right now." Mean internal consistency for each scale was good (i.e., happy mood: $\alpha = .88$; anxious mood: $\alpha = .92$; sad mood: $\alpha = .86$).

Attention Task

Stimuli materials. Stimuli consisted of pairs of pictures comprising an emotional and a neutral facial expression of the same person. Faces were selected from the Karolinska Directed Emotional Faces (KDEF) database (Lundqvist, Flykt, & Öhman, 1998). Following the procedures used by Williams, Moss, Bradshaw, and Mattingley (2005), and Calvo and Lunqvist (2008), original KDEF frontal view pictures were fit within an oval window. The hair, neck, and surrounding parts of the images were darkened to remove noninformative aspects of the faces. Stimuli selection was based on two parameters: the emotional discreteness of faces for the corresponding emotion and their intensity ratings. Selection was made on the basis of the results from a previous validation study of the KDEF emotional pictures (Sanchez & Vazquez, in press). Based on these data, 36 happy, angry, and sad expressions (18 men and 18 women for each emotional category), together with the corresponding neutral expression of the same actors, were selected as the stimuli for the current study.

Experimental design and attention indices. The attention task comprised 108 trials (36 happy, 36 angry, and 36 sad expressions paired with the corresponding neutral expression of the same actor), which were randomly presented for each participant. Emotional and neutral expressions were presented equally often on the left as on the right. The task also included six practice trials, followed by a brief pause before starting the actual trials.

Stimuli were displayed on an 88.5 cm (width) × 50.5 cm (height) screen. The size of each face was 19.5 cm (width) × 21 cm (height). Pictures were centered on the screen, 39 cm apart (measured from their centers). Participants were seated approximately 195 cm from the screen's center, resulting in a visual angle of approximately 5.7 degrees between each picture's center and the screen's center.

The experimental design is presented in Figure 1. Each trial started with a black screen for 500 ms, followed by the display of a white fixation cross in the middle of a black screen for 500 ms. A white random 1-digit number (ranging from 1 to 9) replaced the fixation cross, appearing in the center for 1,000 ms. Participants were instructed to fixate on the number and say it aloud as quickly as possible. This procedure has been used previously by Calvo and Avero (2005) to assure that participants' attention was focused on the center of the screen before the face pairs appeared. Immediately after the offset of the 1-digit number, a pair of faces (either happy−neutral, angry−neutral, or sad−neutral) was presented for 3,000 ms and participants were told to freely watch the screen without constraints. Free watching of face pairs was implemented to encourage naturalistic information processing (Isaacowitz, 2005) and fixation data recorded with the eye-tracker during the 3,000 ms period were used to estimate three indices of naturalistic processing employed in previous research (e.g., Kellough et al., 2008): (a) Initial orientation refers to the probability of recording an initial fixation to an emotional expression after the expressions onset, reflecting tendencies of initial shifts of attention to emotional information; (b) Fixation frequency refers to the numbers of times that participants direct and redirect their gaze to an emotional expression during the 3,000 ms period, reflecting the proportion of fixations made to emotional information; and (c) Fixation time refers to the total time that participants fixate on an emotional expression during the 3,000 ms period, reflecting the proportion of time that participants attend to emotional information.

A novel engagement−disengagement task was performed after the 3,000 ms of natural processing stimuli presentation. This novel task allowed for the assessment of direct measures of attentional engagement and disengagement together with naturalistic processing indices employed in previous research. Specifically, the task assessed ability to disengage attention from emotion stimuli, as measured by Sears at al. (2010), but also the ability to engage attention with emotion stimuli, allowing for a comparison of these two different attention components.

The engagement−disengagement task was comprised of three different conditions: (a) One third of the trials in each emotion condition (happy, sad, angry) assessed attentional engagement with emotional expressions. As can be seen in Figure 1, in this engagement condition, after 3,000 ms of naturally viewing, stimuli presentation did not continue until participants had fixated on the neutral face. This time was defined as a "wait for fixation" period. After participants fixated on the neutral face for 100 ms, stimuli presentation continued: A frame consisting of a square or a circle appeared surrounding the opposite face (i.e., emotional face). Participants were instructed to move their gaze as quickly as possible toward that frame and press one of two response keys on the keyboard to indicate whether the frame was a square or a circle. Thus, the engagement condition assessed how long participants took to disengage attention from the neutral face to engage with the emotional face. (b) Another third of the trials in each emotion condition assessed disengagement from emotional expressions. The procedure was similar to the engagement condition, but, in this case, the "wait for fixation" period after the 3,000 ms naturally viewing of pictures was dependent on participants' fixation on the emotional face with the frame appearing around the neutral face. Thus, the disengagement condition assessed how long participants took to disengage attention from the emotional face to engage with the neutral face. (c) Finally, we included a control condition for another third of trials in each emotion condition, in which after the 3,000 ms naturally viewing pictures, a new fixation cross appeared indicating the start of the next trial. Trials of engagement, disengagement, and control conditions for each emotional condition (i.e., happy−neutral, angry−neutral, sad−neutral) were randomly presented for each participant. Both types of frames were equally likely to appear in the left and right positions in all conditions.

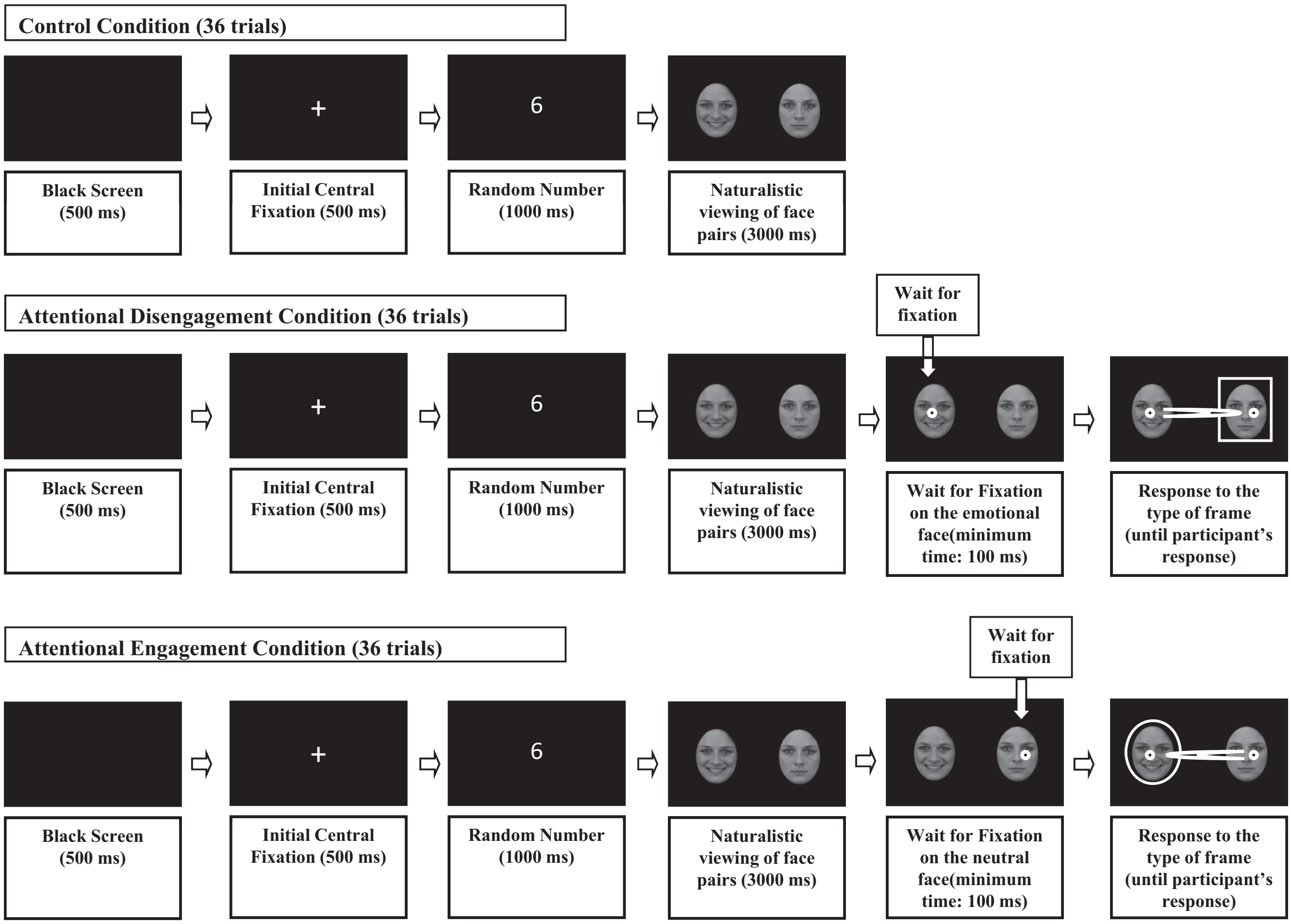

Figure 1. A schematic of a trial sequence. Each trial starts with a black screen for 500 ms, followed by the display of a central fixation cross for 500 ms. A white random 1-digit number replaces the central fixation cross for 1,000 ms After the offset of the 1-digit number, a pair of faces (either happy−neutral, angry−neutral, or sad−neutral) is presented for 3,000 ms. After that, a "wait for fixation" period is defined in the Attentional Disengagement and Attentional Engagement conditions, until participants fixate on the corresponding target stimulus (i.e., emotional and neutral, respectively). After fixation on the target a frame (i.e., square or circle) appears surrounding the opposite stimulus (i.e., neutral and emotional, respectively). Participants have to disengage their attention from the attended stimulus and direct their gaze to the opposite face to indicate the type of frame.

Fixation data recorded with the eye-tracker during the engagement−disengagement task were used to estimate attentional engagement and disengagement indices for each emotion condition. (a) Attentional engagement refers to the latency of the first shift in gaze from the neutral face to the emotional face surrounded by the frame appearing after the "wait for fixation" period. (b) Attentional disengagement refers to the latency of the first shift in gaze from the emotional face to the neutral face surrounded by the frame appearing after the "wait for fixation" period. This time period includes the time that participants spent attending the stimulus fixated during the previous "wait for fixation" period, plus the time participants needed to move their eyes from the initially fixated stimulus to the stimulus surrounded by a frame, plus the minimum 100 ms fixation period necessary to determine that a fixation on the target stimulus has occurred.

Criteria for identifying a first shift in gaze to the stimuli surrounded by the frame on each trial were: (a) participants were fixated on the opposite stimulus before the frame appeared, (b) eye movements occurred at least 100 ms after the frame appeared, (c) gaze was directed to the stimulus surrounded by a frame rather than remaining at the opposite stimulus position, and (d) participants made a fixation of at least 100 ms to the stimulus surrounded by a frame after shifting their gaze to it.

Eye-tracking device. Participants' eye movements were recorded using a Tobii tx-120 eye-tracker system. This system employs a dual-Purkinje eye-tracking method (see Crane & Steele, 1985). An infrared light is projected over the participant's eyes and the gaze position at any given time is calculated by tracking the reflections of the light source from the front of the cornea (first Purkinje image) and the back of the lens (fourth Purkinje image).

The system provided 60 Hz measures of eye-gaze coordinates (e.g., a coordinates' estimation every 16.7 ms). Both stimuli presentation and eye movements recording were controlled by E-prime 2.0 software, with the eye-tracking system automatically synchronized to the program at the beginning of each trial and coordinated the "wait for fixation" periods during the engagement−disengagement task. The participants' head position was comfortably kept stable by using an anatomic chair, with a distance between eyes and eye-tracker capture of approximately 60 cm. All participants had normal or corrected-to-normal vision and were allowed to wear their glasses or contact lenses if required during the attention task. Eye movement signals were converted to visual fixation data by using Tobii software. Visual fixations were defined as a minimum duration of 100 ms and a maximum fixation radius of 1 degree.

Stress Induction

Stress induction was based on a procedure developed by Waugh, Panage, Mendes, and Gotlib (2011). After completing the attention task, participants sat and rested for 5 minutes, and after this rated their current mood. Then participants were told that they would have 2 minutes to prepare a 5-min speech. They were told that their speech would be recorded and judged by evaluators on their clarity, coherence, and persuasiveness. They were then told that a coin flip would determine who actually had to give a speech (i.e., coin landing on head) or not (i.e., coin landing on tail). The experimenter then told participants the speech topic was "Why are you a good friend?"—a topic used successfully in previous studies to induce anticipatory stress responses (Fredrickson, Mancuso, Branigan, & Tugade, 2000)—and left them alone to prepare the speech for 2 minutes. After 2 minutes of speech preparation, participants rated their current mood. The experimenter then flipped a double-tailed coin to ensure that the participants would not have to give the speech. No participant reported suspicion about this fixed coin flip. After anticipating giving the speech, participants sat and rested for 5 minutes, and after this recovery period, participants again rated their current mood. This procedure has been shown to induce stress (Waugh et al., 2011) and served to evaluate both mood changes in anticipation of a stressful situation as well as mood regulation after the subsequent recovery period.

Procedure

All participants took part in the phone interview and the SCID, which took approximately 2 hours. Within 1 week after the SCID interview, participants took part in the experimental session. Participants signed a consent form and completed the BDI-II and the first three VASs (Time 1: baseline), assessing happy, anxious, and sad mood before the start of the attention task. Then participants completed the attention task. After completing the attention task, participants sat and rested for 5 minutes, and after that rated their current mood (Time 2: prestress). Then they received the instructions for the stress task and prepared their speech for 2 minutes. After that they rated again their current mood (Time 3: anticipatory-stress). The experimenter then flipped the two-tailed coin and told participants that they do not have to give the speech. Participants sat and rested for 5 minutes, and after this recovery period, they again rated their current mood (Time 4: poststress). Participants were then thanked for their participation in the study and compensated $30.

Results

Participant Characteristics

Demographic and clinical characteristics of the two participant groups and statistical analyses to test differences between groups are presented in Table 1. The proportion of women was similar in both groups. Likewise, groups did not differ in age, years of education, and ethnicity. With regard to clinical characteristics, the MDD compared with the CTL group reported more depressive symptoms. Ten MDD participants were diagnosed with a comorbid anxiety disorder: four with social anxiety; one with panic disorder; one with a specific phobia; and four with multiple anxiety disorders including generalized anxiety disorder and posttraumatic stress disorder. We also assessed whether MDD participants met criteria for single versus recurrent depressive episode(s): six MDD participants met criteria for a single episode, whereas 10

Table 1
Differences in Demographic and Clinical Characteristics Between Groups

Variables	CTL (N = 19) *M* (*SD*)		MDD (N = 16) *M* (*SD*)		Statistics
Gender (%)					$\chi^2 = 0.34; p = .56$
Male	47.4		37.5		
Female	52.6		62.5		
Years of Education	14.00	3.07	13.50	1.95	$t = 0.51; p = .61$
Ethnicity (%)					$\chi^2 = 1.22; p = .74$
African-American	47.4		43.8		
Caucasian	26.3		25		
Hispanic	21		31.2		
Other	5.3		0		
Age	37.32	9.88	39.56	12.68	$t = -0.58; p = .56$
BDI-II	1.31	1.19	23.00	10.56	$t = -8.16; p = .001^{***}$

Note. *M* = Mean; *SD* = Standard deviation. CTL = Control group; MDD = Major Depressive Disorder group; BDI-II = Beck Depression Inventory II.
*** $p < .001$.

participants met criteria for a recurrent depressive episode. Regarding medication use, four of the participants with MDD reported taking medication at the time of the SCID including neuroleptics and antidepressants.

Naturalistic Processing of Emotional Information

Naturalistic processing data are presented in Table 2. To test differences between groups, 2 × 3 mixed design ANOVAs were conducted, with group (MDD, CTL) as a between-subjects factor, and emotion (happy, angry, sad) as a within-subject factor, for each attention variable (i.e., initial orientation, fixation frequency, fixation time).

For initial orientation, analyses did not reveal significant effects of group, $F(1, 33) = 0.23$, *n.s.*, $\eta^2 = .01$, emotion, $F(2, 66) = 1.02$, *n.s.*, $\eta^2 = .03$, nor an interaction of group by emotion, $F(2, 66) = 0.25$, *n.s.*, $\eta^2 = .01$.

For fixation frequency, analyses did not show a significant effect of group, $F(1, 33) = 1.55$, *n.s.*, $\eta^2 = .05$. There was a significant main effect of emotion, $F(2, 66) = 4.63$, $p < .05$, $\eta^2 = .13$. Bonferroni tests showed that participants directed their gaze more frequently to happy than sad faces, $p < .05$. This effect was not qualified by a significant group by emotion interaction, $F(2, 66) = 2.53$, $p = .08$, $\eta^2 = .07$.

For fixation time, analyses revealed a marginal main effect of group, $F(1, 33) = 3.88$, $p = .058$, $\eta^2 = .11$, and a significant main effect of emotion, $F(2, 66) = 5.11$, $p < .01$, $\eta^2 = .14$. Main effects were qualified by a significant interaction of group by emotion, $F(2, 66) = 5.22$, $p < .01$, $\eta^2 = .14$. Bonferroni between-groups comparisons showed that MDD compared with CTL participants spent more time attending to negative faces ($p < .05$ for both angry and sad face conditions) and less time attending to happy faces but this difference was only at a trend level ($p = .08$). Furthermore, Bonferroni within-group comparisons also showed that whereas MDD participants did not show differences in their fixation time for each face emotion condition, CTL participants were characterized by a significantly longer fixation time for happy compared with angry and sad faces ($p < .01$, in both cases).[1]

Table 2
Means and Standard Deviations of Naturalistic Processing Indices During the 3,000 Ms Period

Variables	CTL ($N = 19$)		MDD ($N = 16$)	
	M	(*SD*)	*M*	(*SD*)
Initial orientation (proportion)				
Happy face	0.58	0.08	0.56	0.07
Angry face	0.55	0.09	0.53	0.06
Sad face	0.55	0.11	0.55	0.08
Fixation frequency (proportion)				
Happy face	0.56	0.04	0.54	0.07
Angry face	0.50	0.07	0.53	0.05
Sad face	0.50	0.05	0.52	0.03
Fixation time (proportion)				
Happy face	0.57	0.06	0.54	0.04
Angry face	0.48	0.07	0.54	0.05
Sad face	0.50	0.05	0.54	0.06

Note. *M* = Mean; *SD* = Standard deviation. CTL = Control group; MDD = Major Depressive Disorder group.

Attentional Engagement and Disengagement From Emotional Information

To test differences between groups in their attentional engagement and disengagement from emotional information, a 2 × 2 × 3 mixed design ANOVA was conducted, with group (MDD, CTL) as a between-subjects factor, and task (engagement, disengagement) as well as emotion (happy, angry, sad) as within-subject factors. Analyses revealed a significant main effect of emotion, $F(2, 66) = 3.94$, $p < .05$, $\eta^2 = .11$, as well as significant interactions of group by task, $F(1, 33) = 5.01$, $p < .05$, $\eta^2 = .13$, and task by emotion, $F(2, 66) = 4.03$, $p < .05$, $\eta^2 = .11$. These effects were further qualified by a significant group by task by emotion interaction, $F(2, 66) = 5.18$, $p < .05$, $\eta^2 = .14$. To follow up on the three-way interaction, separate 2 (group) × 3 (emotion) ANOVAs were conducted.

For the attentional engagement condition, analyses did not reveal significant effects of group, $F(1, 33) = 0.19$, *n.s.*, $\eta^2 = .01$, emotion, $F(2, 66) = 0.34$, *n.s.*, $\eta^2 = .01$, nor an interaction of group by emotion, $F(2, 66) = 1.12$, *n.s.*, $\eta^2 = .03$. Thus, as can be seen in Figure 2, MDD and CTL participants did not differ in shifting their attention to emotional information in the engagement condition.

For the attentional disengagement condition, however, analyses revealed significant main effects of group, $F(1, 33) = 6.74$, $p < .05$, $\eta^2 = .17$, and emotion, $F(2, 66) = 5.83$, $p < .01$, $\eta^2 = .15$, which were qualified by a significant interaction of group by emotion, $F(2, 66) = 4.22$, $p < .05$, $\eta^2 = .11$. Bonferroni tests showed no significant group differences in disengagement of attention from happy and angry faces. However, the MDD compared with the CTL participants took significantly longer to disengage their attention from sad faces, $p < .05$. Post hoc tests also revealed that within the MDD group, time to disengage attention from sad faces was significantly longer than time to disengage attention from both happy and angry faces ($p < .05$ and $p < .01$, respectively). These results are presented in Figure 2.

We additionally tested whether groups differed between attentional engagement and disengagement separately for each emotion condition. Thus, separate 2 (group) × 2 (task condition) ANOVAs were conducted. Analyses for happy and angry faces did not reveal significant effects, all F's < 0.64, all p's $> .05$. For sad faces, analyses showed a marginal main effect of group, $F(1, 33) = 2.92$, $p = .09$, $\eta^2 = .08$. An effect of task was found, $F(1, 33) = 6.37$, $p < .05$, $\eta^2 = .16$, which was qualified by a significant group by task interaction, $F(1, 33) = 9.88$, $p < .01$, $\eta^2 = .23$. Post hoc tests showed that, whereas the CTL participants did not differ in their time to engage or disengage attention from sad faces, the MDD

[1] Further analyses were conducted to assure that the findings were not influenced by outliers. We identified outliers by converting the scores for each attentional index to standard scores. We used a conservative criterion by which a case is identified as an outlier if its standard score is ±2.5 or beyond. Overall, analyses excluding outliers yielded results that were very similar to those found when using the full sample. We also conducted a series of ANCOVAs controlling for comorbid anxiety and medication use. Covariates did not show significant effects for any of the analyses on initial orientation (all F's < 0.73, all p's $> .05$; all $\eta^2 < .02$), fixation frequency (all F's < 0.74, all p's $> .05$; all $\eta^2 < .02$) nor fixation time (all F's < 0.52, all p's $> .05$; all $\eta^2 < .02$).

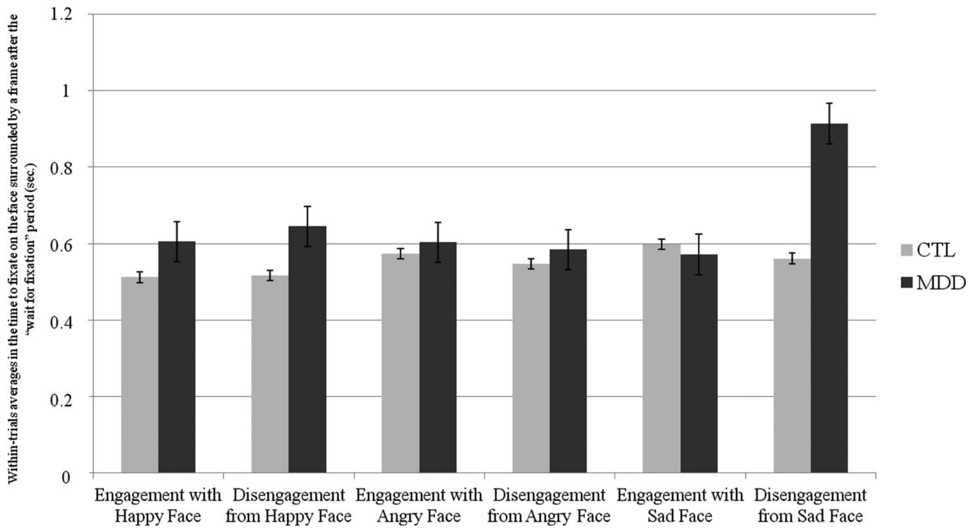

Figure 2. Mean times to direct attention to the face surrounded by a frame in the attentional engagement and disengagement conditions for each emotion condition comparing participants with Major Depressive Disorder (MDD) and controls (CTL). Error bars represent ± 1 standard error.

participants took longer to disengage attention than to engage attention when sad faces were presented, $p < .001$.[2]

Mood Changes Across the Experimental Session

A 2 × 3 × 4 mixed design ANOVA was used to examine group differences in stress reactivity, with group (MDD, CTL) as a between-subjects factor, and mood state (happy, anxious, sad) and assessment time (Time 1: baseline, Time 2: prestress, Time 3: anticipatory-stress, Time 4: poststress) as within-subject factors. Analyses revealed a significant three-way interaction, $F(6, 198) = 4.91$, $p < .01$, $\eta^2 = .51$. Consequently, separate 2 (group) × 4 (assessment time) ANOVAs were conducted for each mood state.

For happy mood, analyses revealed a significant effect of group, $F(1, 33) = 18.03$, $p < .001$, $\eta^2 = .35$. MDD compared with CTL participants showed lower happy mood scores across the session. Analyses also showed a significant effect of assessment time, $F(3, 99) = 6.07$, $p < .001$, $\eta^2 = .15$, which was not qualified by a group by assessment time interaction, $F(3, 99) = 1.27$, *n.s.*, $\eta^2 = .04$. Happy mood in both groups did not change either from baseline to prestress, nor from prestress to the anticipation period, but it significantly increased from the anticipation to the poststress period, $p < .05$. Thus, happy mood increased during the recovery period in both groups.

For anxious mood, analyses revealed a significant effect of group, $F(1, 33) = 24.69$, $p < .001$, $\eta^2 = .43$. MDD compared with CTL participants showed higher anxious mood scores across the session. Analyses also showed a significant effect of assessment time, $F(3, 99) = 8.97$, $p < .001$, $\eta^2 = .21$, which was not qualified by a group by assessment time interaction, $F(3, 99) = 1.49$, *n.s.*, $\eta^2 = .04$. Anxious mood in both groups did not change from baseline to prestress, but it significantly increased from prestress to the anticipation period, $p < .05$. Subsequently, anxious mood in both groups significantly decreased, $p < .001$. Thus, anxious mood in both groups increased during the preparation of the speech, but subsequently decreased during the recovery period.

For sad mood, analyses revealed a significant effect of group, $F(1, 33) = 14.99$, $p < .001$, $\eta^2 = .31$. MDD compared with CTL participants showed higher sad mood scores across the session. Analyses also showed a group by assessment time interaction, $F(3, 99) = 2.87$, $p < .05$, $\eta^2 = .08$. Bonferroni tests showed that there were no significant changes in sad mood in the CTL group. As for participants in the MDD group, Bonferroni test showed that sad mood did not change from baseline to prestress, but it significantly increased from the prestress to the anticipation period, $p < .05$. Subsequently, sad mood in MDD participants remained stable. Thus, depressed participants exhibited increases in anxious and sad mood when anticipating the stressful situation and sad mood remained stable during the recovery period (see Table 3).[3]

Predictors of Mood Changes

To test our second hypothesis we examined whether individual differences in disengagement from sad stimuli were associated with mood changes in response to the anticipation of a stressor or with mood changes during the subsequent recovery period. To

[2] For attentional engagement and disengagement indices, a 2 × 2 × 3 mixed design ANOVA still yielded a significant group by task by emotion interaction, $F(2,60) = 3.47$, $p < .05$, $\eta^2 = .11$, when outliers were excluded. Separate 2 (group) × 2 (task condition) ANOVAs were conducted, again not revealing significant effects for happy and angry faces (all F's < 1.22, all p's $> .05$, all $\eta^2 < .04$). For sad faces, however, the analysis continued to show a significant group by task interaction, $F(1,30) = 8.46$, $p < .01$, $\eta^2 = .22$. We also conducted an ANCOVA controlling for comorbid anxiety and medication use. No significant interactions with task, emotion, or task by emotion were found for comorbidity of anxiety disorders (all F's < 1.28; all p's $> .05$; all $\eta^2 < .04$), nor medication use (all F's < 2.38; all p's $> .05$; all $\eta^2 < .07$).

[3] A 2 × 3 × 4 mixed design ANCOVA was used to examine group differences in stress reactivity controlling for clinical covariates. Again, covariates did not show significant effects in these analyses (Comorbidity of anxiety disorders: all F's < 1.28; all p's $> .05$; all $\eta^2 < .04$; medication use: all F's < 2.38; all p's $> .05$; all $\eta^2 < .07$).

Table 3
Mood Changes Across the Experimental Session in Each Group

	Time 1: Baseline	Time 2: Prestress	Time 3: Anticipatory-stress	Time 4: Poststress
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Happy mood				
CTL group	20.18 (6.79)	18.84 (7.92)	18.63 (7.99)	21.00 (6.94)*
MDD group	8.50 (6.39)	8.44 (7.76)	8.88 (7.42)	12.50 (9.45)*
Anxious mood				
CTL group	0.89 (2.18)	1.58 (3.71)	3.26 (3.97)*	1.11 (2.26)**
MDD group	12.00 (9.71)	11.38 (9.16)	14.44 (8.05)*	9.81 (9.19)**
Sad mood				
CTL group	0.16 (0.37)	1.16 (2.39)	0.63 (2.29)	1.21 (3.01)
MDD group	7.13 (7.18)	5.13 (5.65)	8.88 (9.21)*	7.00 (8.48)

Note. *M* = Mean; *SD* = Standard deviation; CTL = Control group; MDD = Major Depressive Disorder group.
* Significant differences from previous mood assessment at $p < .05$. ** Significant differences from previous mood assessment at $p < .01$.

analyze mood changes we constructed residualized VASs change scores using simple linear regression models in which VAS happy mood, anxious mood, and sad mood scores at a given time (i.e., Time 3: anticipatory-stress; Time 4: poststress) were predicted by their previous VAS scores (i.e., Time 2: prestress, Time 3: anticipatory-stress, respectively), and the resulting standardized residuals were saved. Using this method, mood change is computed as the residual of the postmood score and the expected postmood score as predicted by the premood score (Curran & Muthén, 1999). Residualized mood change scores were thus created by regressing postmood scores on premood scores, and then the resultant residuals were used in subsequent analyses. This method served to construct measures of mood change for each mood state from the prestress period to the anticipatory period, as well as from the anticipatory-stress period to the poststress period. Using standardized residuals is a reliable method to control variability among previous mood scores (Segal et al., 2006), as the variability among residuals can be considered independent from the previous VAS score variability, compared with other less reliable measures of mood change such as difference scores (Cohen, Cohen, West, & Aiken, 2003).

A series of regression analyses were conducted with each standardized mood change index as the dependent variable and group and attentional disengagement from sad faces as predictors. The attentional disengagement from sad faces measure was standardized by transforming original raw scores to z-scores to be included as the predictor variable of standardized mood change scores in the regression analyses. In each model, main effects of group and disengagement were entered in the first step, followed by their two-way interaction in the second step.

For happy mood changes from the prestress to the anticipation period, Step 1 only accounted for 3.6% of the variance (*n.s.*), whereas Step 2 only accounted for an additional 4.2% (*n.s.*). Similar results were found for happy mood changes from the anticipation to the poststress period, with Step 1 accounting for a 2.5% (*n.s.*) of variance and Step 2 account for an additional 0.9% (*n.s.*).

For anxious mood changes from the prestress to the anticipation period, Step 1 accounted for 28.6% of the variance ($p < .01$), but Step 2 only accounted for an additional 1% (*n.s.*). For anxious mood changes from the anticipation to the poststress period, Step 1 only accounted for 2.3% of the variance (*n.s.*) whereas Step 2 only accounted for an additional 5.5% (*n.s.*)

For sad mood changes from the prestress to the anticipation period, Step 1 accounted for 11.2% of the variance, (*n.s.*), whereas the interaction between group and attentional disengagement from sad faces in Step 2 was significant, $\beta = .498$, $p < .05$, explaining 13.5% of variance. Simple slopes analysis indicated that for participants in the CTL group, disengagement from sad faces did not predict sad mood changes during the anticipation of stress, $\Delta R^2 = .05$, $\beta = -.232$ (*n.s.*) For participants in the MDD group, however, analyses revealed a trend of disengagement from sad faces to predict sad mood increases during the anticipation of stress, $\Delta R^2 = .23$, $\beta = .481$, $p = .059$.

For sad mood changes from the anticipation to the poststress period, Step 1 accounted for 8.2% of the variance (*n.s.*) whereas the interaction between group and attentional disengagement from sad faces in Step 2 was significant, $\beta = .503$, $p < .05$, explaining 13.8% of variance. Simple slopes analysis indicated that for participants in the CTL group, disengagement from sad faces did not predict sad mood changes during the recovery period, $\Delta R^2 = .01$, $\beta = -.110$ (*n.s.*) Disengagement from sad faces in the MDD group, however, significantly predicted sad mood changes during the recovery period, $\Delta R^2 = .27$, $\beta = .523$, $p = .038$. This result indicates that difficulties in attentional disengagement from sad faces in MDD participants predicted sustained sad mood state in the recovery period. A graphic representation of this interaction is presented in Figure 3.[4]

[4] Further regression analyses excluding outliers yielded similar results. We also conducted regression analyses controlling for comorbid anxiety and medication in the first step of the regression model, followed by the main effects of group and disengagement in the second step and by their two-way group by disengagement interaction in the third step. These analyses yielded similar results. No significant predictors were found for happy and anxious mood changes. For sad mood changes from the prestress to the anticipation period, Step 1 and Step 2 only accounted for 7.3% (*n.s.*) and 4.1% (*n.s.*) of the variance, respectively, whereas the interaction between group and attentional disengagement from sad faces in Step 3 was significant, $\beta = .502$, $p < .05$, explaining 13.7% of variance. For sad mood changes from the anticipation to the poststress period, Step 1 and Step 2 only accounted for 5.2% (*n.s.*) and 9% (*n.s.*) of the variance, respectively, whereas the interaction between group and attentional disengagement from sad faces in Step 3 was significant, $\beta = .482$, $p < .05$, explaining 12.6% of variance.

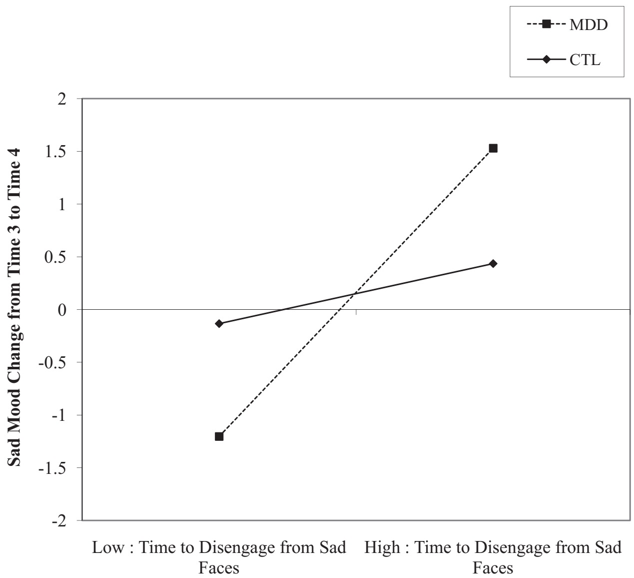

Figure 3. Disengagement from sad faces as a predictor of change in sad mood from Time 3 (anticipatory-stress) to Time 4 (poststress) in participants with Major Depressive Disorder (MDD) and controls (CTL). Time to Disengage from sad faces: Low Time refers to faster times in disengaging attention from sad faces (−1 SD); High Time refers to slower times in disengaging attention from sad faces (+1 SD). Sad mood change from Time 3 to Time 4: Scores greater than zero indicates mood increases, whereas scores lower than zero indicates mood decreases.

Discussion

Using a novel eye-tracking task that allows for a direct assessment of attentional engagement and disengagement, the present study tested whether clinically depressed people show difficulties disengaging attention from depression-related stimuli and whether those difficulties are associated with mood changes during and after a stress induction. Previous eye-tracking studies have shown that depressed individuals are no more likely than controls to shift their attention toward negative stimuli, but once their attention is focused on negative stimuli they spend significantly more time looking at these stimuli (e.g., Caseras et al., 2007; Kellough et al., 2008). In the natural viewing part of our study, we replicated this finding. MDD compared with CTL participants did not show differences in their initial orientation nor in their frequency to fixate on negative material, but they were characterized by a significantly higher maintained attention to negative material. Moreover, CTL participants were characterized by a bias to fixate longer on positive material that was absent in MDD participants. This lack of a positivity bias in depressed individuals has been reported in previous eye-tracking research (e.g., Kellough et al., 2008; Sears et al., 2010) and suggests that the attentional processing of both positive and negative information is affected in this disorder.

Previous eye-tracking research has speculated that the bias in maintained attention to negative material observed in depressed individual may reflect difficulties in disengagement (Caseras et al., 2007). However, experimental and eye-tracking designs used thus far do not allow to systematically test this hypothesis. The engagement−disengagement task employed in our study allowed for a direct assessment of these attention components through the registration of eye movements. Our results support that depression is associated with difficulties disengaging attention from depression-related stimuli. Specifically, MDD compared with CTL participants took longer to look away from sad faces when prompted to focus on a neutral face. Recent research using eye tracking has shown that dysphoric undergraduate students were slower to disengage their attention from depression-related compared with nondysphoric images (Sears et al., 2010). The present study replicates this finding and extends the results to a sample of clinically depressed participants. Yet, the method employed by Sears et al. (2010) does not permit a direct assessment of different components of attention. The eye-tracking paradigm developed for this study allowed to monitor and compare attentional components of engagement versus disengagement in controlled conditions. Our results indicate that disengagement difficulties in MDD participants were specific to depression-related stimuli (i.e., sad faces) and that attentional engagement and disengagement from other emotional stimuli (i.e., angry faces, happy faces) did not differ from CTL participants.

Difficulties disengaging attention from depression-relevant material may reflect deficits in inhibitory control that are associated with depression (e.g., Joormann, 2004; MacQueen, Tipper, Young, Joffe, & Levitt, 2000). Overriding prepotent responses and inhibiting the processing of irrelevant material that captures attention are core abilities that allow us to respond flexibly and to adjust our behavior and emotional responses to changing situations. Thus, malfunctioning inhibition of irrelevant negative stimuli could result in prolonged processing of negative, goal-irrelevant aspects of presented information and thereby hindering recovery from negative mood and leading to the sustained negative affect that characterizes depressive episodes (Gotlib & Joormann, 2010).

Indeed, it has been argued that attention biases in depression may play an important role in mood regulation, precluding depressed people from using effective regulation strategies when coping with stressful situations (Joormann & D'Avanzato, 2010). In the present study we tested if depressed participants' difficulty disengaging attention from depression-related stimuli predicts their mood changes after exposure to a stressor. MDD compared with CTL participants not only showed increases in anxious mood when anticipating a stressful situation (i.e., giving a speech) but also increases in sad mood. Furthermore, MDD participants did not recover from their sad mood up to 5 minutes after being informed that they would not have to give the speech. Importantly, depressed participants' disengagement from sad faces was related to higher sad mood levels during the recovery phase. The association between attention and stress recovery found in this study is congruent with previous results indicating that a reduced ability to disengage attention is associated with changes in negative mood in a subsequent stress task (e.g., Compton, 2000; Ellenbogen et al., 2006). Our study replicates and extends these findings in a sample of clinically depressed individuals, using an eye-tracking assessment of patterns of attentional disengagement. Furthermore, the study replicates a recent finding that attention biases (assessed with a visual probe task) were related specifically to mood recovery after a negative mood induction in MDD participants (Clasen, Wells, Ellis, & Beevers, 2012).

Taken together, these results are congruent with the proposition that difficulties in disengaging attention are linked to an ineffective use of mood regulation strategies and thus, to maintained negative affect (Joormann & D'Avanzato, 2010). Difficulties disengaging from negative stimuli may preclude depressed people from using effective emotion regulation strategies such as distraction when confronted with stressful events, resulting in sustained processing of negative information, which leads to prolonged negative affect. In addition, attentional biases may interfere with the ability to successfully reframe negative situations using reappraisal. Furthermore, difficulties in attentional disengagement may contribute to the continuous processing of negative information observed in depressed individuals, such as rumination (Koster, De Lissnyder, Derakshan, & De Raedt, 2011), which in turn may lead to prolonged negative affect (De Raedt & Koster, 2010).

Future research should address these questions by directly examining the causal links between attention and sad mood persistence in depression. For instance, several studies have aimed to train people to overcome biased cognitive processes thereby changing emotional responding. These studies have demonstrated that training anxious people to disengage their attention from threat material leads to changes in mood and reduced reactivity to stressful events (e.g., Amir, Weber, Beard, Bomyea, & Taylor, 2008; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). However, the relation between the modification of attentional disengagement and mood regulation under stressful events has not yet been examined in clinical depression. A recent study has yielded promising results, indicating that training mild to moderately depressed college students to disengage their attention from mood-congruent stimuli leads to decreases in their depressive symptoms (Wells & Beevers, 2010). Further research should examine if training depressed individuals to disengage their attention from mood-congruent stimuli leads to changes in the use or effectiveness of emotion regulation strategies during a stressful event.

Our findings promise to increase our understanding of how attentional biases may contribute to the maintenance of sad mood in depression. However, it should be noted that the analysis of the relation between attention and stress recovery was correlational. More direct evidence for a causal role of attentional biases in mood generation and regulation will require studies that examine how the modification of attention biases is related to changes in mood reactivity and recovery. Further research directed to modify attentional disengagement in depressed individuals, as noted above, will be necessary to clarify this question. Another limitation of this study is the small sample size. Given this, it is possible that the regression analyses presented were underpowered and, as such, drawing conclusions from the null findings is cautioned against. Replication of the current findings within a larger clinically depressed sample is clearly needed to further elucidate these relations. That attentional disengagement from depression-related stimuli predicted depressed participants' mood recovery status after the stress induction despite a potential lack of power, however, speaks to the strength of this relation. Furthermore, future studies should try to recruit groups of pure depression and comorbid depression/anxiety so that the role of anxiety in attention bias in MDD can be more directly examined. Previous research has shown that patients with comorbid depression and anxiety disorders were characterized by specific patterns of negative information processing (e.g., Musa, Lepine, Clark, Mansell, & Ehlers, 2003). Thus, further research using large clinical samples should examine more specifically the role of anxiety in attention bias in MDD.

The current study should be noted for its methodological rigor. The study examined a diagnosed sample of depressed participants using eye-tracking methodology that allowed for a continuous monitoring of visual orienting. Furthermore, the study used a novel eye-tracking paradigm that allowed for the assessment of engagement and disengagement components in controlled conditions, an aspect not addressed by previous eye-tracking research. Finally, the stress induction was based on a previously well-validated procedure that has been shown to induce stress as assessed not only by self-reported mood changes but also by psychophysiological indicators (Waugh et al., 2011). This procedure also allowed us to examine reactivity and recovery from an acute stressor, two different aspects of stress responding not commonly differentiated in previous research in this field.

In sum, our study has replicated previous findings that depressed individuals exhibit maintained attention to negative information. Moreover, the present study extends these findings using a novel task which supports the proposition that difficulties in disengaging from depression-relevant stimuli characterize attention biases in depression. Importantly, individual differences in disengagement predicted higher sadness ratings in response to the stress induction in the MDD group. These results indicate that difficulties in attentional disengagement may contribute to the sustained negative affect that characterizes depressive disorders. Thus, attentional processing may have important implications for the maintenance and recovery from depressive disorders.

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