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Temporal changes in attention to sad and happy faces distinguish currently and remitted depressed individuals from never depressed individuals

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ABSTRACT

Depression is associated with attentional biases for emotional information that are proposed to reflect stable vulnerability factors for the development and recurrence of depression. A key question for researchers is whether those who have recovered from depression also exhibit attentional biases, and if so, how similar these biases are to those who are currently depressed. To address this question, the present study examined attention to emotional faces in remitted depressed ($N=26$), currently depressed ($N=16$), and never depressed ($N=33$) individuals. Participants viewed sets of four face images (happy, sad, threatening, and neutral) while their eye movements were tracked throughout an 8-s presentation. Like currently depressed participants, remitted depressed participants attended to sad faces significantly more than never depressed participants and attended to happy faces significantly less. Analyzing temporal changes in attention revealed that currently and remitted depressed participants did not reduce their attention to sad faces over the 8-s presentation, unlike never depressed participants. In contrast, remitted depressed participants attended to happy faces similarly to never depressed participants, increasing their attention to happy faces over the 8-s presentation. The implications for cognitive theories of depression and depression vulnerability are discussed.

1. Temporal changes in attention to sad and happy faces distinguish currently and remitted depressed Individuals from never depressed Individuals

Cognitive theories of depression propose that biased attention to emotional information is an important risk factor associated with the onset, maintenance, and recurrence of depression (Beck, 1987; Beck and Clark, 1988; Gotlib and Joormann, 2010). Two distinct manifestations of biased attention in depressed individuals have been identified (Peckham et al., 2010; Yiend, 2010; Armstrong and Olatunji, 2012). The first is increased attention to depression-relevant themes and stimuli (e.g., negatively valenced words; images related to sadness) relative to never depressed individuals, which is often referred to as a negative attentional bias. The second is decreased attention to positive stimuli (e.g., positively valenced words and images) relative to never depressed individuals. Attentional biases are proposed to be stable, trait-like characteristics, rather than a transient state-like symptom of depression (e.g., Beck and Clark, 1988; DeRaedt and Koster, 2010; Gotlib and Joormann 2010; Ingram et al., 2008; Koster et al. 2011), and cognitive theories predict that these biases will be present in both currently and remitted depressed individuals. The evidence for these biases in remitted depressed individuals has been mixed, however, and not all researchers agree that attentional biases should be stable (e.g., Just et al., 2001; Mathews and MacLeod, 2005; Scher et al., 2005). One purpose of the present study was to determine if remitted depressed individuals exhibit biased attention to emotional information similar to currently depressed individuals in an eye gaze tracking paradigm known to be especially effective for measuring biased attention (see Armstrong and Olatunji, 2012). In addition, we examined changes in attention over time to determine if remitted and currently depressed individuals differed in their temporal profiles of attention to emotional information.

1.1. Attentional biases in currently and remitted depressed Individuals

The majority of studies examining depression-related attention biases have focused on currently depressed or dysphoric

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individuals. Researchers have used several tasks to examine attentional biases in these populations, including the dot-probe task (e.g., Joormann and Gotlib, 2007; Joormann et al., 2007; see Peckham et al., 2010, for a review), the emotional Stroop task (see Epp et al., 2012, for a review), the dichotic listening task (e.g., Ingram et al., 2008), visual search tasks (e.g., Wenzlaff et al., 2001), and the deployment of attention task (e.g., McCabe et al., 2000). Although a great deal has been learned about attention in depression using these tasks, most of these tasks use response latencies to infer attentional engagement and are therefore not direct and objective measures of attention (see Yiend, 2010, for a review). Several studies have used eye gaze tracking paradigms to examine attention to emotional images or words in depressed individuals (see Armstrong and Olatunji, 2012, for a review). The major advantage of eye gaze tracking is that it provides a direct and moment-by-moment record of the allocation of attention, because the direction of gaze and the focus of attention are tightly coupled (Wright and Ward, 2008). An additional advantage is that the allocation of attention can be measured over extended intervals, as opposed to the single "snapshot" of attention captured in other attention tasks. This ability to measure changes in attention over time was an important feature of the present study.

A meta-analysis of studies that used eye tracking to assess attention to emotion in currently depressed and dysphoric individuals found evidence of both increased attentional engagement with negative stimuli and decreased engagement with positive stimuli, relative to never depressed individuals (Armstrong and Olatunji, 2012). In contrast to the threat-related attentional bias consistently observed for anxious individuals (Bar-Haim et al., 2007), the bias for negative stimuli for depressed individuals was specific to dysphoric stimuli (i.e., words and images involving themes of sadness or loss) and was not present for threatening stimuli (Armstrong and Olatunji, 2012). For example, Eizenman et al. (2003) used an eye gaze tracking paradigm to compare currently and never depressed individuals' attention to emotional images. Displays of four images (a neutral image, dysphoric image, threatening image, and positive/social image) were presented for 10.5 s while participants' eye movements were tracked and recorded. Eizenman et al. found that depressed participants attended to dysphoric images significantly more than never depressed participants, with no differences for threatening images. In a similar study, with displays of 30 s, Kellough et al. (2008) also found that depressed participants attended to dysphoric images significantly more than never depressed participants (with no differences for threatening images). They also found that depressed participants attended to positive images less than never depressed participants. Similar results were reported by Sears et al. (2010) and Arndt et al. (2014), who compared dysphoric and never depressed participants' attention to positive and negative images. Leyman et al. (2011) compared dysphoric and never depressed participants' attention to happy, sad, angry, and neutral face images and found that dysphoric participants attended to sad faces significantly more than never depressed participants and attended to happy faces significantly less. Note that in none of the studies comparing dysphoric and never depressed individuals were there group differences in attention to threatening stimuli, which further demonstrates the specificity of the negative bias to dysphoric content.

In contrast to the generally consistent findings of eye tracking studies of currently depressed and dysphoric individuals, few studies have used this methodology to examine attention to emotion in remitted depressed individuals, and the results of these studies have not been consistent. Two studies found evidence of attentional biases among remitted depressed participants, although the nature of the bias differed somewhat in the two studies. Sears et al. (2011) showed participants sets of depression-related, anxiety-related, positive, and neutral images and found that both dysphoric and remitted depressed participants attended to positive images significantly less than never depressed participants. They also found that remitted depressed participants attended to threat-related images significantly more than never depressed participants. Newman and Sears (2015) used a similar methodology and found that remitted depressed participants attended to depression-related images significantly more than never depressed participants (with a trend toward the opposite difference for positive images).

Very different results were reported by Isaac et al. (2014), who showed currently depressed, remitted depressed, and never depressed participants sets of four faces, with angry, sad, neutral, and happy expressions—they found no evidence of emotion-specific attentional biases among remitted depressed participants. Currently and remitted depressed participants attended to all face types more than never depressed participants, but did not show specific biases in overall fixation time to sad or happy expressions. Isaac et al. did find that currently depressed participants had shorter glance durations to happy faces than never depressed participants, whereas the remitted and never depressed participants did not differ. Their results were interpreted as a possible indication that successful treatment of depression may ameliorate reduced processing of positive stimuli. Thus, despite the advantages of eye gaze tracking for measuring biased attention, the results of these studies indicate that there is no consensus at present as to whether the attentional biases characteristic of current depression persist or ameliorate upon remission of a depressive episode. Given the small number of eye tracking studies that have examined attentional biases in remitted depressed individuals, the present study contributes significantly to the literature on attention in remitted depression.

1.2. Time course of attention to emotional stimuli in depression

Another important question for depression researchers concerns the temporal pattern of attention to emotion in depression: how does attention to emotional stimuli change over time and do these temporal changes differ among currently depressed, remitted depressed, and never depressed individuals? The answers to these questions will lead to a better understanding of the nature of attentional biases in depression, which aspects of attention to emotion are most relevant for depression vulnerability, and how attentional biases may be effectively altered. In their review of the literature on depression-related attentional biases, Mogg and Bradley (2005) suggested that the biases operate at later, more elaborative stages of stimulus processing. This was based on their observation that studies that employed longer stimulus durations (e.g., 1000 ms) in response latency paradigms such as the dot probe and emotional Stroop task were more likely to observe attentional biases than studies with shorter stimulus durations (e.g., 14–500 ms; Mogg and Bradley, 2005). This would suggest that in contrast to the exogenous capture of attention by threatening stimuli observed with anxious individuals (e.g., Bar-Haim et al., 2007), the bias in depression may be a more controlled and motivated process (Mogg and Bradley, 2005). On the other hand, a subsequent meta-analysis of biased attention in depression found no difference in effect sizes for studies that used stimulus presentations greater than 1000 ms and those that used 500 ms presentations (Peckham et al., 2010).

A major advantage of eye tracking paradigms is that the focus of attention can be tracked continuously over extended periods of viewing, which makes these paradigms optimally suited for examining temporal changes in attention. Surprisingly, only two eye tracking studies have examined temporal changes in attention to emotional stimuli in depressed/dysphoric individuals and never

depressed individuals. In one of these studies, Kellough et al. (2008) presented clinically depressed and never depressed younger adults with sets of four different images (dysphoric, threatening, positive, and neutral) and tracked and recorded participants' gaze throughout a 30-s presentation. Kellough et al. (2008) carried out a series of analyses (dividing the fixation data into six 5-s intervals) and found that group differences in attention to dysphoric and positive images were similar throughout the 30-s presentation—during each 5-s interval, depressed participants spent more time attending to dysphoric images and less time attending to positive images than never depressed participants. Arndt et al. (2014) carried out a similar study and compared dysphoric participants to never depressed participants. Their analyses divided each 10-second presentation into 2-s intervals and revealed that differences in attention between dysphoric and non-dysphoric participants to positive and depression-related images emerged after 4 s. Arndt et al. (2014) also carried out trend analyses to examine changes in attention over time for the dysphoric and non-dysphoric groups. They found that non-dysphoric participants decreased their attention to depression-related images, whereas dysphoric participants maintained their attention to depression-related images over the course of the presentation. For positive images, non-dysphoric participants displayed a sharp increase in attention over the presentation. Dysphoric participants' attention to positive images also increased over the course of the presentation, although this increase was considerably attenuated relative to non-dysphoric participants. These results support the view that attentional biases in depression emerge after elaborative processing has begun and are maintained over time. No study has evaluated temporal changes to emotional stimuli in remitted depressed individuals or compared the temporal profile of attention of remitted depressed individuals to those of currently and never depressed individuals.

1.3. The present research

The first goal of the present study was to determine if remitted depressed individuals exhibit biases in their attention to emotional stimuli similar to currently depressed individuals; the second goal was to determine if previously and currently depressed individuals were similar in terms of temporal changes in attention. Participants viewed sets of four face images (each set included a happy, sad, threatening, and neutral face) while their eye movements were tracked throughout an 8-s presentation time. Presenting happy and sad faces allowed us to test for the depression-related biases observed in previous studies (i.e., increased attention to negative stimuli and decreased attention to positive stimuli), and presenting threat faces allowed us to test for the specificity of any negative attentional bias. Like other investigators (e.g., Isaac et al., 2014), we reasoned that face images may be especially effective for measuring biased attention to emotional information in depression. Facial emotion is recognized as a key source of social information and plays a significant role in social functioning and emotion regulation (Bistricky et al., 2011). Facial expressions provide insights into the emotional states of others and interpersonal connections, and are therefore quick to engage attention (Leyman et al., 2011). According to interpersonal theories of depression (e.g., Joiner and Coyne, 1999), depressed individuals are highly vigilant for signs of interpersonal rejection, and therefore facial expressions may be especially salient stimuli because of the information they provide about the emotional states of others. Consistent with this reasoning, several studies have reported differences in the processing of emotional faces in depressed individuals; for example, Wu et al. (2012) reported differences in facial affect processing and emotion recognition among individuals high in depressive symptoms compared to those low in depressive symptoms. ERP research also suggests that happy faces are less salient and receive less attention in depressed individuals, as measured by the P300, which is proposed to reflect processes involved in stimulus evaluation or categorization (Cavanagh and Geisler, 2006).

The second goal of our study was to examine temporal changes in attention to emotional faces. To measure changes in attention over time, we divided the fixation data from each 8-s presentation into 2-s intervals and analyzed this time course data using two different methods: we evaluated between-group differences in fixation times to each face type for each 2-s interval, and we evaluated within-group differences in fixation times to each face type across the 2-s intervals to measure group-specific changes in attention over time. These analyses allowed us to determine at what point in the 8-s presentation group differences in attention to the face images would arise and how attention to the face images would change over time for remitted depressed, currently depressed, and never depressed participants. Based on the view that biased attention is a trait-like vulnerability factor for depression (e.g., Beck and Clark, 1988; DeRaedt and Koster, 2010; Gotlib and Joormann, 2010; Ingram et al., 2008; Koster et al., 2011), we predicted that remitted depressed participants would exhibit attentional biases similar to the documented attentional biases of currently depressed participants; specifically, increased attention to sad faces and decreased attention to happy faces relative to never depressed participants. With respect to temporal changes in attention to the emotional faces, based on the previous literature (Arndt et al., 2014; Kellough et al., 2008), we predicted that group differences would develop over time and that remitted depressed and currently depressed participants would exhibit similar temporal changes of attention that would be different than the changes observed for never depressed participants.

2. Method

2.1. Participants

Participants consisted of community members and university students. Only females were recruited to participate in order to minimize potential gender differences that could obscure any group differences in attention, as there is evidence of gender differences in the processing of facial affect and emotional stimuli (e.g., Donges et al., 2012; Kemp et al., 2004; Montagne et al., 2005). In addition, previous research has documented robust gender differences in the frequency and experience of depression (e.g., Kessler et al., 1993; Piccinelli and Wilkinson, 2000). There were 16 currently depressed, 26 remitted depressed, and 33 never depressed participants. Participants were recruited as part of a longitudinal study examining predictors of depression relapse. Recruitment was carried out using an online research participation system and by placing posters on campus and in the community. In exchange for taking part in the study, participants received either bonus credit in a psychology course or a $25 (CAN) gift card. Participants were classified into the currently depressed, remitted depressed, or never depressed group according to criteria described below. The descriptive statistics for each group are shown in Table 1.

2.1.1. Measures

The Patient Health Questionnaire-9 (PHQ-9; Spitzer et al., 1999) is a 9-item depression scale based on the diagnostic criteria for major depressive disorder as described in the Diagnostic and Statistical Manual 4th Edition (DSM-IV). Two versions of the PHQ-9 were used to assess past (PHQ-Lifetime) and current (PHQ-Current) depression. The PHQ-Current assesses how often the

Table 1
Participant characteristics for the never depressed, remitted depressed, and currently depressed groups.

Measure	Never depressed ($N=33$)		Remitted depressed ($N=26$)		Currently depressed ($N=16$)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Age	24.1_a	11.5	29.3_a	10.7	25.1_a	11.7
Mood	2.9_a	1.5	2.2_a	1.6	-0.6_b	2.2
BAI	2.7_a	3.4	8.9_b	9.0	21.6_c	11.5
BDI-II	1.6_a	2.1	6.1_b	3.8	33.5_c	10.5
PHQ-C	0.7_a	1.0	2.9_b	2.4	17.8_c	4.4
PHQ-L	1.8_a	3.4	20.3_b	4.6	21.3_b	3.8

Note: Descriptive statistics are based on the second, in-lab administration of these measures. Age=in years. Mood=current mood rating from −5 (*very negative*) to +5 (*very positive*). BAI=Beck Anxiety Inventory. BDI-II=Beck Depression Inventory. PHQ-C=Patient Health Questionnaire (Current). PHQ-L=Patient Health Questionnaire (Lifetime). Means in the same row that do not share a subscript differ at $p<.05$ in a t-test comparison.

respondent has experienced each depression symptom over the past two weeks, whereas the PHQ-Lifetime assesses the frequency of depression symptoms during any two-week or longer period during which the respondent felt most depressed in his or her life. The internal consistency of the PHQ is high, with Cronbach alphas of 0.86 and 0.89 in a study of two different patient populations (Kroenke et al., 2001). The internal consistency (Cronbach's alpha) of the PHQ-Lifetime for this sample was 0.96 and for the PHQ-Current it was 0.91. The PHQ-Lifetime has been found to have convergent validity with a diagnosis of a history of depression using the Structured Clinical Interview for DSM-IV Disorders (SCID; Cannon et al., 2007).

The BDI-II (Beck et al., 1996) is a 21-item self-report inventory that measures a participant's depressive symptoms over the past two weeks. Each item is rated from zero to three, with higher scores indicating greater severity of depression symptoms. As reported by Beck et al. (1996), the BDI-II has excellent internal consistency in student (Cronbach's alpha=0.93) and outpatient samples (0.92), and excellent test-retest reliability ($r=0.93$). The internal consistency of the BDI-II for this sample was 0.96.

The Beck Anxiety Inventory (BAI; Beck and Steer, 1993) is a 21-item self-report measure that assesses current anxiety symptoms over the most recent week. Each item is rated from zero to three, with higher scores indicating greater anxiety symptom severity. The internal consistency (Cronbach's alpha) of the BAI for this sample was 0.94.

The Structured Clinical Interview for Axis I Disorders (SCID-I; First et al., 1995) is a comprehensive semi-structured interview that assesses current and lifetime presence of Axis I disorders using the diagnostic criteria outlined in the DSM-IV-TR (APA, 2000). The SCID-I was used to assess past and current depressive episodes, past and current mania, dysthymia, psychotic symptoms, and substance abuse. A randomly selected 20% of the interviews were checked by a registered clinical psychologist (KS Dobson) for their diagnostic accuracy.

2.2. Stimuli

Stimuli consisted of 120 face images taken from the NimStim Database (Tottenham et al., 2009). The database consists of face images depicting a variety of expressions created for use in studies of face and emotion recognition. Four categories of faces were used in the present study: happy, sad, threatening, and neutral. We used happy and sad faces because of the documented depression-related differences for positive and dysphoric stimuli. The distinction between sad and threatening faces was intended to differentiate between themes of sadness and threat; because both types of images contain negative emotional content, it was important to differentiate between the two in order to assess the specificity of any attentional biases observed. The happy faces consisted of faces that were smiling and friendly-looking. The sad faces depicted individuals frowning or looking upset. The threatening faces showed individuals that appeared either angry or fearful (e.g., furrowed brows and snarling mouths). The neutral faces showed individuals with blank expressions (neither smiling nor frowning). Faces were selected to ensure that there were an equal number of open and closed mouths for each face type. An equal number of male and female faces were presented (60 male and 60 female), and for each face type (happy, sad, threatening, and neutral) there were an equal number of male and female faces (15 for each face type).

2.3. Apparatus

Eye movements were recorded using an EyeLink 1000 eye tracking system (SR Research Ltd., Ottawa, Ontario), which uses infrared video-based tracking technology. The system has a 1000 Hz sampling rate, a temporal resolution of 2 ms, and a typical gaze accuracy of 0.25–0.50 degrees of visual angle. Stimuli were shown on a 21-inch monitor positioned approximately 60 cm away from the participant. Participants used a chin rest to minimize head movements and increase tracking accuracy.

2.4. Procedure

An initial online prescreen (using Survey Monkey; www.surveymonkey.com), consisting of two versions of the PHQ-9 (the PHQ-Current and the PHQ-Lifetime) and the BDI-II was first completed. Individuals were invited to participate in a clinical interview to determine their study eligibility if they met criteria for one of the three study groups (currently depressed, remitted depressed, or never depressed), based on their prescreen responses. The criteria used to classify participants were as follows: (1) currently depressed participants endorsed five or more of the criteria on the PHQ-Current, with at least one of them being either depressed mood or loss of interest/pleasure for over half the days of the most recent two weeks, along with a BDI-II score of 20 or greater, (2) remitted depressed participants endorsed five or more of the criteria on the PHQ-Lifetime, with at least one of them being either depressed mood or loss of interest/pleasure for over half the days, but did not meet criteria for current depression on the PHQ-Current, (3) never depressed participants endorsed no symptoms on the PHQ-9 (Current or Lifetime) and had a BDI-II score less than or equal to 6. Remitted depressed individuals also reported their most recent episode of depression; 38% reported that their last episode occurred within the past year, and the remainder reported that their last episode occurred more than a year ago.

Participants were given detailed information about the study and provided informed consent at the time of their lab visit. To confirm study eligibility, a researcher then administered the SCID-I. Interviewers consisted of graduate and undergraduate psychology students who had received training in administration of the SCID-I. Currently depressed participants had to meet criteria for a current major depressive episode. Remitted depressed participants had to meet criteria for a past major depressive episode, but not for a current depressive episode. The never depressed participants could not meet criteria for either past or current major depressive episodes, nor could they report a history of depression in their immediate family. Exclusion criteria for all participant groups were the presence of mania, psychosis, or substance abuse.

For the eye tracking phase of the study, participants viewed 30 sets of four face images (happy, sad, threatening, and neutral) for

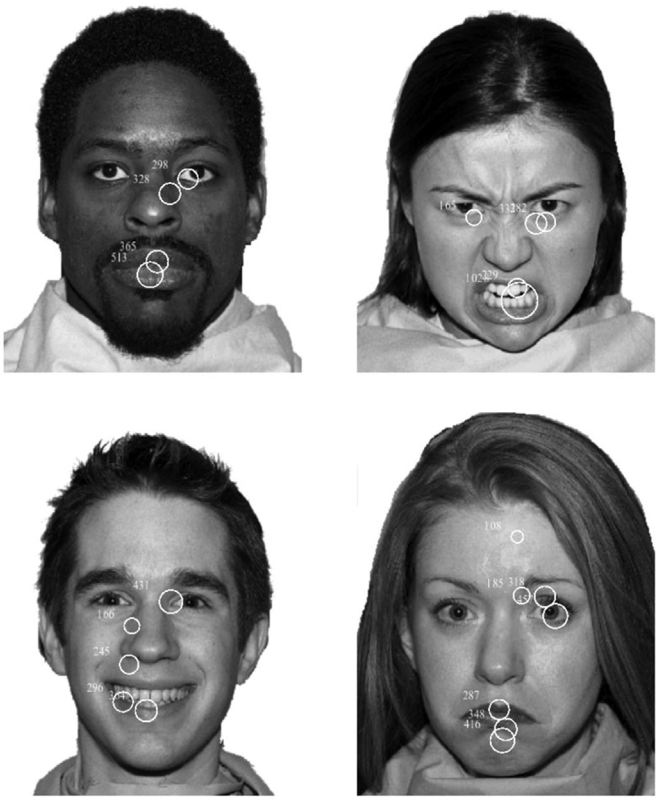

Fig. 1. An example display with eye tracking data. The small white circles denote individual fixations; numbers adjacent to fixations indicate the duration of the fixation (in milliseconds). These fixation data are superimposed on the faces for illustration purposes and were not visible to participants. The faces are shown in gray scale to increase the contrast of the markings; they were shown in color to participants.

8 s each. One image was presented in each of the four quadrants of the computer display. Unlike the displays used by Isaac et al. (2014), each display consisted of the faces of four different individuals; our concern with using four faces of the same individual was that it creates an unnatural and unusual viewing situation. The placement of the faces in the display was randomized. Fig. 1 shows an example display (with fixation data superimposed on the face images). At the beginning of each trial, the participant was asked to fixate on a dot in the middle of the display to ensure proper gaze measurement. Participants were instructed to look freely at the images throughout the presentation. Two practice trials preceded the 30 experimental trials, in order to familiarize the participant with the procedure.

Following the eye tracking task, participants were asked to complete an online questionnaire battery, including the PHQ-9, the BDI-II, the BAI, a demographic survey, and questions about personal and family history of depression and current mood.

3. Results

The fixation data were processed using the EyeLink Data Viewer analysis software (SR Research) to filter for blinks, missing data, and other recording artifacts (using the default settings). To be included in the analyses, a fixation had to be at least 100 ms in duration. The dependent variable was the total fixation time for each face image within each 2-s interval (0–2 s, 2–4 s, 4–6 s, 6–8 s), calculated for each face image for each of the 30 trials and then averaged across all trials. The data were converted to percentages for ease of interpretation (percentage of total fixation time within each interval; e.g., a fixation percentage of 25% for happy faces for the 0–2 s interval indicates that on average happy faces were fixated for 25% of the total fixation time within this interval). The longer an image was fixated within an interval the larger the percentage of fixation time it would receive, and therefore higher percentages reflect greater attention to an image. The design was a 3 (Group: currently depressed, remitted depressed, never depressed) × 4 (Face Type: happy, sad, threatening, neutral) × 4 (Time Interval: 0–2 s, 2–4 s, 4–6 s, 6–8 s) mixed-model analysis of variance (ANOVA), with Face Type and Time Interval as within-subject factors. The fixation data are listed in Table 2.

Table 2
Percentage of fixation time for sad, happy, threatening, and neutral faces for each time interval.

Face type	Never depressed	Remitted depressed	Currently depressed
0–2 s			
Sad	23.0 (3.0)	23.1 (4.3)	23.8 (3.4)
Happy	24.0 (3.9)	22.7 (3.4)	20.2 (4.3)
Threatening	20.2 (3.3)	21.1 (3.8)	21.4 (3.5)
Neutral	20.8 (2.7)	19.3 (3.2)	21.5 (3.8)
2–4 s			
Sad	22.9 (6.8)	23.9 (4.6)	23.5 (4.5)
Happy	30.0 (8.3)	25.1 (5.9)	26.5 (5.6)
Threatening	21.7 (4.8)	25.0 (7.0)	24.2 (5.6)
Neutral	24.6 (5.2)	24.5 (4.7)	24.8 (4.7)
4–6 s			
Sad	18.2 (4.3)	21.4 (5.0)	23.9 (5.5)
Happy	34.3 (11.8)	27.4 (8.7)	23.9 (6.0)
Threatening	23.2 (7.1)	25.0 (6.6)	23.2 (6.0)
Neutral	22.7 (5.7)	23.9 (3.7)	26.6 (7.2)
6–8 s			
Sad	17.9 (6.2)	21.9 (8.3)	25.7 (9.0)
Happy	36.9 (15.6)	29.2 (10.1)	22.4 (10.1)
Threatening	19.9 (7.3)	21.7 (7.4)	21.1 (4.5)
Neutral	21.9 (7.3)	22.6 (7.1)	26.5 (8.0)

Note: standard deviations in parentheses. Percentages may not sum to 100% within each interval due to fixations outside of the four face images in the displays.

The most important results were the two-way interaction between Group and Face Type, $F(6, 216)=6.47$, $p<0.001$, partial $\eta^2=0.15$, and the three-way interaction between Group, Face Type, and Time Interval, $F(18, 648)=2.46$, $p<0.01$, partial $\eta^2=0.06$. The interaction between Group and Face Type was followed up using one-factor ANOVAs, one for each face type. These analyses showed that the three groups differed in their percentage of fixation time for sad faces, $F(2, 72)=5.39$, $p<.01$, partial $\eta^2=0.13$, happy faces, $F(2, 72)=9.27$, $p<0.001$, partial $\eta^2=0.20$, and neutral faces, $F(2, 72)=3.10$, $p=0.05$, partial $\eta^2=0.08$, but not for threatening faces, $F(2, 72)=1.69$, $p=0.19$. The significant group differences were followed up with t-tests. Currently depressed and remitted depressed participants attended to sad faces significantly more than never depressed participants (24.3%, 22.6%, and 20.6%, respectively), whereas the difference between currently depressed and remitted depressed participants was not significant (see Table 3).

Table 3
Percentage of fixation time for sad, happy, threatening, and neutral face images, averaged over the 8-s presentation.

Face type	Never depressed	Remitted depressed	Currently depressed
Sad	20.6_a	22.6_b	24.3_b
Happy	31.4_a	26.1_b	23.3_b
Threatening	21.3_a	23.2_a	22.5_a
Neutral	22.5_a	22.6_a	24.9_b

Note: Means in the same row that do not share subscripts differ at $p<.05$ in a t-test comparison. Percentages may not sum to 100% within each group due to fixations outside of the four face images in the displays.

For happy faces, currently depressed and remitted depressed participants attended to the faces significantly less than never depressed participants (23.3%, 26.1%, and 31.4%, respectively), whereas currently depressed and remitted depressed participants did not differ. Interestingly, currently depressed participants attended to neutral faces significantly more than never depressed and remitted depressed participants (24.9%, 22.6%, and 22.5%, respectively). Taken together, these results indicate that remitted depressed participants attended to happy and sad faces similarly to currently depressed participants when the fixation data were averaged over the 8-second presentation (i.e., ignoring changes in attention over time).[1]

The significant three-way interaction between Group, Face Type, and Time Interval indicated that the differences between the groups for each face type varied over the 8-s presentation. The three-way interaction was followed up using simple interaction effects (Group × Time Interval interactions), one for each of the four face types, to determine how the groups differed in their attention to each face type over the 8-s. To control the Type I error rate, these interaction effects were followed up only if the interaction was statistically significant ($p < 0.05$). The interaction effect was significant for sad faces, $F(6, 216)=3.16$, $p < 0.01$, partial $\eta^2=0.08$, and happy faces, $F(6, 216)=3.58$, $p < 0.01$, partial $\eta^2=0.09$, but not for threatening faces, $F < 1$, or neutral faces, $F(6, 216)=1.27$, $p=0.27$. Thus, only for sad and happy faces was there evidence that the group differences varied over the 8-s presentation. The data for the sad faces are shown in Fig. 2 and the data for the happy faces are shown in Fig. 3.

3.1. Attention to sad faces

Fig. 2 reveals very minor differences between the groups in their attention to sad faces during the first 4 s of the 8-s presentation. This was confirmed by analyzing the fixation data for each interval separately using simple main effects. For the 0–2 s interval and the 2–4 s interval the groups did not differ significantly in their attention to sad faces (both $Fs < 1$). In contrast, for the 4–6 s interval there were significant group differences, $F(2, 72)=7.87$, $p < 0.01$, partial $\eta^2=0.18$. Currently depressed and remitted depressed participants attended to sad faces more than never depressed participants (23.9%, 21.4%, and 18.2%, respectively), $t(47)=3.80$, $p < 0.001$, $d=1.15$; $t(57)=2.48$, $p < 0.05$, $d=0.69$, respectively. The difference between remitted depressed and currently depressed participants was not significant, $t(40)=1.59$, $p=0.11$. There was a similar pattern of group differences for the 6–8 second interval, $F(2, 72)=5.83$, $p < .01$, partial $\eta^2=0.14$, with currently depressed and remitted depressed participants attending to sad faces more than never depressed participants (25.7%, 21.9%, and 17.9%, respectively), $t(47)=3.32$, $p < 0.01$, $d=1.01$; $t(57)=2.1$, $p < 0.05$, $d=0.55$, respectively. Currently depressed and remitted depressed participants did not differ, $t(40)=1.55$, $p=0.12$.

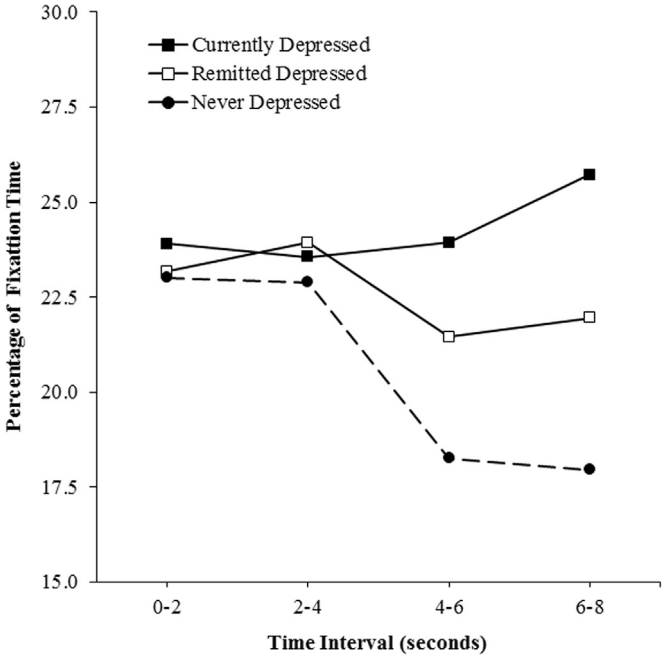

Fig. 2. Percentage of fixation time for sad faces for each 2-s interval.

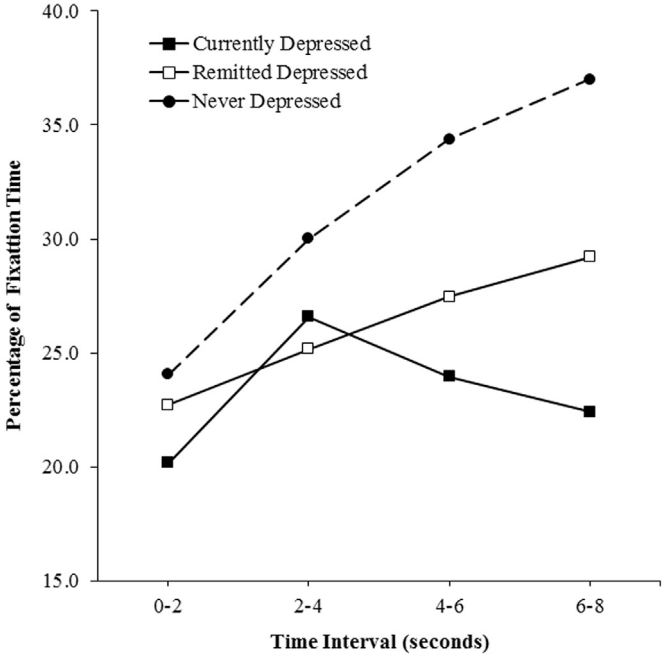

Fig. 3. Percentage of fixation time for happy faces for each 2-s interval.

3.2. Attention to happy faces

Fig. 3 depicts a completely different pattern of group differences for happy faces. Unlike the data for sad faces, there were significant group differences for each interval. For the 0–2 s interval, $F(2, 72)=5.34$, $p < 0.01$, partial $\eta^2=0.13$, currently depressed participants attended to happy faces significantly less than never depressed and remitted depressed participants (20.2%, 24.0%, and 22.7%, respectively), $t(47)=3.26$, $p < 0.01$, $d=0.92$; $t(40)=2.05$, $p < 0.05$, $d=.64$, respectively. The never and remitted depressed participants did not differ, $t(57)=1.31$, $p=0.19$. For the 2–4 s interval, $F(2, 72)=3.66$, $p < 0.05$, partial $\eta^2=0.09$, the only

[1] We also examined overall differences in attention to the faces within each group (averaged over the 8-second presentations; see Table 3). For the never depressed participants there was a significant main effect of Face Type, $F(3, 288)=23.69$, $p < 0.001$, partial $\eta^2=0.42$. Happy faces were attended to significantly more (31.4%) than sad, threatening, and neutral faces (20.6%, 21.3%, and 22.5%, respectively; all $ps < 0.01$). Sad faces were attended to significantly less than neutral ($p < 0.05$) and happy faces ($p < 0.05$). For the remitted depressed participants there was also a significant main effect of Face Type, $F(3, 225)=3.10$, $p < 0.05$, partial $\eta^2=0.11$, although there were only two significant differences: the difference between happy faces and sad faces (26.1% vs. 22.6%; $p=0.05$), and the difference between happy faces and neutral faces (26.1% vs. 22.6%; $p < 0.05$). For the currently depressed participants there was no main effect of Face Type ($F < 1$). Of course, these main effects are averaged over the 8-second presentations, and because the three-way interaction between Group, Face Type, and Time Interval was significant they must be interpreted with caution.

significant difference was between never depressed and remitted depressed participants (30.0% vs. 25.1%), $t(47)=2.62$, $p<0.05$, $d=0.68$. Remitted depressed and currently depressed participants did not differ, $t(40)=0.63$, $p=0.52$.

For the 4–6 second interval and the 6–8 s interval there were consistent group differences, $F(2, 72)=7.15$, $p<0.01$, partial $\eta^2=0.16$; $F(2, 72)=7.34$, $p<0.01$, partial $\eta^2=0.17$, respectively. For the 4–6 s interval, currently depressed and remitted depressed participants attended to happy faces significantly less than never depressed participants (23.9%, 27.4%, and 34.3%, respectively), $t(47)=3.48$, $p<0.01$, $d=1.11$; $t(57)=2.68$, $p<0.01$, $d=0.67$, respectively. Remitted depressed and currently depressed participants did not differ, $t(40)=1.12$, $p=0.26$. The same pattern of group differences was found for the 6–8 s interval: currently depressed and remitted depressed participants attended to happy faces significantly less than never depressed participants (22.4%, 29.2%, and 36.9%, respectively), $t(47)=3.70$, $p<0.001$, $d=1.10$; $t(57)=2.29$, $p<0.05$, $d=0.59$, and remitted depressed and currently depressed participants did not differ, $t(40)=1.65$, $p=0.10$.

3.3. Trend analyses

Trend analyses of the data for each group were carried out to provide additional insight into how attention to sad and happy faces changed over time. For currently depressed participants, attention to sad faces did not change significantly over the 8-s presentation time ($F<1$), and there were no linear, quadratic, or cubic trends (all Fs <1). Attention to sad faces also did not vary over the 8-s presentation for remitted depressed participants, $F(3, 75)=1.41$, $p=0.24$, and there were no linear, quadratic, or cubic trends. In contrast, for never depressed participants there was a substantial change in attention to sad faces over the 8-second presentation, $F(3, 96)=12.96$, $p<0.001$, partial $\eta^2=0.28$. As can be seen in Fig. 2, attention to sad faces was relatively constant for the first 4 s and then decreased for the remainder of the presentation, resulting in significant linear and cubic trends, $F(1, 32)=30.16$, $p<0.001$, partial $\eta^2=0.48$; $F(1, 32)=5.93$, $p<0.05$, partial $\eta^2=0.15$, respectively.

The trend analyses for happy faces produced a different pattern of results. For currently depressed participants attention to happy faces varied over time, $F(3, 45)=3.04$, $p<0.05$, partial $\eta^2=0.17$ (see Fig. 3), as their attention to happy faces increased between the 0–2 and 2–4 s intervals and decreased thereafter, resulting in a significant quadratic trend, $F(1, 15)=6.48$, $p<0.05$, partial $\eta^2=0.30$. In contrast, for remitted depressed participants attention to happy faces increased throughout the 8-s presentation, $F(3, 75)=5.40$, $p<0.01$, partial $\eta^2=0.17$, with a significant linear trend only, $F(1, 25)=10.33$, $p<0.01$, partial $\eta^2=0.29$. The same was true for never depressed participants, with a significant increase in attention to happy faces over time, $F(3, 96)=15.93$, $p<0.001$, partial $\eta^2=0.33$, resulting in a significant linear trend, $F(1, 32)=20.93$, $p<0.001$, partial $\eta^2=0.39$. Taken together, the trend analyses indicate that with respect to temporal changes in attention, remitted depressed participants attended to happy faces similarly to never depressed participants, whereas for sad faces they attended similarly to currently depressed participants.

4. Discussion

The purpose of this study was to determine if remitted depressed individuals would exhibit biases in their attention to emotional faces similar to the biases of currently depressed individuals. In addition, we sought to examine the biases more closely, by determining at what point in the 8-s presentations group differences in attention to the faces would arise and whether remitted and currently depressed participants would exhibit similar temporal changes in attention. Consistent with previous eye tracking research (Armstrong and Olatunji, 2012), currently depressed participants attended to sad faces significantly more than never depressed participants, and attended to happy faces significantly less, when the fixation data were averaged over the 8-s presentation interval. Remitted depressed participants also attended to happy and sad faces differently than never depressed participants; like currently depressed participants, they attended to sad faces significantly more than never depressed participants, and to happy faces significantly less. Moreover, remitted depressed participants did not differ from currently depressed participants in their attention to sad and happy faces when the fixation data were averaged over the 8-s presentation interval. These findings contribute to a small but growing body of evidence that attentional biases for emotional stimuli may persist beyond an active depressive episode and may therefore represent an underlying vulnerability factor for future depression.

Recall that, averaging over the 8-s presentation, we found that currently depressed participants attended to neutral faces significantly more than never depressed and remitted depressed participants. This result may be related to the tendency for currently depressed individuals to interpret ambiguous faces in a negative manner (Gur et al., 1992; Leppänen et al., 2004; Surguladze et al., 2004; Beevers et al., 2009). In particular, Leppänen et al. (2004) compared the speed and accuracy of recognizing happy, sad, and neutral faces for depressed and non-depressed participants and found that depressed participants recognized neutral faces less accurately than happy and sad faces. In addition, depressed participants were slower than non-depressed participants to recognize neutral faces. Leppänen et al. proposed that depressed individuals often do not immediately perceive neutral faces as emotionally neutral and/or require additional processing to make their judgment. If this was the case for the currently depressed participants in our study, then it would explain why they attended to neutral faces longer than never depressed participants. If this interpretation is correct, then the absence of a difference between remitted depressed and never depressed participants in their attention to neutral faces suggests that impairments in the recognition of neutral faces are unique to those currently experiencing a depressive episode.

Recall that we did not observe any differences between currently depressed, remitted depressed, and never depressed participants in their attention to threatening face images. This outcome is consistent with previous eye tracking research (Armstrong and Olatunji, 2012) and adds further weight to the conclusion that the negative attentional bias in depression is congruent with the symptomatology of the disorder and centers on content involving themes of sadness and loss rather than fear or threat.

4.1. Temporal changes in attention to sad and happy faces

An important feature of our study was the ability to evaluate temporal patterns of attention to emotional faces in currently, remitted, and never depressed individuals. Temporal patterns of attention were examined in two ways: first, we divided the 8-s presentation duration into four 2-s intervals and compared attention to faces between-groups at each interval, and second, we used trend analyses to evaluate within-group differences in attention to faces over the 8-s presentation. The first set of analyses allowed us to evaluate at what point in the 8-s presentation did currently and remitted depressed participants begin to attend to the faces differently than never depressed participants, and the second set allowed us to measure temporal changes in attention to the images unique to each group.

With respect to the group differences observed at each of the

2-s intervals, we found that depression-related attentional biases for sad faces did not arise until the 4–6 s interval—currently and remitted depressed participants attended to sad faces significantly more than never depressed participants only during the last four seconds of the presentation. For happy faces the results were more complex. During the 0–2 s interval, currently depressed participants attended to happy faces significantly less than remitted depressed and never depressed participants, which was the only evidence of an early attentional bias. During the last four seconds of the presentation currently and remitted depressed participants attended to happy faces significantly less than never depressed participants. Our results indicate that the magnitude of the attentional biases for currently and remitted depressed participants did not differ during the 4–8 s interval, as there were no significant differences in their attention to sad or happy faces during this interval. Taken together, the results of the time interval analyses support the notion that attentional biases for negatively valenced stimuli in currently and remitted depressed individuals are most likely to be observed during later stages of processing (i.e., after four seconds; see also Arndt et al., 2014). Our data further suggest that reduced engagement with positive stimuli may arise earlier, as currently depressed participants attended to happy faces significantly less than never depressed participants during the 0–2 s interval.

The trend analyses that evaluated within-group differences in attention to sad and happy faces produced several important findings. First, we found that never depressed participants increased their attention to happy faces and decreased their attention to sad faces over the course of the 8-s presentation, a pattern also observed by Arndt et al. (2014). Thus, there appears to be a strong attentional bias present in never depressed individuals, characterized by the favoring of happy faces and avoidance of sad faces, particularly later in the time course as attention becomes more controlled and goal-directed. This pattern of attending likely reflects a "protective" attentional bias observed in other studies of attention to emotion (Matthews and Antes, 1992; McCabe et al., 2000; Caseras et al., 2007; Joormann and Gotlib, 2007; Leyman et al., 2011; Ingram et al., 2008; Kellough et al., 2008; Peckham, et al., 2010; Ellis et al., 2011; Newman and Sears, 2015). Never depressed individuals appear to divert their attention away from negative information and toward positive information in a way that is likely adaptive and may help to protect against negative mood states.

In contrast, for both currently and remitted depressed participants, attention to sad faces was relatively constant throughout the 8-s presentation and did not decrease over time. This result is consistent with previous eye tracking studies that have found that biased attention to negative stimuli is maintained over time in currently depressed (Kellough et al., 2008) and dysphoric (Arndt et al., 2014) individuals. This pattern of attending likely reflects the sustained processing of negative material that has been proposed to underlie depressed individuals' impaired ability to cease negative elaborative processes such as rumination (Goeleven et al., 2006; De Raedt and Koster, 2010; Koster et al., 2011). For happy faces, on the other hand, the temporal profiles of currently and remitted depressed participants' did differ. Remitted depressed participants were similar to never depressed participants in that attention to happy faces increased throughout the presentation, although not as sharply. Thus, whereas currently depressed participants began to decrease their attention to happy faces early in the presentation, remitted and never depressed participants increased their attention to happy faces throughout the presentation. This finding suggests that although remitted depressed participants attended to happy faces *quantitatively* less than never depressed participants, their temporal profile of attention to happy faces was *qualitatively* similar to that of never depressed participants. This result raises the question of whether this temporal profile represents a risk factor for depression or is a protective factor associated with current remission from depression. A related question is whether it is the overall amount of attention allocated toward positive and negative stimuli or the temporal pattern of engagement and disengagement with positive and negative stimuli that is most relevant for depression vulnerability. These are important questions for future research that will further refine depression researchers' understanding of attentional biases. The present study showed that measuring changes in attention over time was quite valuable because temporal changes in attention to sad and happy faces distinguished currently and remitted depressed individuals from never depressed individuals.

4.2. Limitations and considerations for future research

There were several limitations of this study that should be considered. First, all of the participants were women, and most of them were under 30 years of age, and these restrictions limit the generalizability of our findings. Second, the use of faces for emotional stimuli also may have limited generalizability, given that faces are a special category of stimulus with respect to both their social significance and neural processing (Haxby et al., 2000; McKone et al., 2009). It will therefore be important to determine if similar results are observed when a different type of emotional image is used (e.g., images of naturalistic scenes, like those used by Eizenman et al., 2003, Kellough et al., 2008, and Newman and Sears, 2015). One other limitation is the relatively small size of the currently depressed group ($n=16$). For the comparisons between the currently depressed and never depressed groups ($n=33$) this was not an issue, as most of these differences were large and statistically significant (with effect sizes ranging from 0.92 to 1.15, all considered to be "large" effects according to convention; Cohen, 1988). On the other hand, some of the comparisons between the currently depressed and remitted depressed groups ($n=26$) should be interpreted with caution because the absence of a significant difference may have been influenced by the lower statistical power of these comparisons (e.g., the absence of a difference between currently and remitted depressed participants in their attention to sad faces during the 4–6 and 6–8 s intervals). Although the statistical power to detect a large difference between these groups was more than adequate (for a "large" effect size, defined as $d=0.80$, power was 79%, as computed using the G*Power 3.1 software package; Faul et al., 2007), the power to detect a "medium" effect ($d=0.50$) was not (46%). Thus, the size of the currently depressed group would have made it difficult to detect small differences between the currently depressed and remitted depressed groups in their attention to happy and sad faces. Fortunately, the comparisons between the remitted depressed and never depressed groups revealed that remitted depressed individuals differed significantly in their attention to happy and sad faces, which demonstrated the uniqueness of their attentional bias. Nonetheless, a larger group of currently depressed participants would have increased our confidence in the interpretation of a few key comparisons.

Our results provide additional evidence that the attentional biases observed in currently depressed individuals persist beyond the course of a depressive episode and reflect a pre-existing trait-like characteristic, or a stable, residual scar-like effect of illness. This finding has clinical implications for the treatment of major depression and the prevention of depression relapse. Major depression is characterized by high rates of relapse and recurrence, such that the risk of experiencing subsequent depressive episodes increases with each episode experienced (Solomon et al., 2000; Monroe and Harkness, 2011). Researchers have begun to investigate the use of attentional training (AT) procedures as a

method to target attentional biases and reduce the risk of depression recurrence (e.g., Baert et al., 2010; Wells and Beevers, 2010). Our results have implications for these procedures. Many AT procedures use a variant of the dot-probe task, presenting a pair of words or images (e.g., one neutral face, one sad face) for a short duration (500–2000 ms) and then presenting a probe in the location of one of the words or images. In the standard dot-probe task the probe appears in the location of the neutral stimulus and the negative stimulus with equal probability (50%), whereas in an AT procedure the probe appears in the location of the neutral stimulus with a much higher probability. The logic of the AT procedure is that depressed individuals will learn to reflexively allocate their attention to neutral stimuli and away from negatively valenced stimuli, reversing their habitual tendency to direct attention to negatively valenced information. Most AT procedures, however, target and train the reflexive orienting of attention, due to the brief stimulus presentations used in the typical dot-probe paradigm (see Wells and Beevers, 2010, for an exception). Our results indicate that attentional differences between currently depressed, remitted depressed, and never depressed individuals are most pronounced during extended viewing and are present for both negatively and positively valenced stimuli. One implication is that the objective of these procedures should be to counteract the sustained processing of negatively valenced stimuli, while at the same time reinforcing engagement with positively valenced stimuli, in order to train an attentional profile similar to the one observed in never depressed individuals.

4.3. Conclusions

The results of our study indicate that remitted depressed individuals exhibit a pattern of biased attention to emotional faces that is similar but not identical to the biased attention of currently depressed individuals. Our findings build and expand on those of other investigators who have also reported that remitted depressed individuals exhibit attentional biases (Joormann and Gotlib., 2007; Sears et al., 2011; Newman and Sears, 2015). Our study is one of the few to use eye gaze tracking to examine attention to emotion in remitted depressed individuals and the first to examine temporal changes in attention in the remitted depressed, and so our results contribute significantly to the understanding of attentional biases in those with a history of depression.

There is a growing consensus that depressed individuals attend to emotional information differently than never depressed individuals (Gotlib and Joormann, 2010). The existence of similar attentional biases in remitted depressed individuals has important theoretical implications for depression researchers. Consistent with cognitive models of depression, our results suggest that attentional biases can be observed outside of depressive episodes and therefore may represent trait-like characteristics of vulnerable individuals that could play a role in maintaining vulnerability to future depression. Two goals for future research will be to further delineate the precise patterns of attention to emotional information associated with depression vulnerability, and to determine whether global differences in attention or temporal profiles of attention are most predictive of future episodes of depression.

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