

# Emotion

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Online First Publication, November 8, 2010. doi: 10.1037/a0020022

### CITATION

Wells, T. T., Beevers, C. G., Robison, A. E., & Ellis, A. J. (2010, November 8). Gaze Behavior Predicts Memory Bias for Angry Facial Expressions in Stable Dysphoria. *Emotion*. Advance online publication. doi: 10.1037/a0020022

# Gaze Behavior Predicts Memory Bias for Angry Facial Expressions in Stable Dysphoria

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Interpersonal theories suggest that depressed individuals are sensitive to signs of interpersonal rejection, such as angry facial expressions. The present study examined memory bias for happy, sad, angry, and neutral facial expressions in stably dysphoric and stably nondysphoric young adults. Participants' gaze behavior (i.e., fixation duration, number of fixations, and distance between fixations) while viewing these facial expressions was also assessed. Using signal detection analyses, the dysphoric group had better accuracy on a surprise recognition task for angry faces than the nondysphoric group. Further, mediation analyses indicated that greater breadth of attentional focus (i.e., distance between fixations) accounted for enhanced recall of angry faces among the dysphoric group. There were no differences between dysphoria groups in gaze behavior or memory for sad, happy, or neutral facial expressions. Findings from this study identify a specific cognitive mechanism (i.e., breadth of attentional focus) that accounts for biased recall of angry facial expressions in dysphoria. This work also highlights the potential for integrating cognitive and interpersonal theories of depression.

*Keywords:* anger, attention, depression, eye tracking, memory

Cognitive theories of depression (e.g., Beck, 1976; Teasdale, 1988) propose that memory processes are negatively biased in depression. Specifically, depressed individuals are hypothesized to recall and recognize salient negative information but not positive information (see Matt, Vazquez, & Campbell, 1992 for a review). For example, depressed participants show enhanced implicit and explicit memory for depression-relevant words compared to anxious and control participants (Bradley, Mogg, & Williams, 1995; Rink & Becker, 2005). Depressed individuals are also more likely to falsely remember negative words compared to nondepressed controls (Joormann, Teachman, & Gotlib, 2009).

Interpersonal theories of depression (e.g., Coyne, 1976; Joiner & Metalsky, 1995) posit that depressed individuals are particularly alert for signs of interpersonal rejection and engage in reassurance seeking and other behaviors to reduce this sense of rejection. This suggests that stimuli signaling interpersonal rejection (e.g., angry facial expressions directed at the individual) would be particularly salient to depressed individuals. Indeed, Gotlib and Hammen (1992) have speculated that information processing biases, such as enhanced recall of negative or disapproving faces, may contribute to some of the interpersonal difficulties often experienced by depressed people.

Relatively few studies have examined memory biases for angry faces in depressed populations. In one of the first studies, Gilboa-Schechtman, Erhard-Weiss, and Jeczemien (2002) found that depressed participants demonstrated enhanced recognition memory for angry faces compared to controls. Depressed participants also showed diminished recognition memory for happy faces compared to controls and exhibited more of a "yes-saying" bias for sad faces (i.e., were more likely to endorse previously unseen sad faces as having been seen) compared to controls. Further, Van Honk et al. (2003) demonstrated that depressed mood was also associated with enhanced recall of angry faces in healthy individuals. In contrast, Pine et al. (2004) reported that children with a history of Major Depressive Disorder displayed deficits in recall of fearful but not happy or angry faces.

This preliminary evidence tentatively suggests that depression may be associated with biased recall of angry faces. However, the mechanisms that produce these memory biases in depression have not been identified. Attention is integral to the memory process. Specifically, attention is critical to memory encoding and to the formation of conscious memories (see Chun & Turk-Browne, 2007 for a review). Due to the memory system's limited capacity, attention governs what information will be encoded. Thus, biased attentional processing of angry faces may contribute to subsequent biased recall of those faces among depressed individuals.

A key method for assessing visual attention for emotional faces is through the use of eye movement registration to track visual gaze. In standard viewing conditions, individuals typically direct their gaze toward stimuli that attract their attention (Jonides, 1981) and visual gaze is closely associated with attentional focus (Kowler, 1995). Eye movement registration provides several indices of attention processing. The most common indices are total fixation time, number of fixations, and distance between fixations. Total fixation time and number of fixations are related assessments

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Preparation of this article was facilitated by a grant (R01MH076897) from the National Institute of Mental Health to Christopher Beevers. We thank B. Allison Yost from the Mood Disorders Laboratory at the University of Texas for her assistance with data collection.

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that reflect time spent viewing a stimulus. Distance between fixations is a putative measure of breadth of attentional focus. Greater distance between fixations indicates broader scanning of a stimulus, whereas smaller distance reflects a more narrow focus of attention. Total fixation time and number of fixations are typically computed for a priori areas of interest. In the case of viewing facial expressions, areas of interest typically involve certain facial features, such as the mouth or nose (e.g., Horley, Williams, Gonsalvez, & Gordon, 2004; Schwarzer, Huber, & Dummler, 2005). Distance between fixations is typically calculated for the entire face area (Green, Williams, & Davidson, 2003a; Green, Williams, & Davidson, 2003b; Horley et al., 2004). Together, these indices provide a comprehensive assessment of attentional focus.

Eye movement registration has been used to demonstrate that depressed and dysphoric individuals spend more time attending to dysphoria-related images than nondepressed controls (Caseras, Garner, Bradley, & Mogg, 2007; Eizenman et al., 2003; Kellough, Beevers, Ellis, & Wells, 2008), but these studies used nonface stimuli. While this technology has been used to examine visual processing of faces in autism spectrum disorders (e.g., Rutherford & Towns, 2008) and schizophrenia (e.g., Bestelmeyer et al., 2006), it has not been used specifically to investigate visual attention for emotional faces among depressed or dysphoric individuals.

Healthy, nondepressed individuals spend the most time looking at the eyes, nose, and mouth of emotionally neutral faces (Mertens, Siegmund, & Grusser, 1993; Schwarzer et al., 2005). When examining emotional facial expressions, healthy individuals show greater interfixation distances (i.e., broader attentional focus) for angry faces compared to neutral, happy, and sad faces (Green et al., 2003a). An interesting finding is that individuals with social phobia display a broadened attentional focus for angry faces compared to nonanxious controls (Horley et al., 2004). Furthermore, there is some evidence that such visual spread is associated with increased memory for visual information (Mueller, Jackson, & Skelton, 2008).

The current study expands on previous research by examining gaze behavior and memory for emotional facial expressions in stably dysphoric and stably nondysphoric individuals. Consistent with previous research on visual gaze of emotional faces (i.e., Horley et al., 2004), we measured number of fixations, fixation time, and distance between fixations for happy, sad, angry, and neutral faces. As in previous work (e.g., Mertens et al., 1993; Schwarzer et al., 2005), we identified the eyes, nose, and mouth as regions of interest for each face. We also included the forehead as a region of interest as it has been shown to be important in the perception of emotional expression (Knoll, Attkiss, & Persing, 2008).

As predicted by interpersonal theories of depression, we hypothesized that stably dysphoric individuals would demonstrate better memory for angry faces compared to stably nondysphoric individuals. Given the important relationship between attention and memory formation, we hypothesized that stably dysphoric individuals would show a broader attentional focus (i.e., greater distance between fixations) than nondysphoric people when viewing angry faces (cf. Horley et al., 2004). Furthermore, we expected distance between fixations to mediate the associations between dysphoria status and memory for angry facial expressions. Exploratory analyses examined whether dysphoria groups viewed the anatomical features (i.e., eyes, nose, mouth, and forehead) of the emotional expressions differently.

## Methods

### Participants

Participants were 66 undergraduate students who completed the study as part of a research requirement for an introduction to psychology course. Participants completed the short form of the Beck Depression Inventory (Beck, Rial, & Rickels, 1974) during mass pretesting. Participants whose scores were above 9 (indicating the presence of depressive symptoms) or below 4 (indicating minimal depressive symptoms) were contacted about participating in the current study. Of the 362 who were contacted, 85 attended the laboratory session where they completed the full Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) to ensure the stability of their dysphoria status. Mean time between pretesting and the laboratory session was 6.2 weeks with a range of 1 to 10.7 weeks.

Among those who attended the laboratory session, 32 were included in the dysphoric group (BDI-II  $\geq 16$ ) and 34 in the nondysphoric group (BDI-II  $\leq 9$ ). The remaining 19 participants did not maintain their dysphoria status from pretesting to the laboratory session and were excluded from the study. We defined dysphoria as a 16 or above on the BDI-II because previous research has demonstrated that a cut score of 16 on the BDI-II yielded the best balance of sensitivity and false positive rate for predicting a mood disorder among a college student sample (Sprinkle et al., 2002). We used a score of 9 or less for the nondysphoric group to ensure adequate separation between the dysphoria groups. Average BDI-II score was in the moderate range for the dysphoric group and in the minimal range for the nondysphoric group (see Table 1).

### Measures

The Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) is a 21-item self-report questionnaire that assesses symptoms of depression. The BDI-II is one of the most widely used self-report measures of depressive symptomatology and has demonstrated adequate internal consistency, test-retest reliability and construct validity (Dozois, Dobson, & Ahnberg, 1998).

The Inventory of Depression and Anxiety Symptoms (IDAS; Watson et al., 2007) is a 64-item scale that measures symptoms of depression and anxiety. The scales demonstrate good internal consistency as well as convergent and discriminant validity

Table 1  
*Demographic and Clinical Characteristics*

Characteristic	Group			
	Stably nondysphoric ( <i>N</i> = 34)		Stably dysphoric ( <i>N</i> = 32)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Age	18.7	3.32	19.6	1.75
Sex (number of women)	19		22	
BDI-II	4.59	2.73	24.32	6.66
IDAS social anxiety	6.97	2.74	12.16	4.75

(Watson, et al., 2008; Watson et al., 2007). To assess for social anxiety in our sample, we used the Social Anxiety subscale of the IDAS.

### Eye Tracking Paradigm

This task involved the presentation of individual faces selected from the NimStim face stimulus set (Tottenham et al., 2009). The NimStim set contains 672 images of emotional facial expressions and has been found to be valid and reliable in portraying prototypical emotional expressions (Tottenham et al., 2009). We selected a total of 24 images of different actors with 6 images from each of the following emotional categories: happy, sad, angry, and neutral (calm). An equal number of male and female actors portrayed each emotion. Each face was presented once for a total of 24 eye tracking trials.

For each eye-tracking trial, the face was presented in the center of the screen for 12 seconds and measured approximately  $25.4 \times 19$  cm (subtending to a visual angle of  $20.6^\circ \times 15.5^\circ$ ). Each trial began with a fixation cross in the center of the screen and remained until the participant fixated within approximately  $1^\circ$  of visual angle of the cross for 1 second. The presentation order of the stimuli was randomized for each participant. Stimuli were presented on a 17-inch LCD monitor. Participants sat approximately 70 cm from the screen.

### Eye Tracking System

Line of visual gaze was assessed using a remote optics eye tracking system model R6 from Applied Science Laboratories (Bedford, MA). Head location was fixed using a chin rest and forehead bar. The location of gaze was sampled every 16.7 ms (60Hz). Eye movements that were stable for more than 100ms within a  $1^\circ$  of visual angle were classified as a fixation. Distance between fixations was measured in degree of visual angle between fixations. Areas of interest (AOIs) were identified individually for each face stimulus and corresponded with the eyes, nose, mouth, and forehead of the actor. E-prime software was used to present the stimuli and to automate the recording of eye location with the eye tracking system.

### Memory Task

After completing the eye tracking task, participants performed an incidental recognition task where they viewed individual faces one at a time and were queried whether they had seen that actor displaying that particular facial expression in the eye tracking portion of the study. In addition to the 24 faces presented during eye movement registration, 24 previously unseen expressions by those same actors were presented for a total of 48 trials. Each actor was presented twice; once with the facial expression shown in the eye tracking task and once with a previously unseen expression. All emotional valences were equally represented across seen and unseen stimuli and were balanced across actor gender. Participants responded to the images by pressing a “yes” key on a response box key if they thought they had seen that actor with that expression during the eye tracking task and by pressing the “no” key if they had not seen that face. The order of the presentation of the faces

was randomized for each participant and the size of the images was identical to the eye tracking task ( $25.4 \times 19$  cm).

### Procedure

After obtaining informed consent, participants completed the BDI-II to determine whether they remained eligible for the study. Eligible participants were then escorted to the eye tracking room and seated in a height-adjustable chair. A chin rest and forehead bar was used to standardize participants’ head location. While in the chin rest, participants’ eyes were level with the middle of the 17-inch monitor on which the stimuli were presented. Camera adjustments were made to best capture the right eye of the participant, and a 9-point calibration was completed to confirm that all calibration points were within  $1^\circ$  of visual angle. The calibration process was repeated until this criterion was met.

Following successful calibration, participants were instructed via computer screen to view the images of faces naturally with the only constraint that they were to look at each face for the duration of the trial. All instructions emphasized that the study was measuring pupil dilation (a secondary measure not relevant to this study) in response to emotional faces. Recording eye movements was not mentioned in order to minimize any demand effects. There was also no mention of a later memory task regarding these stimuli. The experimenter was located in an adjacent room and monitored the stimulus presentation and eye tracking throughout each trial.

After the eye tracking task, participants engaged in two filler tasks that used nonfacial stimuli and are not relevant to the current study. These filler tasks provided a 15-min delay between the presentation of the faces in the eye tracking task and the incidental recognition task. Participants then completed the recognition memory task as described above. Before debriefing, participants were asked if they had expected a memory task involving the faces from the eye tracking task. No participants indicated expecting a memory task.

### Data Analysis Plan

Memory for emotional faces was calculated based on signal detection theory. Signal detection threshold ( $d'$ ) is a measure of the ability to differentiate target stimuli from distracter stimuli. It was calculated for each emotion by subtracting the z-score transformed false alarms (i.e., indicating “yes” to previously unseen stimuli) for a particular emotion from the z-score transformed hits (i.e., indicating “yes” to previously presented stimuli) for that emotion. Higher scores indicate better ability to distinguish targets from distracters.

We also measured a memory response bias for each emotion category. Response bias was calculated by subtracting the number of false negative responses (i.e., indicating “no” to previously presented stimuli) for a given emotion from the number of false alarms for that emotion and then dividing the difference by the sum of false negatives and false alarms. Positive scores indicate a more liberal response style (a “yes-saying” bias) while negative scores indicate a more conservative style (a “no-saying” bias).

Based on previous research examining visual gaze with faces (Horley et al., 2004; Mertens et al., 1993; Schwarzer et al., 2005) we classified the eyes, nose, mouth, and forehead of each face as AOIs. Mean fixation time and mean number of fixations were calculated for each AOI. Mean distance between fixations (in

degrees of visual angle) was calculated for the entire face for each emotion category.

## Results

### Participant Characteristics

The stably dysphoric and stably nondysphoric groups differed significantly in BDI-II score,  $t(64) = 15.87, p < .001$ , Cohen's  $d = 3.97$ , and IDAS social anxiety subscale score,  $t(63) = 5.46, p < .001$ , Cohen's  $d = 1.38$ . The two groups did not differ significantly in age,  $t(64) = 1.31, p = .20$ , or in number of women,  $\chi^2(1, N = 64) = 1.23, p = .27$  (see Table 1).

### Memory Data

**Signal detection threshold.** A 4 (face emotion: sad, angry, happy, neutral)  $\times$  2 (dysphoria group: dysphoric, nondysphoric) ANOVA with  $d'$  as the dependent variable revealed no main effects for face emotion or dysphoria group, all  $F_s < 1, p_s = ns$ , but there was a significant interaction between face emotion and dysphoria group,  $F(3, 62) = 3.58, p = .019$ , partial  $\eta^2 = .15$ . This interaction remained significant after covarying social anxiety symptoms,  $F(3, 60) = 3.65, p = .017$ , partial  $\eta^2 = .15$ . Post hoc  $t$  tests revealed a significant difference between the dysphoric and nondysphoric groups in accurately recognizing angry faces,  $t(62) = 2.46, p = .017$ , Cohen's  $d = .62$ , with the dysphoric group exhibiting greater accuracy ( $M = 0.31, SD = 1.05$ ) than the nondysphoric group ( $M = -0.41, SD = 1.28$ ). Further analyses indicated the difference in  $d'$  was driven by dysphoria group differences in correctly recognizing previously seen angry faces,  $F(1, 64) = 7.96, p = .006, d = .69$ , rather than in rejecting previously unseen angry faces,  $F(1, 64) < 1, p = .64$ . There were no other significant differences between dysphoria groups in  $d'$  for sad, happy, or neutral faces, all  $t < .5, ns$  (see Figure 1).

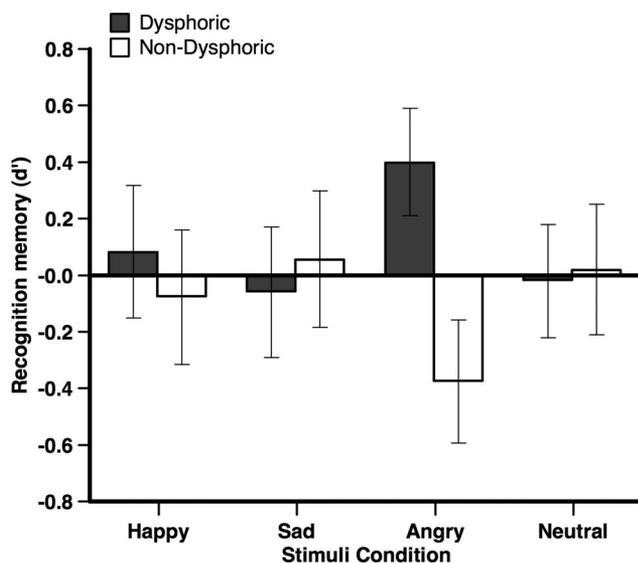


Figure 1. Mean memory accuracy ( $d'$ ) for each facial emotion by dysphoria group. Error bars represent the standard error of the mean.

**Response bias.** A 4 (face emotion: sad, angry, happy, neutral)  $\times$  2 (dysphoria group: dysphoric, nondysphoric) ANOVA with response bias as the dependent variable revealed no significant main effects or interaction for face emotion and dysphoria group, all  $F_s < 2, p_s = ns$ . Mean response bias for the sample was  $-0.22$  with a standard deviation of  $.55$  indicating a slight conservative (“no-saying”) response bias for the overall sample.

### Eye-Tracking Data

**Fixation duration.** A 4 (face emotion: sad, angry, happy, neutral)  $\times$  4 (face region: eyes, mouth, nose, forehead)  $\times$  2 (dysphoria group: dysphoric, nondysphoric) mixed plot ANOVA with fixation duration as the dependent variable revealed significant main effects for face emotion,  $F(3, 55) = 24.65, p < .001$ , partial  $\eta^2 = .57$ , and face region,  $F(3, 55) = 10.24, p < .001$ , partial  $\eta^2 = .36$ . There was also a significant interaction for face emotion and region,  $F(9, 49) = 9.78, p < .001$ , partial  $\eta^2 = .64$ . Interactions between face emotion and dysphoria group, face region and dysphoria group, as well as the 3-way interaction, were all nonsignificant, all  $F_s < 1, p_s = ns$ .

Follow-up analyses indicated that fixation duration for the eye region,  $F(3, 56) = 3.46, p = .022$ , partial  $\eta^2 = .16$ , mouth region,  $F(3, 56) = 18.47, p < .001$ , partial  $\eta^2 = .49$ , nose region,  $F(3, 56) = 5.27, p = .003$ , partial  $\eta^2 = .22$ , and forehead region,  $F(3, 56) = 10.42, p < .001$ , partial  $\eta^2 = .36$ , differed significantly between emotions. Fixation duration was longer for the eyes of happy faces compared to angry faces. Time spent viewing the mouth was greater for happy faces compared to all others. Fixation duration for the forehead was longest for angry faces compared to all others. Bonferroni corrected comparisons (at  $p < .009$ ) can be seen in Table 2.

In addition, fixation duration for each of the AOIs differed significantly within happy,  $F(3, 58) = 13.03, p < .001$ , partial  $\eta^2 = .40$ , sad,  $F(3, 58) = 20.67, p < .001$ , partial  $\eta^2 = .52$ , angry,  $F(3, 58) = 8.95, p < .001$ , partial  $\eta^2 = .32$ , and neutral,  $F(3, 58) = 17.84, p < .001$ , partial  $\eta^2 = .47$ , facial expressions. Specifically, participants spent more time viewing the eyes and nose areas of sad faces compared to the mouth area. Fixation duration was greater for the eyes and nose than the mouth and forehead of neutral faces. Time spent viewing the eyes, nose and mouth of happy faces was greater than time viewing the forehead. Fixation duration for the eyes, nose, and forehead of angry faces was greater than fixation duration for the mouth area. All comparisons are significant at a Bonferroni-corrected  $p < .009$ . An important feature fixation duration for anatomical features of the facial expressions was not different across dysphoria groups.

**Number of fixations.** The pattern of results for number of fixations was nearly identical to results for fixation duration. Specifically, a 4 (face emotion: sad, angry, happy, neutral)  $\times$  4 (face region: eyes, mouth, nose, forehead)  $\times$  2 (dysphoria group: dysphoric, nondysphoric) mixed plot ANOVA with number of fixations as the dependent variable revealed significant main effects for face emotion,  $F(3, 55) = 18.64, p < .001$ , partial  $\eta^2 = .5$ , and face region,  $F(3, 55) = 11.17, p < .001$ , partial  $\eta^2 = .38$ . There was also a significant interaction for face emotion and region,  $F(9, 49) = 15.08, p < .001$ , partial  $\eta^2 = .74$ . Interactions between face emotion and dysphoria group, face region and dys-

Table 2  
Fixation Duration by AOI and Face Emotion

AOI	Face emotion							
	Happy		Sad		Angry		Neutral	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Eyes	1.44 <sup>a</sup>	0.93	1.27 <sup>ab</sup>	0.91	1.20 <sup>b</sup>	0.80	1.40 <sup>ab</sup>	0.85
Mouth	1.09 <sup>a</sup>	1.12	0.41 <sup>c</sup>	0.53	0.66 <sup>b</sup>	0.64	0.52 <sup>bc</sup>	0.60
Nose	1.28 <sup>a</sup>	0.81	1.01 <sup>b</sup>	0.74	1.15 <sup>ab</sup>	0.80	1.13 <sup>ab</sup>	0.74
Forehead	0.52 <sup>c</sup>	0.65	0.78 <sup>b</sup>	0.91	1.27 <sup>a</sup>	1.50	0.59 <sup>c</sup>	0.71

Note. AOI = area of interest. Means in each row with different superscripts are significantly different with a Bonferroni correction of  $p < .009$  for multiple tests.

phoria group, as well as the 3-way interaction, were all nonsignificant, all  $F_s < 1$ ,  $ps = ns$ .

Follow-up analyses indicated that number of fixations for the eye region,  $F(3, 56) = 13.41$ ,  $p < .001$ , partial  $\eta^2 = .42$ , mouth region,  $F(3, 56) = 27.26$ ,  $p < .001$ , partial  $\eta^2 = .59$ , nose region,  $F(3, 56) = 7.66$ ,  $p < .001$ , partial  $\eta^2 = .29$ , and forehead region,  $F(3, 56) = 12.95$ ,  $p < .001$ , partial  $\eta^2 = .41$ , differed significantly between emotions. Number of fixations was greater for the eyes of happy and neutral faces compared to angry and sad faces. There were more fixations of the mouth for happy faces compared to all others. There were more fixations on the forehead for angry faces compared to all others. Bonferroni corrected comparisons can be seen in Table 3.

In addition, number of fixations for each of the AOIs differed significantly within happy,  $F(3, 58) = 13.03$ ,  $p < .001$ , partial  $\eta^2 = .4$ , sad,  $F(3, 58) = 20.67$ ,  $p < .001$ , partial  $\eta^2 = .52$ , angry,  $F(3, 58) = 8.95$ ,  $p < .001$ , partial  $\eta^2 = .32$ , and neutral,  $F(3, 58) = 17.84$ ,  $p < .001$ , partial  $\eta^2 = .47$ , facial expressions. Specifically, participants had more fixations for the eyes, nose, and forehead areas of sad faces compared to the mouth area. Number of fixations was greater for the eyes and nose than the mouth of neutral faces. Number of fixations for eyes of neutral faces was also greater than for the forehead. There were greater number of fixations for the eyes and nose of happy faces compared to the forehead. Number of fixations for the eyes, nose, and forehead of angry faces was greater than for the mouth area. All comparisons are significant at a Bonferroni-corrected  $p < .009$ . Number of fixations for anatomical features of the facial expressions was not

different across dysphoria groups. Patterns for both fixation duration and number of fixations were very similar.

**Interfixation distance.** A 4 (face emotion: sad, angry, happy, neutral)  $\times$  2 (dysphoria group: dysphoric, nondysphoric) ANOVA revealed a significant main effect for face emotion,  $F(3, 57) = 12.24$ ,  $p < .001$ , partial  $\eta^2 = .39$ , and a significant interaction between face emotion and dysphoria group,  $F(3, 57) = 6.01$ ,  $p = .001$ , partial  $\eta^2 = .24$ . However, the main effect for dysphoria group was not significant,  $F(1, 59) = 3.22$ ,  $p = .08$ , partial  $\eta^2 = .05$ . The interaction remained significant when social anxiety was entered as a covariate,  $F(3, 55) = 6.23$ ,  $p = .001$ , partial  $\eta^2 = .25$ . Follow-up independent samples  $t$  tests revealed a significant difference between dysphoric and nondysphoric participants in interfixation distance for angry faces,  $t(59) = 3.17$ ,  $p = .002$ ,  $d = .83$  (see Figure 2). Interfixation distance did not differ between dysphoria groups for happy, sad, or calm faces, all  $t < 1.5$ ,  $ps = ns$  (see Figure 3).

### Mediation Analysis

Our final analyses examined whether mean distance between fixations when viewing angry faces accounted for the enhanced recognition of angry faces observed in the stably dysphoric group. Mediation analyses were performed with path analysis. Several indices are often used to determine quality of path model fit. Among the most commonly used are:  $\chi^2$ , comparative fit index (CFI), and standardized root mean square residual (SRMR). Model fit that includes  $CFI \geq .85$  and  $SRMR \leq .10$  is generally accept-

Table 3  
Number of Fixations by AOI and Face Emotion

AOI	Face emotion							
	Happy		Sad		Angry		Neutral	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Eyes	2.73 <sup>a</sup>	1.56	2.33 <sup>b</sup>	1.44	2.19 <sup>b</sup>	1.46	2.81 <sup>a</sup>	1.60
Mouth	2.39 <sup>a</sup>	1.78	0.99 <sup>c</sup>	1.03	1.44 <sup>b</sup>	1.30	1.17 <sup>bc</sup>	1.17
Nose	2.67 <sup>a</sup>	1.34	2.18 <sup>b</sup>	1.34	2.45 <sup>ab</sup>	1.38	2.46 <sup>ab</sup>	1.35
Forehead	1.46 <sup>c</sup>	1.96	1.96 <sup>b</sup>	2.18	2.92 <sup>a</sup>	3.14	1.66 <sup>bc</sup>	1.84

Note. AOI = area of interest. Means in each row with different superscripts are significantly different with a Bonferroni correction of  $p < .009$  for multiple tests.



Figure 2. Plot of fixations for an angry face for a nondysphoric (left) and a dysphoric (right) participant indicating greater interfixation distance for the dysphoric participant. Data are from a single trial.

able (see Kline, 1998). These criteria were used in the present study.

We started with a fully saturated path model that examined whether mean distance between fixations when viewing angry faces partially mediated the association between dysphoria group and recognition memory for angry faces. Specifically, we posited a direct effect from dysphoria group to mean distance between fixations for angry faces, and a direct effect from mean distance between fixations for angry faces to recognition memory for angry faces. Further, we also modeled a direct effect from dysphoria status to recognition of angry faces.

Because this model is fully saturated (i.e., there are no degrees of freedom) the model fit statistics are not applicable. The results indicated significant direct effects from dysphoria group to interfixation distance for angry faces ( $B = .38, z = 3.26, p < .05$ ) and

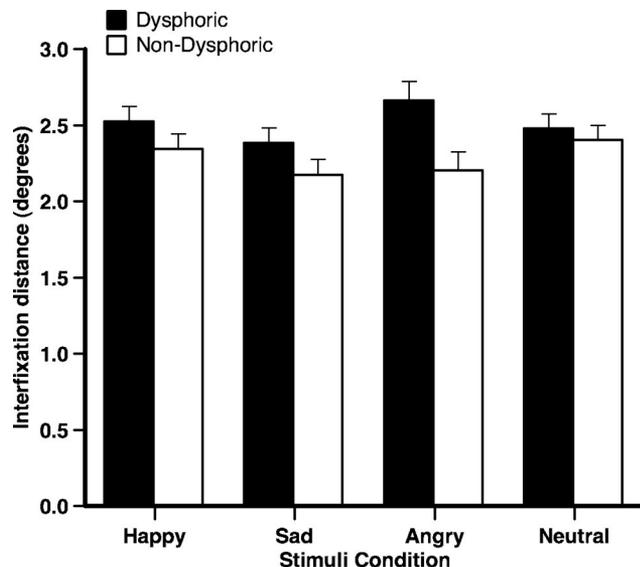


Figure 3. Mean distance between fixations (measured in degrees of visual angle) for each facial emotion category presented by dysphoria group. Error bars represent the standard error of the mean.

a significant direct effect from interfixation distance for angry faces to recognition of angry faces ( $B = .26, z = 2.01, p < .05$ ). The direct effect from dysphoria group to recognition of angry faces approached significance ( $B = .21, z = 1.75, p = .08$ ). This model explained 16% of the variance in recognition of angry faces and 14.9% of the variance in distance between fixations for angry faces.

We next tested whether a full mediation model differed significantly from the partial mediation model. To do so, we removed the direct effect from dysphoria group to recognition memory for angry faces from the previous model. Model fit was not significantly different from the initial model,  $\Delta\chi^2(1) = 3.02, p = .08$ . Thus, the full mediation model was retained, as it is more parsimonious. This full mediation model achieved adequate fit,  $\chi^2(1) = 3.02, p = .08, CFI = .88, SRMR = .06$ . More important, greater mean distance between fixations mediated the association between dysphoria status and incidental recognition of angry faces (see Figure 4). This model explained 12.6% of the variance in recall of angry faces and 14.9% of the variance in distance between fixations for angry faces.

## Discussion

This study examined differences between stably dysphoric and stably nondysphoric young adults in recognition memory for emotional faces and in visual processing of emotional faces using eye movement registration. We also examined relations between visual processing and subsequent recognition memory of emotional faces. Hypotheses based on interpersonal theories of depression (e.g., Coyne, 1976; Joiner & Metalsky, 1995) were supported. Specifically, the stably dysphoric group exhibited better recognition memory for angry faces compared to the nondysphoric group. In addition, dysphoric individuals' attentional focus was significantly broader for angry faces (as measured by distance between fixations) than nondysphoric individuals. Both of these relationships remained significant when covarying levels of social anxiety. Furthermore, a path analysis revealed that distance between fixations mediated the relationship between dysphoria status and recognition memory for angry faces.

Our finding of enhanced recognition memory for angry faces is consistent with Gilboa-Schechtman, Erhard-Weiss and Jeczemien (2002). The study by Gilboa-Schechtman and colleagues and the current study are the only studies that have examined memory for angry facial expressions in a depressed or dysphoric sample. Other previous studies examining memory biases for facial expressions in depression or dysphoria used only happy, sad, and neutral expressions (Jermann, Van der Linden, & D'Argembeau, 2008; Ridout, Astell, Reid, Glen, & O'Carroll, 2003).

The current study also provides a putative cognitive mechanism for enhanced recall of angry faces among dysphoric individuals: greater breadth of attentional focus. This is the first study to

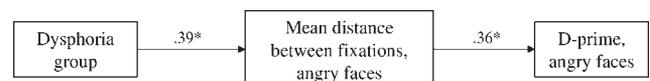


Figure 4. Results from path analyses indicating that mean distance between fixations for angry faces mediates the association between dysphoria group and recognition memory angry faces.

demonstrate differences in visual processing of emotional faces between stably dysphoric and stably nondysphoric individuals. It is also consistent with previous research demonstrating longer distances between fixations when viewing angry faces in people diagnosed with social phobia (Horley et al., 2004). Important in the current study, greater distance between fixations for angry faces remained significant even when controlling for levels of social anxiety. This suggests that the difference observed in fixation distances is not due to differences in social anxiety, *per se*. Rather, greater breadth of attentional focus when viewing angry faces may reflect a shared psychological process between social anxiety and dysphoria rather than arising from symptoms or processes specific to each disorder.

One potential shared construct is interpersonal sensitivity. Interpersonal sensitivity, also termed interpersonal rejection sensitivity, is an enduring personality characteristic that may also fluctuate somewhat with mood state (Boyce & Parker, 1989). Interpersonal sensitivity is associated with depression, particularly so-called atypical depression (Boyce, Hickie, Parker, & Mitchell, 1993; Sato et al., 2001). It has also been associated with social anxiety (Harb, Heimberg, Fresco, Schneier, & Leibowitz, 2002). As interpersonal sensitivity increases this may increase attentional vigilance and visual processing of stimuli signaling potential rejection or criticism.

Increased scanpath lengths for angry faces have also been observed in healthy individuals and putatively healthy, delusion-prone individuals (Green et al., 2003a; 2003b). Although depression and social anxiety symptoms were not assessed, these studies suggest that greater breadth of visual attention for angry faces may be part of normal functioning. Results from the current study further suggest that this tendency may be exacerbated among individuals with elevated symptoms of depression. Future work should continue to investigate visual processing of emotional faces in healthy and psychiatric samples to better understand the associated underlying factors.

Also of note in the current study is the absence of a significant difference between dysphoria groups and memory for happy faces. This absence is consistent with a previous study (Jermann et al., 2008) but inconsistent with others (Gilboa-Schechtman et al., 2002; Ridout et al., 2003). The lack of a significant difference in memory for happy faces could be most easily explained by the use of dysphoric rather than clinically depressed samples. Studies that examined memory bias for emotional faces in clinically depressed versus nondepressed participants found significant differences in bias for happy faces, with depressed participants showing diminished memory for those faces (Gilboa-Schechtman et al., 2002; Ridout et al., 2003). Both the present study and the study by Jermann and colleagues (Jermann et al., 2008) used a dysphoric versus nondysphoric sample and did not detect a significant difference in memory for happy faces. Thus, the general positivity bias for happy faces observed in nondepressed participants (e.g., D'Argembeau & Van der Linden, 2007; Shimamura, Ross, & Bennett, 2006) might diminish only in the context of depressive symptoms severe enough to warrant a clinical diagnosis. While some of our participants may have met criteria for a major depressive episode, others likely did not, possibly reducing our ability to observe a potential effect.

Similarly, the lack of a bias for sad faces in individuals with elevated symptoms of depression in the present study is consistent

with one previous study (Gilboa-Schechtman et al., 2002) but inconsistent with others (Jermann et al., 2008; Ridout et al., 2003). This inconsistency between studies cannot be explained by differences in the use of dysphoric versus depressed samples. Methodological differences such as presentation time of stimuli, explicit versus implicit encoding of stimuli, and the nature of the memory task could have contributed to the mixed findings. Furthermore, these studies did not include angry facial expressions. It may be that angry faces receive processing priority in contrast to other emotional expressions among dysphoric individuals, and therefore are remembered to a greater degree than sad or happy faces. Additional research that tests the recall of a variety of negative facial expressions (including angry and sad) is clearly needed before a definitive explanation for differences across studies can be determined.

We also found interesting differences in gaze behavior for facial features across facial expressions regardless of dysphoria status. Across emotions, participants gazed longer and fixated more often in the eye region of happy faces compared to angry faces. Gaze and shared eye contact are important for a number of social interactions (Kleinke, 1986) and the relative reduction in gaze toward the eyes of angry and sad faces may be particularly informative. Avoiding eye contact with an angry individual can serve to limit aggression by that individual in both nonhuman primates and humans (Ellsworth & Carlsmith, 1973; Van Hooff, 1967), and may represent a reflexive, instinctual response when confronted with an angry face.

Similarly, participants fixated less often on the eye region of sad faces compared to happy and neutral faces. Averted gaze can represent avoidance or disinterest (Kleinke, 1986) and the low levels of gaze directed at sad faces may represent an early stage of avoidance or rejection. Increased gaze duration and number of fixations for the mouth area of happy faces compared to angry, sad, and neutral expressions likely reflects that the broad smile or grin is a distinctive feature of happy facial expressions (Shimamura, Ross, & Bennett, 2006). Increased gaze duration and number of fixations for the nose of happy faces compared to sad faces likely represents the nose's position between the eyes and mouth. Increased gaze duration and number of fixations for the forehead of angry faces reflects the importance of the forehead in the expression of anger (Knoll et al., 2008).

In addition to these interesting findings, there are some limitations to the current study. The dysphoric group was defined by self-report measure rather than by clinical interview, thus our results may not generalize to a clinically depressed sample. However, participants exhibited depression symptom stability over several weeks, suggesting that the dysphoria experienced by these participants was more than a brief reaction to a single negative event. We also used a college student sample and the results obtained may not generalize to other samples. Lastly, we did not conduct an emotion recognition task to ensure that participants accurately perceived the emotion content of the facial stimuli. Though misperception of the emotional faces cannot be completely ruled out, it seems unlikely as recent research suggests that depressed or dysphoric participants have difficulty identifying ambiguous or less intense emotional facial expressions rather than prototypical facial expressions (Beevers, Wells, Ellis, & Fischer, 2009; Frewen & Dozois, 2005; Joermann & Gotlib, 2006).

Consistent with interpersonal theories of depression (e.g., Joiner & Metalsky, 1995), this study documents that stably dysphoric individuals exhibit memory biases for interpersonally relevant facial stimuli. Further, this study is also the first to identify a putative mechanism that explains this enhanced recall among dysphoric individuals; greater breadth of attentional focus. Dysphoric individuals had significantly greater distance between fixations when viewing angry faces than nondysphoric individuals. This, in turn, was associated with enhanced recall of angry faces. This study represents an important step toward understanding the relationship between visual attention processes and memory for emotional faces in dysphoria. Indeed, this integration of interpersonal and cognitive models of depression is an important step toward developing comprehensive etiological models of depression.

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Received May 22, 2009

Revision received March 2, 2010

Accepted March 18, 2010 ■