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## An Eye Tracking Study of the Time Course of Attention to Positive and Negative Images in Dysphoric and Non-dysphoric Individuals

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### Abstract

Researchers studying selective attention in depressed and dysphoric individuals have documented biases in the allocation of attention to emotional information (Gotlib & Joormann, 2010; Yiend, 2010). Recent studies using eye gaze tracking have shown that when images are presented for extended durations (5-30 seconds), depressed and dysphoric individuals attend to depression-related images more than never depressed individuals and attend to positive images less (Armstrong & Olatunji, 2012). The present study used eye gaze tracking and time course analyses to look for differences between dysphoric and non-dysphoric individuals in their attention to emotional images over time. Participants viewed sets of four images (a depression-related image, a threat-related image, a positive image, and a neutral image) while their eye fixations were tracked and recorded throughout a 10-second presentation. The time course analyses, which divided each 10-second presentation into 2-second intervals, revealed that group differences in attention to positive and depression-related images emerged only after 4 seconds had elapsed and then persisted for the remainder of the 10-second presentation. Dysphoric and non-dysphoric participants were further distinguished by the temporal profiles of their attention to positive and depression-related images. The implications for researchers' understanding of attention to emotion in dysphoria and depression are discussed.

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Keywords: Dysphoria, Depression, Attention, Emotion, Eye Tracking, Time Course

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## Introduction

There is a growing consensus among depression researchers that depressed and dysphoric individuals attend to emotional information differently than never depressed individuals (see Gotlib & Joormann, 2010, for a review). A great deal of this research has been motivated by cognitive models of depression, which maintain that biases in the processing of emotional information, including biases in attention, are not merely symptoms of depression, but underlie the disorder and are causally related (Beck, 1987; DeRaedt & Koster, 2010; Gotlib & Joormann, 2010; Ingram, Miranda, & Segal, 1998). Researchers have identified two distinct manifestations of biased attention in depressed individuals (Armstrong & Olatunji, 2012; Yiend, 2010). The first is increased attention to depression-relevant themes and stimuli (e.g., depression-related words; images related to sadness) relative to never depressed individuals, which is often referred to as a negative or mood-congruent attentional bias. The second is decreased attention to positive stimuli (e.g., positively valenced words and images) relative to never depressed individuals; in many studies, never depressed individuals have been found to attend to positive stimuli significantly more than neutral stimuli, whereas for depressed and dysphoric individuals this positive attentional bias is either absent or significantly reduced relative to the bias observed in never depressed individuals. These attentional biases are proposed to be stable trait-like characteristics that endure beyond depressive episodes and contribute to their recurrence.

Researchers have used a variety of tasks to examine attentional biases in depressed and dysphoric individuals, including the emotional Stroop task, the dot-probe task, the deployment of attention task, and visual search tasks (see Mogg & Bradley, 2005; Peckham, McHugh, & Otto, 2010; Yiend, 2010, for reviews). In many of these tasks attention effects are measured over brief intervals (typically less than 1 second) in simple displays (e.g., pairs of words), using reaction time measures. However, a few studies have used eye gaze tracking to measure the allocation of attention in more complex displays, over longer intervals. Because the direction of an individual's gaze and the focus of their attention are tightly coupled (Wright & Ward, 2008), eye gaze tracking can provide a direct, continuous record of the focus of an individual's attention in a variety of display conditions, without the requirement to measure reaction times. This is especially advantageous when researchers wish to assess how depressed and never depressed individuals differ in their engagement with positive and negative material over extended intervals.

Eizenman et al. (2003) were the first to use eye gaze tracking for this purpose. To compare depressed and never depressed individuals' attention to emotional images, they presented sets of four different images (an image with a neutral theme, an image with a dysphoric theme, an image with a threatening theme, and an image with a positive/social theme) and tracked and recorded participants' eye fixations to the images throughout a 10.5 second

presentation time. Their results showed that depressed individuals had longer total fixation times for dysphoric images than never depressed individuals, whereas for the other image types there were no group differences. Eizenman et al. concluded that depressed individuals' greater attention to dysphoric images was evidence of a negative attentional bias similar to that observed in other attention tasks.

Kellough, Beevers, Ellis, and Wells (2008) conducted a similar eye-tracking study using the same image types but with a longer presentation time (30 seconds). Like Eizenman et al. (2003), Kellough et al. found that depressed individuals attended to dysphoric images more than non-depressed individuals. Unlike Eizenman et al., Kellough et al. also found that depressed individuals attended to positive images significantly less than non-depressed individuals. In a similar study comparing dysphoric and non-dysphoric individuals, Sears, Thomas, LeHuquet, and Johnson (2010) presented sets of four images (positive, depression-related, anxiety-related, and neutral) for 10 seconds and found that dysphoric individuals attended to positive images significantly less than non-dysphoric individuals (see also Sears, Newman, Ference, & Thomas, 2011). Another recent eye-tracking study (Leyman, De Raedt, Vaeyens, & Philippaerts, 2011) presented sets of sad, happy, angry, and neutral faces for 10.5 seconds to dysphoric and non-dysphoric individuals and found that dysphoric individuals differed only in their attention to happy faces, attending to them less than non-dysphoric individuals. A recent meta-analysis of this literature (Armstrong & Olatunji, 2012) concluded that depressed and dysphoric individuals attend to dysphoric stimuli more than non-depressed individuals under extended viewing conditions (10 to 30 s), a bias most pronounced in depressed individuals meeting full diagnostic criteria for major depressive disorder. For positive stimuli, Armstrong and Olatunji found the opposite pattern, with depressed and dysphoric individuals attending to positive stimuli less than non-depressed individuals. Taken together, these findings lend support to cognitive models of depression (Beck, 1976; Beck & Clark, 1988; Gotlib & Joormann, 2010) and cognitive theories of depression vulnerability (e.g., DeRaedt & Koster, 2010; Ingram et al., 1998; Ingram, Steidtmann, & Bistricky, 2008). The key prediction that depressed individuals will selectively attend to negative stimuli and reduce their attention to positive stimuli is strongly confirmed by eye tracking studies.

The purpose of the present study was to use eye gaze tracking to determine how attention to emotional information changes over time, and whether the changes are similar for dysphoric and never depressed individuals. When viewing a display with multiple images for 10 seconds, for example, do dysphoric individuals attend to depression-related images immediately and exclusively before shifting their attention to other images, or do they increase their attention to these images gradually over the course of the 10-second presentation? Do dysphoric individuals attend to positive images differently than never depressed individuals throughout a 10-second presentation or only during particular intervals (e.g., during the first few seconds or during the last few seconds of the presentation)? When do group differences in attention to positive and depression-related images arise? Researchers have documented that depressed mood states are associated with elaborative and sustained processing of negative information (e.g., Siegle, Granholm, Ingram, & Matt, 2001), and therefore one might expect that dysphoric individuals would dwell on depression-related images throughout a 10-second presentation. On the other hand, dysphoric individuals may ignore these images initially to avoid exacerbating their negative mood, but once attended they may experience difficulty disengaging attention from such images (Koster, De Lissnyder, Derakshan, & De Raedt, 2011) and inhibiting their content (Goeleven, De Raedt, Baert, & Koster, 2006). If so, then group differences in attention to depression-related images would not be expected early in the presentation, but would instead develop over time. In previous eye tracking studies (with the exception of Kellough et al., 2008), fixation time data was averaged over the entire presentation time, and as a consequence group differences in attention to emotional images over time were not considered.

Kellough et al. (2008) were the first to analyze their eye tracking data in a way that allowed these types of questions to be addressed. They 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-second presentation. Kellough et al. carried out a time course analysis of their data by dividing the 30-second presentation time into six 5-second intervals and then comparing the fixation data of the depressed and never-depressed groups for each of these intervals. They found that the group differences in attention to the dysphoric and positive images were very similar throughout the 30-second presentation and did not vary significantly. For all six 5-second intervals, depressed individuals spent more time attending to dysphoric images

and less time attending to positive images relative to never-depressed individuals. This pattern of results indicated that depressed individuals attended to the dysphoric images more than never-depressed individuals early in the trial (the 0-5 second interval) and sustained this heightened attention throughout the remainder of the 30-second presentation, whereas for positive images the opposite pattern was observed. Kellough et al. concluded that their results support the idea that biased attention in clinical depression is characterized by an increased and sustained processing of negative material and a concurrent reduction in the processing of positive material.

## The Present Research

The present study builds and expands on previous research by examining the time course of attention to emotional images in dysphoric and non-dysphoric individuals. Given that symptoms of depression can be conceptualized on a continuum of severity (e.g., Flett, Vredenburg, & Krames, 1997), an examination of biased attention in dysphoric individuals (i.e., individuals with elevated but sub-clinical levels of depressive symptomatology) provides depression researchers with important comparative information on how attention is affected by sub-clinical levels of depression. Research with dysphoric individuals also provides information about cognitive processes in those who are vulnerable to developing major depressive disorder, given the finding that young adults with elevated depressive symptoms are at a greater risk of developing major depressive disorder in the future (e.g., Fergusson, Horwood, Ridder, & Beautrais, 2005; Lewinsohn, Solomon, Seeley, & Zeiss, 2000).

Our design was similar to that of Kellough et al. (2008), but our analyses looked for group differences in attention to emotional images over a shorter presentation time (10 seconds versus 30 seconds in the Kellough et al. study) and used a finer temporal interval (2 seconds versus 5 seconds in the Kellough et al. study). We expected that a shorter viewing time and a finer temporal interval would make it easier to detect group differences in the time course analyses. Dysphoric and non-dysphoric participants were shown sets of four images (one depression-related image, one threat-related image, one positive image, and one neutral image) while their gaze was tracked and recorded. We presented multiple images with different valences on each trial to look for group differences in attention to both positive and negative images when multiple images compete for attention. Like Kellough et al., we had participants freely view the images rather than giving them an explicit task (e.g., study each image for a memory test; rate each image for pleasantness), because any task that requires participants to purposefully attend to each image would likely lead to a more uniform distribution of attention that would attenuate individual differences (Sears et al., 2010). Based on previous research (Armstrong & Olatunji, 2012), our prediction was that dysphoric individuals would spend less time attending to positive images and possibly more time attending to depression-related images than non-dysphoric individuals, when fixation times were averaged over the entire 10-second presentation. The time course analyses allowed us to determine when group differences in attention to the images would arise and how attention to the images would change over time.

## Method

### Participants

Participants were undergraduate students from the University of Calgary who volunteered to participate in the study in exchange for extra course credit or a gift card of \$20.00 (CAD). To control for gender, only females were recruited for the study. To be eligible to participate, students were required to have normal or corrected-to-normal vision and could not wear eyeglasses during data collection because of the potential for interference with the eye gaze recording. A total of 171 individuals participated in the study.

Participants completed the second edition of the Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996), the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), and a demographics questionnaire. The BDI is a self-report inventory consisting of 21 items that assesses participants' depressive symptoms over the past two weeks. Each item is rated on a scale from 0 to 3, with summary scores ranging between 0 and 63. The PANAS assesses participants' pleasant and unpleasant mood states. It consists of 20 words that describe different emotions (e.g., excited, proud, upset, guilty, distressed); participants read each word and indicate "to what extent you have felt this way", using a scale from 1 (very slightly or not at all) to 5 (extremely).

These same 20 words were rated for two time frames: “during the past few days” and “during the past few weeks”. For the 10 positive affect items and for the 10 negative affect items the minimum score was 10 and the maximum score was 50. The demographics questionnaire included questions about previous episodes of depression, experiences with psychotherapy, and current mood (rated on a scale from -5 to +5 with a midpoint of zero).

Dysphoric and non-dysphoric groups were created using participants’ scores on the BDI-II. Participants assigned to the dysphoric group ( $N = 25$ ) had BDI scores greater than or equal to 20, the BDI cut-off score recommended by Dozois, Dobson, and Ahnberg (1998) for a “dysphoric-depressed” classification when using undergraduate samples. Participants assigned to the non-dysphoric group ( $N = 37$ ) had BDI scores less than or equal to 6, a lower cut-off than recommended by Dozois et al. (less than or equal to 12), but having the advantage of creating a larger separation between the groups. The statistical characteristics of the two groups are shown in Table 1.

*Table 1: Participant characteristics for the dysphoric and non-dysphoric groups*

	Non-Dysphoric ( $n = 37$ )		Dysphoric ( $n = 25$ )		<i>t</i> statistic
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	
Age	20.8	3.5	22.4	3.3	$t(60) = 1.98$
BDI	2.5	2.1	28.5	6.6	$t(60) = 22.0^*$
PANAS Pos	14.3	3.2	28.8	7.9	$t(60) = 9.99^*$
PANAS Neg	35.0	6.8	21.6	7.0	$t(60) = 7.47^*$
Mood Rating	2.1	1.6	-0.3	2.2	$t(60) = 5.04^*$

*Note.* BDI = Beck Depression Inventory. PANAS Pos = PANAS positive affect score (“past few days” score). PANAS Neg = PANAS negative affect score (“past few days” score). Mood Rating = -5 to +5 rating of current mood.

\*  $p < .001$ , two-tailed.

## Stimuli

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

The images were categorized before the study by 152 female undergraduate students, none of whom participated in the eye tracking study. For the categorization task a total of 200 images were presented on a computer display, one at a time. For each image, participants were asked to choose one of four categories that best described the image: 1) positive/happy, 2) sad/depressing/gloomy, 3) threatening/dangerous/fearful, and 4) neutral/no emotion. For each of the 160 images shown in the present study, at least 85% of the raters agreed upon its category. A different group of 50 female undergraduates rated the valence of these 160 images using a scale from -5 (*very negative*) to +5 (*very positive*), with a midpoint of zero (*neutral*). The mean valence ratings for the positive, depression-related, threat-related, and neutral images were 3.43, -3.31, -3.61, and 0.12, respectively. T-tests confirmed that the positive images were rated as significantly more positive than the neutral images, and that the

depression-related and threat-related images were rated as significantly more negative than the neutral images (all  $p$ s < .001).

## Apparatus

Eye movements were recorded by an EyeLink I eye tracking system (SR Research Ltd., Ottawa, Ontario, Canada), which uses infrared video-based tracking technology. Participants wore a small, lightweight headband equipped with cameras positioned below their eyes that tracked the position of their pupils as they moved. The system has an average gaze error of less than 0.5 degrees of visual angle and a sampling rate of 250 Hz (allowing for a temporal resolution of 4 ms). The eye-tracking system was connected to a Dell microcomputer and a ViewSonic G225fb 21-inch flat screen monitor. The computer controlled the visual display and recorded the horizontal and vertical coordinates corresponding to the fixation of the right eye every 4 ms.

## Procedure

Participants were provided with written and spoken instructions at the beginning of the session. They were told that they would be viewing a slide show of positive, negative, and neutral images and that their pupil dilation would be recorded while they viewed the images. They were told to look at the images in any manner they wished. Participants were then fitted with the headband camera and the eye tracking system was calibrated in preparation for data collection.

Participants were shown four images on each trial: a depression-related image, a threat-related image, a positive image, and a neutral image. One image was placed in each of the four corners of the display. Images were randomly assigned to the four display locations; across all of the trials each image type was equally likely to appear in each corner. The images were presented at a display resolution of 1024 x 768 pixels on a white background. At the start of each trial participants fixated on a black dot in the center of the display to ensure proper gaze measurement. Each set of four images was then presented for 10 seconds. There were 45 trials in total: the first five trials were practice trials to familiarize participants with the procedure, the remaining 40 trials were used for data collection. There were two versions of the 40-trial sequence, the second version opposite the first, to control for order effects. The two versions were alternated across participants. All the participants were shown the same images. After they viewed the images, participants were seated in a private room and completed the questionnaires.

## Data Screening and Preparation

The fixation data were processed using the EyeLink Data Viewer software (SR Research) to filter for blinks and other recording artifacts. To be included in the analyses, a fixation had to be at least 100 ms in duration; adjacent, sequential fixations less than 100 ms were merged into one fixation. Participants with significant calibration issues were excluded from all analyses. The dependent measures were the number of fixations to each image type (depression-related, threat-related, positive, and neutral) and the total fixation time to each image type (the sum of all fixation times). These measures were computed for each image type on a trial by trial basis and then averaged over the 40 trials. For the time course analyses these measures were computed for each 2-second interval of the 10-second presentation (0-2 seconds, 2-4 seconds, 4-6 seconds, 6-8 seconds, and 8-10 seconds).

## Results

The analyses of the number of fixations and the total fixation times averaged over the 10-second presentation are presented first, followed by the time course analyses that examined changes in attention to the images over time.

### Number of Fixations and Total Fixation Times over the 10-second Presentation

In this analysis we examined whether there were group differences in attention to the images when the data were averaged over the entire 10-second presentation (i.e., ignoring changes in attention over time). The number of fixations and the total fixation times to each image type were first analyzed together using multivariate analysis of

variance (MANOVA) because these two variables are always correlated (i.e., as the number of fixations to an image increases, the total fixation time also increases) and MANOVA is the appropriate analysis for correlated dependent variables (Tabachnick & Fidell, 2007). The design was a 2 (Group: non-dysphoric vs. dysphoric)  $\times$  Image Type (depression-related, threat-related, positive, neutral) mixed-model MANOVA, with Image Type a within-subject factor. The critical statistical test was the interaction between Group and Image Type; follow-up tests were carried out only if this interaction was statistically significant in order to control the Type I error rate. Statistically significant interactions were followed up with between-group t-tests and an alpha of 5% to maximize statistical power.

There was a main effect of Image Type, Wilk's  $\Lambda = .44$ ,  $F(6, 358) = 29.98$ ,  $p < .001$ , partial  $\eta^2 = .33$ , with more fixations and longer fixation times for positive, depression-related, and threat-related images than for neutral images (2255 ms, 2486 ms, and 2205 ms vs. 1149 ms, and 8.5, 8.3, and 9.4 vs. 4.5, respectively, all  $ps < .001$ ). Most important was the significant interaction between Group and Image Type, Wilk's  $\Lambda = .88$ ,  $F(6, 358) = 3.94$ ,  $p < .01$ , partial  $\eta^2 = .06$ , which indicated that the two groups differed in their attention to the four types of images. This interaction was present in separate analyses of the number of fixations,  $F(3, 180) = 5.64$ ,  $MSE = 3.91$ ,  $p < .01$ , partial  $\eta^2 = .09$ , and the fixation times,  $F(3, 180) = 6.06$ ,  $MSE = 396,274.09$ ,  $p < .01$ , partial  $\eta^2 = .09$ . For brevity only the fixation time analyses are described further, because the pattern in the number of fixations was identical.

To follow up the Group  $\times$  Image Type interaction, independent groups t-tests were used to compare the dysphoric and non-dysphoric groups on their total fixation times for each image type (depression-related, threat-related, positive, and neutral). The t-tests revealed significant differences for depression-related images,  $t(60) = 2.06$ ,  $p < .05$ , partial  $\eta^2 = .07$ , and positive images,  $t(60) = 3.47$ ,  $p < .01$ , partial  $\eta^2 = .17$ . For depression-related images, dysphoric participants had longer total fixation times than non-dysphoric participants (2380 ms vs. 2030 ms), whereas for positive images dysphoric participants had shorter total fixation times (1972 ms vs. 2538 ms). There was also a significant difference for neutral images,  $t(60) = 2.44$ ,  $p < .05$ , partial  $\eta^2 = .09$ , with dysphoric participants having shorter total fixation times than non-dysphoric participants (1050 ms vs. 1247 ms). For threat-related images there was no group difference (2557 ms and 2415 ms for the dysphoric and non-dysphoric groups, respectively),  $t(60) = 0.94$ ,  $p > .10$ . Taken together, these analyses indicate that over the course of the entire 10-second presentation, dysphoric participants attended to depression-related images more than the non-dysphoric participants and attended to positive images less.

*Table 2: Mean total fixation time (in milliseconds) and number of fixations for depression-related, positive, threat-related, and neutral images*

Image Type	Non-Dysphoric group		Dysphoric group	
	Fixation time	Fixations	Fixation time	Fixations
Depression-related	2030 (377)	8.1 (1.5)	2380 (930)	8.5 (2.2)
Positive	2538 (702)	9.7 (2.8)	1972 (497)	7.3 (2.0)
Threat-related	2415 (608)	9.5 (2.2)	2557 (563)	9.3 (1.9)
Neutral	1247 (301)	4.9 (1.1)	1050 (323)	4.2 (1.3)

Note. Standard deviations in parentheses.

## Time Course Analyses

For the time course analyses each 10-second presentation was divided into five 2-second intervals (0-2 seconds, 2-4 seconds, 4-6 seconds, 6-8 seconds, and 8-10 seconds). The design was a 2 (Group: non-dysphoric vs. dysphoric)  $\times$  Image Type (depression-related, threat-related, positive, neutral)  $\times$  Time Interval (0-2 s, 2-4 s, 4-6 s, 6-8 s, 8-10 s) mixed-model MANOVA, with Image Type and Time Interval being within-subject factors. The most important result was the significant three-way interaction between Group, Image Type, and Time Interval, Wilk's  $\Lambda = .94$ ,  $F(24, 1438) = 1.75$ ,  $p < .05$ , partial  $\eta^2 = .03$ . This interaction indicated that the group differences in attention to depression-related and positive images described above were not the same for each of the five time intervals. (Note that the equivalent interaction was not present in Kellough et al.'s, 2008, time course analysis.) The three-way interaction was significant for both the number of fixations and the total fixation time when these variables

were analyzed separately: for number of fixations,  $F(12, 720) = 2.48$ ,  $MSE = 0.20$ ,  $p < .01$ , partial  $\eta^2 = .04$ , and for fixation time,  $F(12, 720) = 2.07$ ,  $MSE = 12,778.7$ ,  $p < .05$ , partial  $\eta^2 = .03$ . To follow up the three-way interaction we used Group x Image Type interaction contrasts, one for each of the five time intervals (for brevity we report only the results from the analysis of fixation times because the results from the analysis of the number of fixations were essentially identical). To control the Type I error rate, these interaction contrasts were followed up with planned between-group t-tests only if the interaction contrast was statistically significant ( $p < .05$ ). The total fixation time data are shown in Table 2.

During the first two time intervals (0-2 seconds and 2-4 seconds) the Group x Image Type interaction was not significant, indicating that the two groups did not differ in their total fixation times to the different image types,  $F(3, 180) = 1.43$ ,  $MSE = 10,443.9$ ,  $p > .10$ , and  $F(3, 180) = 2.38$ ,  $MSE = 18,246.9$ ,  $p = .07$ , partial  $\eta^2 = .04$ , respectively. Thus, for the first four seconds of each trial, dysphoric and non-dysphoric participants attended to the images in a similar manner. In contrast, for the last three time intervals (4-6 seconds, 6-8 seconds, and 8-10 seconds) there were significant interactions between Group and Image Type,  $F(3, 180) = 4.52$ ,  $MSE = 23,179.2$ ,  $p < .05$ , partial  $\eta^2 = .07$ ,  $F(3, 180) = 4.13$ ,  $MSE = 33,515.7$ ,  $p < .05$ , partial  $\eta^2 = .06$ , and  $F(3, 180) = 6.54$ ,  $MSE = 34,199.1$ ,  $p < .01$ , partial  $\eta^2 = .10$ , respectively. These interactions were followed up by using t-tests to look for differences between the groups for each image type.

*Table 3: Mean total fixation time (in milliseconds) and number of fixations for depression-related, positive, threat-related, and neutral images for each time interval.*

Image Type	Non-Dysphoric group		Dysphoric group	
	Fixation time	Fixations	Fixation time	Fixations
<b>0-2 seconds</b>				
Depression-related	406 (77)	2.0 (0.5)	431 (140)	2.0 (0.5)
Positive	422 (89)	2.0 (0.4)	372 (93)	1.8 (0.4)
Threat-related	587 (107)	2.7 (0.5)	584 (97)	2.5 (0.5)
Neutral	170 (45)	0.8 (0.2)	149 (66)	0.8 (0.3)
<b>2-4 seconds</b>				
Depression-related	460 (102)	2.1 (0.4)	514 (170)	2.2 (0.5)
Positive	407 (135)	1.8 (0.7)	356 (96)	1.5 (0.4)
Threat-related	516 (147)	2.3 (0.5)	521 (132)	2.1 (0.4)
Neutral	271 (85)	1.2 (0.4)	208 (79)	1.0 (0.4)
<b>4-6 seconds</b>				
Depression-related	418 (100)	1.8 (0.5)	488 (212)	2.0 (0.6)
Positive	505 (169)*	2.1 (0.7)*	376 (120)*	1.6 (0.5)*
Threat-related	425 (154)	1.8 (0.6)	441 (109)	1.8 (0.4)
Neutral	299 (90)	1.3 (0.3)	276 (85)	1.2 (0.3)
<b>6-8 seconds</b>				
Depression-related	389 (131)*	1.7 (0.5)	483 (228)*	1.9 (0.6)
Positive	557 (214)*	2.3 (0.8)*	417 (145)*	1.6 (0.6)*
Threat-related	409 (176)	1.7 (0.7)	412 (141)	1.7 (0.6)
Neutral	276 (105)	1.1 (0.4)	258 (114)	1.0 (0.4)
<b>8-10 seconds</b>				
Depression-related	396 (140)	1.6 (0.5)	475 (230)	1.8 (0.7)
Positive	601 (228)*	2.4 (0.9)*	415 (140)*	1.5 (0.5)*
Threat-related	378 (164)	1.5 (0.7)	443 (161)	1.7 (0.6)
Neutral	255 (76)	1.0 (0.3)*	222 (118)	0.8 (0.4)*

\* Dysphoric group vs. non-dysphoric group comparison  $p < .05$ , two-tailed.

Note: Standard deviations in parentheses.

For the 4-6 second time interval, the two groups differed in their total fixation times for positive images only; dysphoric participants' mean total fixation time for positive images was significantly shorter than non-dysphoric participants' (376 ms vs. 505 ms),  $t(60) = 3.28$ ,  $p < .01$ , partial  $\eta^2 = .15$ . For depression-related images the dysphoric participants had longer total fixation times than non-dysphoric participants (488 ms vs. 418 ms), but this difference was not significant,  $t(60) = 1.74$ ,  $p = .09$ . For the 6-8 second interval there was again a significant group difference for positive images,  $t(60) = 2.84$ ,  $p < .01$ , partial  $\eta^2 = .12$ , and, in addition, for depression-related images as well,  $t(60) = 2.06$ ,  $p < .05$ , partial  $\eta^2 = .07$ . Dysphoric participants had shorter total fixation times for positive images than non-dysphoric participants (417 ms vs. 557 ms), whereas for depression-related images their total fixation times were longer (483 ms vs. 389 ms). The same pattern of group differences was present for the 8-10 second interval, although only the difference for positive images was statistically significant: dysphoric participants had shorter total fixation times for positive images than non-dysphoric participants (415 ms vs. 601 ms),  $t(60) = 3.63$ ,  $p < .01$ , partial  $\eta^2 = .18$ , and longer total fixation times for depression-related images than non-dysphoric participants (475 ms vs. 396 ms),  $t(60) = 1.69$ ,  $p = .09$ . These patterns can be seen in the time course data for the positive and depression-related images shown in Figure 1.

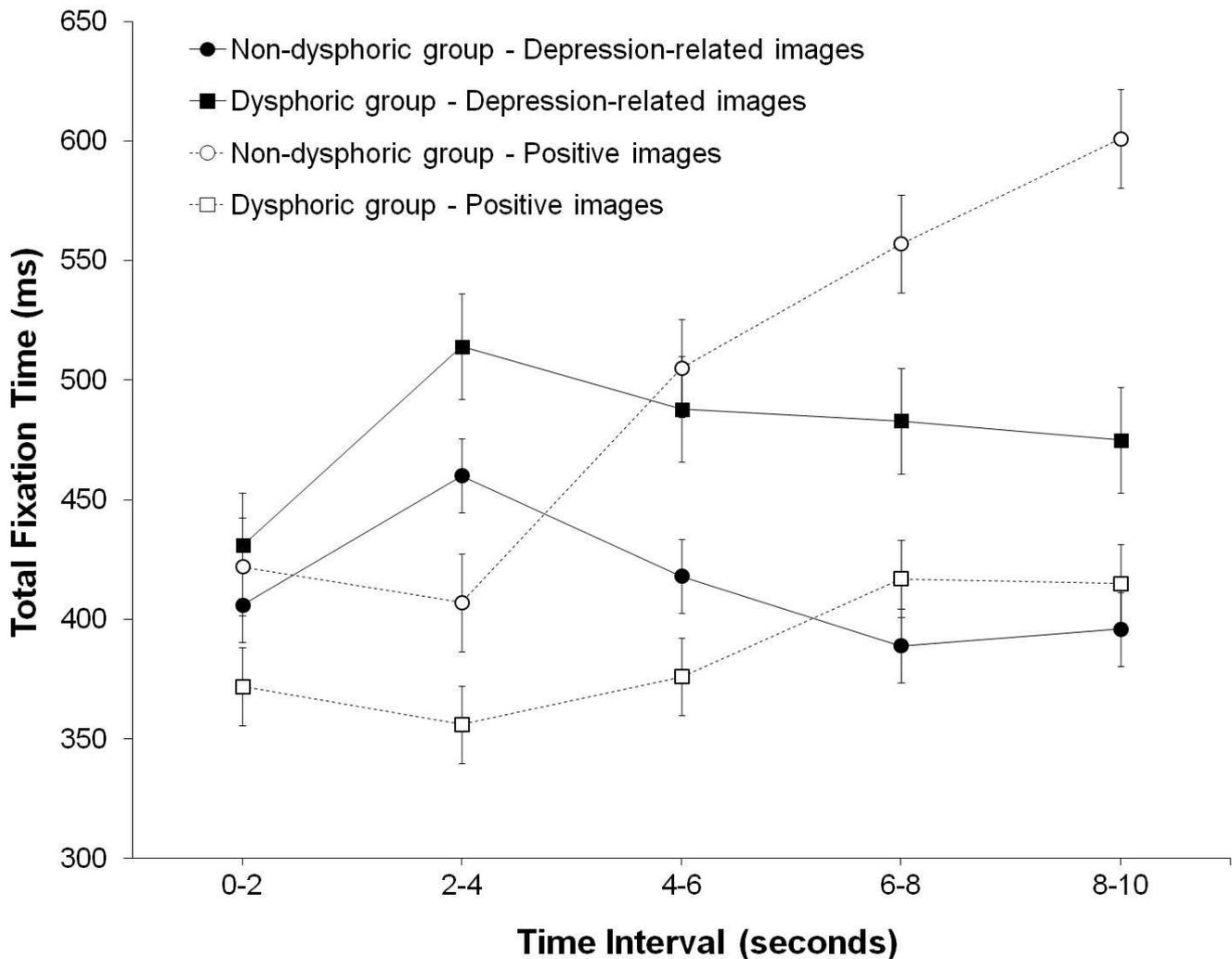


Figure 1: Total fixation time for positive and depression-related images during each 2-second interval, for dysphoric and non-dysphoric groups. Within-subject error bars are shown (Loftus & Masson, 1994).

## Trend Analyses

Trend analyses of the data shown in Figure 1 provided additional insight into how dysphoric and non-dysphoric participants differed in their attention to depression-related and positive images. For dysphoric participants, total fixation times to depression-related images were essentially unchanged throughout the 10-second presentation, with no significant linear,  $F < 1$ , quadratic,  $F(1, 24) = 3.21$ ,  $MSE = 14,416.2$ ,  $p = .09$ , or cubic trend,  $F(1, 24) = 3.82$ ,  $MSE = 7,348.0$ ,  $p = .07$ . For the non-dysphoric participants, on the other hand, there was a significant cubic trend,  $F(1, 36) = 9.40$ ,  $MSE = 6949.2$ ,  $p < .01$ , partial  $\eta^2 = .21$ , indicating that total fixation times did vary over the course of the presentation. As can be seen in Figure 1, for non-dysphoric participants total fixation times to depression-related images increased between the 0-2 and 2-4 second intervals and then decreased throughout the remainder of the presentation. For positive images a different pattern emerged. For both groups, total fixation times to positive images increased over time, with a significant linear trend for dysphoric participants,  $F(1, 24) = 6.03$ ,  $MSE = 8,856.9$ ,  $p < .05$ , partial  $\eta^2 = .20$ , and significant linear and cubic trends for non-dysphoric participants,  $F(1, 36) = 26.78$ ,  $MSE = 35,758.2$ ,  $p < .001$ , partial  $\eta^2 = .43$ , and  $F(1, 36) = 6.59$ ,  $MSE = 8,196.2$ ,  $p < .05$ , partial  $\eta^2 = .16$ , respectively. The significant cubic trend for the non-dysphoric participants reflects the steep increase in total fixation times to positive images after the 2-4 second interval, in contrast to the much more gradual increase for dysphoric participants.

## General Discussion

The purpose of this study was to examine differences and changes in dysphoric and non-dysphoric individuals' attention to emotional images over time. To do so, we tracked the eye gaze of dysphoric and non-dysphoric individuals while they viewed positive, depression-related, threat-related, and neutral images over a 10-second presentation. We found that, averaging over the entire 10-second presentation, dysphoric individuals attended to positive images significantly less than non-dysphoric individuals. This result replicates the findings of other investigators who used similar eye tracking paradigms to examine attention to positive information in dysphoric individuals (Leyman et al., 2011; Mathews & Antes, 1992; Sears et al., 2010; 2011). We also found that dysphoric individuals attended to depression-related images significantly more than non-dysphoric individuals, a result consistent with the findings of previous eye tracking studies with depressed individuals (Eizenman et al., 2003; Kellough et al., 2008). The dysphoric individuals' increased attention to depression-related images in the present study is analogous to depressed individuals' increased attention to dysphoric images in Kellough et al.'s (2008) eye tracking study, and suggests that clinically depressed and dysphoric individuals exhibit similar attentional biases under these conditions. Also consistent with previous studies was our finding that dysphoric and non-dysphoric individuals did not differ in their attention to threat-related images. An equivalent result was reported by Eizenman et al. (2003), Kellough et al. (2008), and Sears et al. (2010), who found that depressed/dysphoric and control groups did not differ on fixation times to threatening images. These findings suggest that, regardless of the high comorbidity of depression and anxiety, depressed and dysphoric individuals are unlike anxious individuals in that they do not attend preferentially to stimuli related to danger and threat (see Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007; Mogg & Bradley, 2005, for reviews).

To determine when group differences in attention to positive and depression-related images emerged, we carried out a time course analysis of our eye tracking data. These analyses revealed that differences between the dysphoric and non-dysphoric groups were evident only after 4 seconds, but then persisted throughout the remainder of the 10-second presentation. The differences were especially pronounced for positive images, as dysphoric individuals attended to positive images significantly less than non-dysphoric individuals throughout the 4-10 second presentation interval. The time course analyses also revealed that for dysphoric individuals attention to depression-related images was relatively constant across the 10-second presentation time, whereas for non-dysphoric individuals attention to depression-related images decreased gradually over this interval. The sustained processing of depression-related images by dysphoric individuals in the present study is similar to the sustained processing of dysphoric images by clinically depressed young adults in Kellough et al.'s (2008) study. This phenomenon likely reflects a common underlying vulnerability factor—a reduced ability to inhibit the processing of depression-related information, which may sustain and exacerbate depressive mood states (Goeleven et al., 2006).

One other important difference between the dysphoric and non-dysphoric groups emerged in the time course analyses of the data for the positive images. Although both groups increased their attention to positive images over the course of the 10-second presentation, this increase was far more pronounced for the non-dysphoric individuals (see Figure 1). Moreover, as can be seen in Figure 1, across the 10-second presentation, only the non-dysphoric individuals increased their attention to positive images while concurrently decreasing their attention to depression-related images, which led to larger differences in attention to these two types of images over the course of the presentation. This pattern of attending likely reflects a “protective” attentional bias observed in other studies of attention to emotion (e.g., Caseras, Garner, Bradley, & Mogg, 2007; Ellis, Beevers, & Wells, 2011; Ingram et al., 2008; Joormann & Gotlib, 2007; Mathews & Antes, 1992; McCabe, Gotlib, & Martin, 2000; Peckham, et al., 2010). Non-dysphoric individuals appear to divert their attention away from depression-related images and towards positive images in a way that is adaptive and helps to protect against negative mood states and cognitions. The fact that dysphoric individuals did not exhibit a similar bias lends support to the notion that depression and dysphoria are characterized by impairments in the ability to use positive and rewarding stimuli to regulate negative mood (e.g., Joormann & Siemer, 2004; Joormann, Siemer, & Gotlib, 2007). Researchers have documented many situations in which previously depressed and at-risk individuals fail to divert their attention away from negative information and toward positive information as never depressed individuals do, and our results are likely another manifestation of this phenomenon.

Taken together, our results support cognitive models of depression (Beck, 1976; Beck & Clark, 1988, Clark, Beck, & Alford, 1999; Gotlib & Joormann, 2010), which predict that depressed and dysphoric individuals will preferentially attend to depression-related information at the expense of positive information. Eye tracking studies have proven to be very useful for evaluating these models because they allow researchers to look for evidence of depression- and dysphoria-related attentional biases under viewing conditions that compliment and extend those of other attention tasks. Our study has demonstrated that the ability to quantify changes in attention over time when individuals freely view multiple images is especially valuable, because one can identify different temporal profiles in attention to emotional information, as evidenced in our study by dysphoric and non-dysphoric individuals' different patterns of attending over a 10-second presentation.

## Limitations and Directions for Future Research

There are several limitations of our study worth considering. Perhaps the most important is that we cannot conclude that the specific time course of attention we have observed for dysphoric individuals (a decrease in attention to positive images and a sustained attention to depression-related images) would also be observed for clinically depressed individuals. (The extent to which our dysphoric participants are representative is also worth keeping in mind, as they were mostly young female college students.) In fact, recall that Kellough et al. (2008) found that their group of clinically depressed young adults exhibited relatively stable patterns of attention to depression-related and positive images throughout a 30-second image presentation. The different patterns we have observed could be related to the different sets of images used and the different presentation times (10 seconds vs. 30 seconds in Kellough et al.), but a more interesting possibility is that they are due to important differences between dysphoric and depressed individuals' attention to positive and depression-related information. Clinical and subclinical depression may be characterized by distinct temporal profiles in the allocation of attention to emotional information, a possibility that eye tracking paradigms like the one we have used are ideally suited to assess. By precisely measuring the focus of attention over extended intervals within complex displays, researchers can look for qualitative differences in the temporal profiles of never depressed, dysphoric, and clinically depressed individuals. This should be a priority for future research. An additional advantage of this paradigm is that participants' memory for the images can be tested to look for evidence of depression- and dysphoria-related memory biases. A straightforward prediction is that biases in attention should predict subsequent memory biases in depression. Few studies have examined the interplay between attention and memory biases in depressed or dysphoric samples (e.g., Ellis et al. 2011) and the potential theoretical and clinical implications of this research are largely unexplored (see Everaert, Koster, & Derakshan, 2012, for a discussion).

We should also point out that although the overall pattern of group differences in the time course data was clear, especially for the later time intervals (the 6-8 and 8-10 second intervals), several of our analyses suggest that additional group differences may have been present. For example, recall that the Group x Image Type interaction for the 2-4 second interval was not quite statistically significant ( $p = .07$ ; see Figure 1). This situation is obviously less than ideal because it is difficult to conclude with any confidence that the groups did not differ in their attention to the images during this interval. The uncertainty in this case is in determining how early in the presentation dysphoria-related group differences arose: as early as 2-4 seconds after image viewing began, or not until 4-6 seconds had elapsed? Although the size of our dysphoric group ( $n = 25$ ) was comparable to those in other eye tracking studies, a larger group would have increased the statistical power of our time course analyses by reducing the variability in the fixation time data..

Our results may have implications for research on cognitive bias modification (CBM) procedures (MacLeod, Koster, & Fox, 2009), particularly as related to attentional training (AT) procedures designed to modify attention to reduce depressive symptoms (e.g., Wells & Beevers, 2010). 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 and then presenting a probe in the location of one of the words or images. The participants' task is to respond to the probe as quickly and as accurately as possible by making a detection or identification response; when the probe appears at the location of an attended word or image, detection and identification responses are facilitated. In the standard dot-probe task the probe appears in the location of the neutral stimulus and the dysphoric stimulus with equal probability (50%); in an AT procedure the probe appears in the location of the neutral stimulus with a much higher

probability (e.g., 85% in the AT procedure designed by Wells & Beevers, 2010). The logic of the AT procedure is that depressed individuals will adapt to this contingency over time and learn to reflexively allocate their attention toward neutral stimuli and away from dysphoric stimuli, reversing their habitual tendency to direct attention toward dysphoric information (see Peckham et al., 2010). Although the effectiveness and therapeutic potential of AT is currently debated (e.g., Baert, De Raedt, Schacht, & Koster, 2010; Kruijt, Putman, & Van der Does, 2013; MacLeod et al., 2009), the results of our time course analyses suggest that the objective of these procedures should be to counteract the sustained processing of dysphoric stimuli observed in depressed and dysphoric individuals, while at the same time reinforcing engagement with positive stimuli, in order to train an attentional profile similar to the one we have observed in non-dysphoric individuals. Most AT procedures, however, target and train the reflexive orienting of attention, due to the brief stimulus presentations (500-2000 ms) used in the typical dot-probe paradigm (see Wells & Beevers, 2010, for an exception). Our time course data showed that differences between dysphoric and non-dysphoric individuals were not pronounced until 4 seconds had elapsed, which suggests that researchers should focus on training attention toward positive stimuli and away from dysphoric stimuli over longer viewing times than have commonly been used.

## Conclusions

Our results show that, like clinically depressed individuals in previous studies (e.g., Kellough et al., 2008), dysphoric individuals spent more time attending to depression-related images and less time attending to positive images when viewing displays of multiple images. Our results therefore demonstrate that the attentional biases of dysphoric individuals can be very similar to those of clinically depressed individuals when attention is measured over extended intervals. In addition, our analyses of the time course of attention revealed different patterns of attending by dysphoric and non-dysphoric individuals. Unlike dysphoric individuals, non-dysphoric individuals increased their attention to positive images and decreased their attention to negative images over the course of a 10-second presentation. The absence of this “protective bias” in dysphoric individuals may constitute an important individual difference related to depression vulnerability. Additional eye tracking studies of the time course of attention to emotional information may allow researchers to identify a temporal profile unique to depressed and depression vulnerable individuals. Our results support one of the major claims of cognitive models of depression—that depression and dysphoria are associated with attentional biases that affect the processing of mood-congruent and mood-incongruent information. Of course, due to the cross-sectional nature of our study and others like it, we cannot infer any causal relations. To determine whether these biases are truly causal risk factors, researchers will need to conduct longitudinal studies to examine the predictive quality of the bias with respect to new onsets of depression (Gotlib & Joormann, 2010; Kraemer et al., 1997).

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