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ORIGINAL ARTICLE

Attention Allocation and Incidental Recognition of Emotional Information in Dysphoria

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Abstract Cognitive models of depression posit that biased emotional processing contributes to the maintenance of depression. Specifically, depression has been associated with biased attention and memory for emotional information; however, few studies have examined relations between these processes. In the current study, stably dysphoric ($n = 23$) and non-dysphoric ($n = 40$) participants' line of visual gaze was assessed while viewing a 2×2 array of emotionally valenced words. Incidental recognition of study stimuli was then assessed. Non-dysphoric individuals demonstrated an attentional bias for positive words, while dysphoric individuals lacked this bias. Further, fixation duration and time spent viewing positive stimuli mediated the association between dysphoria status and incidental recognition of positive words. Results suggest that a "protective bias" to focus on positive stimuli, typically observed among non-dysphoric individuals, is absent in dysphoria.

Keywords Depression · Information processing · Attention · Memory · Eye-tracking

Introduction

Cognitive models of depression highlight the importance of biased information processing as a central feature of the disorder. Specifically, these theories posit that depressed individuals selectively attend to negative stimuli, filter out positive stimuli, display enhanced recall of negative stimuli, and fail to recall positive stimuli (Beck 1976; Bower 1981; Teasdale 1988). Similarly, depression has been associated with a lack of a "protective bias" often displayed by non-depressed adults (McCabe and Gotlib 1995). That is, unlike non-depressed individuals who preferentially process and recall positive or neutral information, depressed individuals often fail to display such biases (McCabe and Gotlib 1995; Gotlib et al. 1988). These biases in attention and memory, in turn, are believed to maintain depression (Beck 1976; Teasdale 1988). Despite this possibility, associations between attention and memory have not yet been examined within the same study among a sample of stably dysphoric individuals.

Attentional Biases

The presence of attentional biases in depression were initially inconsistent, but this was likely related to the duration of stimulus presentation and consequent constraint on depth of processing (e.g., Siegle et al. 2001; Hartlage et al. 1993; Joormann 2004; Williams et al. 1997; Mogg and Bradley 2005). Previous work that used short stimulus presentation latencies (e.g., <500 ms) found that although attentional biases for negative information were evident in anxiety disorders, they were not present in depression (e.g., Gotlib et al. 1988; MacLeod et al. 1986; Mogg et al. 1993).

More consistent and supportive findings emerged when stimuli were presented for longer durations (see Mogg and Bradley 2005). For instance, clinically depressed individuals display an attentional bias for sad faces when paired with a neutral face for 1,000 ms (Gotlib et al. 2004a, b). Stably dysphoric individuals similarly display an attentional bias for negative word stimuli on an exogenous cuing task (Koster et al. 2005, 2009). Further, using eye tracking methodology, depressed individuals spent

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significantly more time viewing dysphoric information than non-depressed controls (Kellough et al. 2008; Eizenman et al. 2003) and maintain gaze on initially viewed negative pictures relative to controls (Caseras et al. 2007). Finally, Mathews and Antes (1992) reported that dysphoric individuals viewed sad regions of single images more often than non-dysphoric individuals. Thus, depression appears to be characterized by biased attention for negative material.

In addition to biased attention for negative stimuli, there is evidence that dysphoric mood states are characterized by the absence of a "protective bias" to focus on positive stimuli (e.g., Gotlib et al. 1988; Mogg et al. 1991). Using a novel reaction time task, depressed women displayed similar attention for positive, negative, and neutral word stimuli. This was contrary to non-depressed women who avoided negative information in favor of positive or neutral stimuli (McCabe and Gotlib 1995). A second study using a similar task found that depressed individuals did not display biased attention bias for emotionally valenced stimuli. However, non-depressed individuals not only avoided negative information, but they also spent more time attending to positive information (Gotlib et al. 1988).

Several eye tracking studies have also found that depressed and non-depressed individuals differ in time spent viewing positive stimuli. For instance, non-depressed participants spent more time viewing positive images than depressed participants when presented with several emotional stimuli simultaneously (Kellough et al. 2008). Similarly, although dysphoric participants viewed positive aspects of images longer than negative aspects, non-dysphoric participants viewed positive regions more often and for a longer period of time (Mathews and Antes 1992). Finally, dysphoric participants spent less time viewing positive scenes than non-dysphorics when a variety of emotional images were simultaneously presented (Sears et al. 2010). Together, these studies document that depression and dysphoria are both characterized by lack of attention for positive stimuli.

Memory Biases

Biased memory has also been documented in dysphoria and depression (for reviews, see Blaney 1986; Matt et al. 1992). A meta-analysis reported that memory biases in depression were influenced by stimuli valence and type of memory task (Burt et al. 1995). Depressed individuals consistently showed better recall of negative over positive information and differences between depressed and non-depressed individuals were most commonly observed for explicit but not implicit memory. Further, another review documented that depressed individuals recalled 10% more negative words than positive words. In contrast, in 80% of studies reviewed, non-depressed individuals displayed a significant memory bias for positive information (Matt et al. 1992). Additionally, a recent study found that depressed individuals had less accurate recall of positive words and more frequently falsely recalled semantically similar negative words than non-depressed people (Joorman et al. 2009).

Memory biases in depression are not only evident in free-recall tasks, but also in recognition tasks. Specifically, based on signal detection analysis, depressed individuals recognized negative material more easily and pleasant material less easily than non-depressed individuals following a 30-min delay (Dunbar and Lishman 1984). A similar pattern of results was observed following a 1-min delay (Jermann et al. 2009). Depressed individuals recognized more negative words than positive or neutral words, while non-depressed individuals displayed increased recollection of positive words. Taken together, these studies suggest that while non-depressed individuals have increased recall of positive information, depressed individuals often display enhanced memory of negative information and decreased memory of positive information.

Current Study

Although dysphoria is associated with biased attention and memory for emotional information, few studies have examined the interplay between these processes even though attention and memory are closely intertwined (see Chun and Turk-Browne 2007). More specifically, attention often determines what information will be encoded into memory (Chun and Turk-Browne 2007, for review). When processing resources are selectively allocated to specific information, memory of this information is enhanced. Therefore, in dysphoria, attentional biases toward negative information and away from positive information should consequently affect later recall of this information.

Surprisingly few studies have tested this possibility. A recent study examined biased attention under conditions that allowed or prevented elaborative processing of negative, positive, and neutral word stimuli among dysphoric and non-dysphoric individuals. Dysphoric individuals exhibited a bias for negative words when elaborative processing was possible, and this bias was associated with enhanced free recall of negative stimuli. No such association was observed among non-dysphoric adults (Koster et al. 2009). Although this work suggests that attention and memory biases are linked under some circumstances, the lack of association between attention and memory among non-dysphoric individuals was somewhat surprising; therefore the current study aimed to clarify this relationship.

More specifically, the current study first examined whether dysphoric and non-dysphoric individuals display biased attention and memory for emotional word stimuli. Attentional bias was measured with an eye tracking paradigm that simultaneously presented positive, sad, neutral, and aversive words for 10 s while line of visual gaze was recorded. Participants subsequently completed an incidental recognition task for these words. Study goals were to: (1) determine whether dysphoric and non-dysphoric individuals differed in the amount of time they viewed words from each stimulus category; (2) determine whether incidental recall of study stimuli differed across dysphoric groups; and (3) conduct mediation analyses testing whether attentional processes mediated the association between dysphoria status and word recognition.

Method

Participants

Sixty-three participants from a large southwestern university and the surrounding area were recruited through their introduction to psychology course and flyers posted around campus. A two-step process was used for subject recruitment. Interested participants first completed the short form of the Beck Depression Inventory (BDI-SF; Beck and Beck 1972). Individuals scoring above a 10 or below a 4 were invited to participate in the current study. Participants had to maintain dysphoria status upon arrival to the laboratory, which typically occurred two to 3 weeks later, when they completed the Beck Depression Inventory-II (BDI-II; Beck et al. 1996). Consistent with recommendations, participants who scored above a 20 on the BDI-II were classified as dysphoric ($n = 23$) and participants who scored 12 or below were classified as non-dysphoric ($n = 40$) (Dozois et al. 1998). Individuals who did not meet these criteria (i.e., did not maintain their dysphoria status from pre-testing to the laboratory session) were excluded from analyses ($n = 21$).

Measures

BDI-II

The Beck Depression Inventory-II (BDI-II; Beck et al. 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 symptomology and has demonstrated adequate internal consistency, test–retest reliability and construct validity (Dozois et al. 1998).

Beck Depression Inventory-Short Form (BDI-SF; Beck and Beck 1972)

This is a shortened version of the BDI with 13 questions and has been shown to have satisfactory reliability in a college sample ($\alpha = .78$) (Gould 1982). This assessment was used to screen individuals for depression symptom severity. At the request of our Institutional Review Board, we omitted the suicidality item of the BDI-SF for this screening assessment.

Demographics

All participants completed a demographics form that included age, gender, and ethnicity (see Table 1). Participants were representative of a college student sample. Importantly, there were no statistically significant differences on any of the demographic characteristics between the dysphoric and non-dysphoric groups.

Eye Tracking Paradigm

Word Selection

The task involved the simultaneous presentation of four words selected from the affective norms for English words (ANEW) (Bradley and Lang 1999). From the ANEW words, 48 were divided equally into the following categories: dysphoric, aversive, neutral and positive. The

Table 1 Means (standard deviation) for fixation time, number of fixations, fixation duration, and recognition accuracy for each stimulus word category presented by non-dysphoric (ND) and dysphoric (D) groups

Stimulus category	Fixation time (% of total)		Number of fixations		Mean fixation duration (s)		Recognition accuracy (d′)		Recognition accuracy (%)	
	ND	D	ND	D	ND	D	ND	D	ND	D
Dysphoric	19.20 (4.03)	20.94 (6.09)	3.44 (1.01)	3.55 (1.21)	1.52 (.46)	1.47 (.69)	.15 (1.32)	.07 (.95)	83.3 (9.19)	83.88 (6.19)
Aversive	20.36 (4.46)	20.66 (5.98)	3.52 (1.02)	3.39 (1.26)	1.61 (.49)	1.46 (.66)	.17 (1.57)	−.15 (1.43)	90.59 (9.13)	89.13 (8.77)
Positive	24.78 (6.42)	19.48 (7.17)	3.73 (1.07)	3.28 (1.1)	1.93 (.64)	1.34 (.60)	.14 (1.58)	−.04 (1.39)	89.92 (10.64)	88.59 (9.08)
Neutral	21.02 (5.22)	18.60 (6.61)	3.51 (.98)	3.29 (1.09)	1.69 (.56)	1.29 (.58)	−.14 (1.60)	.11 (1.52)	90.05 (9.04)	91.67 (8.04)

ANEW words had been previously evaluated based on their arousal, valence and dominance level (Bradley and Lang 1999). Given that these words had not been rated according to specific emotion categories, such as dysphoric and aversive, we had 13 undergraduate students rate how "sad" and "aversive" each word was on a 7-point scale (not at all = 1 to extremely = 7) to differentiate the negatively valenced words. As expected, the dysphoric words were rated as more sad than the aversive words ($M = 3.8$, SD = 1.4; $M = 2.7$, SD = .7, respectively), $t(12) = -3.16$, $P < .01$. Further, the aversive words were rated as significantly more aversive than dysphoric words ($M = 3.7$, SD = 1.1; $M = 2.9$, SD = 1.3, respectively), $t(12) = 3.02$, $P = .01$.

The mean valence ratings for the word categories were: dysphoric, $M = 2.7$ (SD = .8); aversive, $M = 2.7$ (SD = .6); positive, $M = 7.4$ (SD = .4); and neutral, $M = 5.2$ (SD = .4). Mean valence of negative and positive words was significantly different than neutral ($t(2, 33) = 66.54$, $P < .01$ and $t(1, 22) = 189.94$, $P < .01$, respectively). Dysphoric, positive and aversive words did not differ in arousal, ts < .64, $P > .53$. Neutral words differed from aversive and positive words in arousal, $t = -2.13$, $P = .05$ and $t = -2.46$, $P < .05$, respectively, but not from dysphoric words, $t = -1.33$, $P = .20$. There were no differences among word categories for frequency in the English language ($F = .01$, $P = .99$).

Eye-Tracking Task

One word from each category was simultaneously presented into one of four equally sized quadrants. Location of words was randomly assigned and word length was identical within each trial. Words from each stimulus category were located in each of the four quadrants equally across the 12 trials. Each trial began with a 1,000 ms centrally presented fixation cross. The experimenter manually advanced each trial when subjects' line of gaze was stable and within 1° of visual angle around fixation cross. This was followed by presentation of stimuli for 10 s. Stimuli location and order were randomly determined for each participant by stimulus presentation software. However, because letter length was equivalent across word stimuli for each trial, grouping of words was held constant across participants. Figure 1 presents an example trial with gaze density plotted (i.e., a "heatmap") for a dysphoric and non-dysphoric participant.

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. Location of gaze was sampled every 16.7 ms (60 Hz). Eye movements that were stable for more than 100 ms within a 1° of visual angle were classified as a fixation. Areas of interest (AOIs) reflected word location in each of four quadrants on the screen. E-prime software presented stimuli and automated recording of eye location with the eye tracking system. Participants' eye location was 27.5″ from monitor. Height of word stimuli was .25″ (.5° visual angle) and length of word stimuli ranged from 1.13″ to 2.25″ (2.3° to 4.7° visual angle). From center of each word stimulus, these parameters subtended visual angles of 16.6° horizontally, 12.5° vertically, and 20.6° diagonally.

Memory Task

After completing the eye tracking paradigm, participants performed an incidental recognition task where they viewed word stimuli one at a time and were queried whether they had seen that word in the eye tracking portion of the study. In addition to the 48 individual words presented during eye movement registration, 48 previously unseen words were presented for a total of 96 trials. These unseen words were also matched for degree of arousal and frequency in the English language with words used during eye tracking.

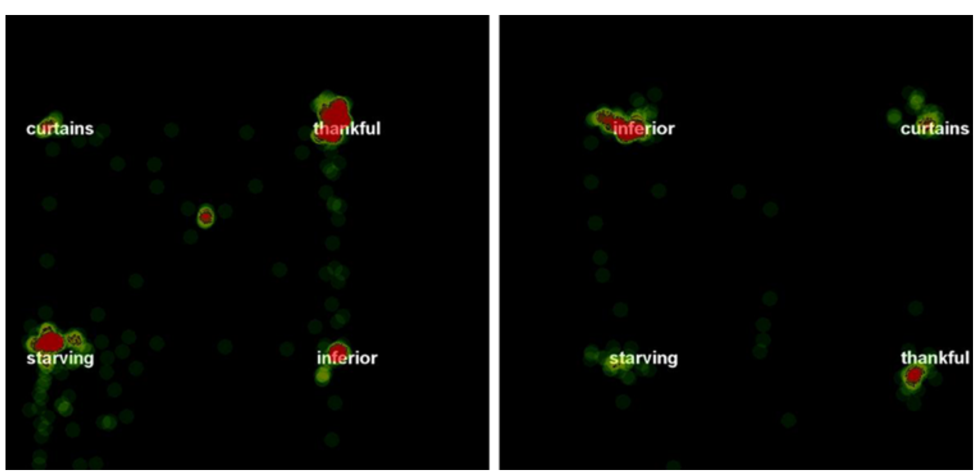

Fig. 1 Plot of gaze density for a non-dysphoric (*left*) and a dysphoric (*right*) participant. *Red* indicates high gaze density, *yellow* indicates moderate density, and *green* indicates low density. Data represent a single trial from each participant

Participants pressed a "yes" key on a response box key if they thought they had seen that word and by pressing the "no" key if they had not seen that word. Words were presented in a new random order for each participant and size of the words was identical to the eye-tracking task.

Our primary assessment of recognition accuracy for emotional words 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 category by subtracting the *z*-score transformed false alarms (i.e., indicating "yes" to previously unseen stimuli) for a particular emotion category from the *z*-score transformed hits (i.e., indicating "yes" to previously presented stimuli) for that same emotion category. Higher scores indicate better ability to distinguish targets from distracters.[1]

Procedure

Following informed consent, participants completed a demographics questionnaire and the BDI-II. They were then escorted into the eye tracking room where they were seated in a chair adjusted to accommodate their chin comfortably into the chin rest. The chin rest was positioned so participants' eyes were in line with the middle of the 17-inch monitor on which stimuli were presented. This also ensured that participants' eyes were 27 inches from the camera. A calibration procedure confirmed that they eye tracker was recording line of visual gaze within 1° of visual angle for each calibration point. This procedure utilized a 9-point calibration and was repeated until this criterion was met.

Following calibration, the task began. Instructions were presented via the computer screen. Instructions asked participants to view word stimuli naturally. The main constraint was that gaze should be directed towards the screen at all times. In addition, to standardize initial gaze location, participants were instructed to look at the fixation cross-hair prior to each trial. The experimenter (positioned in an adjacent room) continuously monitored stimulus presentation and eye tracking throughout each trail.

After eye-tracking was completed, participants were informed that they were going to view a series of words, one at a time, and make judgments (yes/no) about whether or not they had previously seen each word during the eye tracking portion of the experiment. Participants indicated their response by pushing a corresponding response box button. This incidental recognition task occurred immediately after eye tracking. Participants were then debriefed and thanked for their time.

Results

Participant Characteristics

Stably dysphoric and stably non-dysphoric groups differed significantly in BDI-II score, $t(61) = 16.30$, $P < .001$. Dysphoric participants had moderate elevations in depression symptoms ($M = 26.6$, SD = 6.5) compared to non-dysphoric participants ($M = 5.9$, SD = 3.6). The two groups did not differ significantly in age, $t(52) = 1.25$, $P = .22$ (dysphoric: $M = 19.7$, SD = 1.1; non-dysphoric: $M = 18.7$, SD = 3.5), or in number of women, $\chi^2(1, N = 63) = 4.86$, $P = .09$ (dysphoric: 69% female; non-dysphoric: 45% female).

Percent Time Attending to Stimuli

A 4 (stimulus valence: dysphoric, aversive, positive, neutral) × 2 (dysphoria group: dysphoric, non-dysphoric) repeated measures analysis of variance examined whether dysphoria group was associated with time spent viewing stimuli from each category. Analyses indicated a significant main effect for valence, $F(3, 153) = 3.05$, $P < .05$, partial $\eta^2 = .06$, that was qualified by a significant valence × dysphoria group interaction, $F(3, 153) = 6.81$, $P < .001$, partial $\eta^2 = .12$.

To decompose the significant interaction, we first examined time spent attending to stimuli within each dysphoria group with a repeated measures ANOVA. Within the non-dysphoric group, there was a significant main effect for valence, $F(3, 87) = 8.95$, $P < .001$, partial $\eta^2 = .06$. Least significant difference (LSD) pairwise comparisons indicated that non-dysphoric individuals spent more time viewing positive stimuli than all other stimuli (all Ps < .05). Further, they spent more time viewing aversive stimuli than neutral stimuli ($P < .05$). All other comparisons were non-significant. For the dysphoric group, there was no main effect for stimuli valence, $F(3, 66) = 1.58$, $P = .20$, suggesting that time spent viewing the stimuli did not differ (see Table 1).

[1] For secondary analyses, we also calculated the percent correct within each emotion category (i.e., the number of correct yes and no responses given for dysphoric, aversive, positive, and neutral stimuli / total responses × 100). A 4 (valence: dysphoric, aversive, positive, neutral) × 2 (dysphoria group: dysphoric, non-dysphoric) repeated measures ANOVA examined whether dysphoria groups differed in percentage of words from each stimuli category correctly recognized. The valence main effect, $F(3, 156) = 17.32$, $P < .001$, partial $\eta^2 = .25$, was significant. LSD pairwise comparisons indicated that percent of correct responses was lowest for dysphoric words compared to aversive, neutral and positive words (Ps < .01). The interaction between word valence and dysphoria group was non-significant, $F(3, 156) = .91$, $P = .44$, partial $\eta^2 = .02$. Further, the main effect of dysphoria group was also non-significant, $F(1, 52) = .01$, $P = .94$, partial $\eta^2 = .00$. Thus, percentage of correctly identified word stimuli did not differ for dysphoria groups (see Table 1).

We then compared dysphoria groups for time spent attending to stimuli from each emotion category with one-way ANOVAs. The non-dysphoric group spent significantly more time viewing positive stimuli than the dysphoric group, $F(1, 51) = 8.03$, $P < .01$, partial $\eta^2 = .14$. No group differences were observed for time spent viewing dysphoric, $F(1, 51) = 1.56$, $P = .22$, partial $\eta^2 = .03$, aversive, $F(1, 51) = .05$, $P = .83$, partial $\eta^2 = .00$, or neutral, $F(1, 51) = 2.22$, $P = .14$, partial $\eta^2 = .04$, stimuli. In summary, results indicated that the non-dysphoric group had a bias to view positive stimuli that was absent among the dysphoric group (see Table 1).

Number of Fixations Per Stimulus Category

A 4 (valence: dysphoric, aversive, positive, neutral) × 2 (dysphoria group: dysphoric, non-dysphoric) repeated measures ANOVA examined whether dysphoria groups differed in number of fixations per stimulus category. There was a non-significant valence effect, $F(3, 153) = .52$, $P = .67$, partial $\eta^2 = .01$, and a significant valence × dysphoria group interaction, $F(3, 153) = 2.69$, $P < .05$, partial $\eta^2 = .05$. Within the non-dysphoric and dysphoric groups, there was no main effect for valence, $F(3, 87) = 1.67$, $P = .18$, partial $\eta^2 = .05$ and $F(3, 66) = 1.62$, $P = .19$, partial $\eta^2 = .07$, respectively. Further, there were no significant differences between groups for number of fixations for positive, $F(1, 51) = 2.15$, $P = .15$, partial $\eta^2 = .04$, dysphoric, $F(1, 51) = .12$, $P = .74$, partial $\eta^2 = .00$, aversive, $F(1, 51) = .18$, $P = .67$, partial $\eta^2 = .00$, and neutral, $F(1, 51) = .46$, $P = .50$, partial $\eta^2 = .01$, stimuli. This suggests that the lack of a positive bias among dysphoric individuals is not due to number of fixations per category (see Table 1).

Mean Fixation Duration

A 4 (valence: dysphoric, aversive, positive, neutral) × 2 (dysphoria group: dysphoric, non-dysphoric) repeated measures ANOVA examined whether dysphoria groups differed in mean fixation duration by stimulus category. Analyses indicated a significant effect for valence, $F(3, 153) = 3.61$, $P < .05$, partial $\eta^2 = .07$, and a significant valence × dysphoria group interaction, $F(3, 153) = 5.11$, $P < .01$, partial $\eta^2 = .09$.

Within the non-dysphoric group, there was a significant valence effect, $F(3, 87) = 6.17$, $P < .001$, partial $\eta^2 = .18$. LSD pairwise comparisons indicated that fixation duration was longer for positive stimuli compared to aversive ($P < .005$), dysphoric ($P < .05$), and neutral ($P = .06$) stimuli. No other differences were observed. For the dysphoric group, LSD comparisons indicated fixation duration was significantly shorter for neutral compared to threat ($P < .01$) and positive ($P < .05$) stimuli. No other differences were observed. Comparisons between dysphoria groups indicated greater fixation duration for positive stimuli, $F(1, 51) = 5.99$, $P < .05$, partial $\eta^2 = .11$, and neutral stimuli, $F(1, 51) = 6.55$, $P < .05$, partial $\eta^2 = .11$, but no dysphoria group differences for aversive, $F(1, 51) = 2.24$, $P = .14$, partial $\eta^2 = .04$, and dysphoric, $F(1, 51) = 1.82$, $P = .18$, partial $\eta^2 = .03$, word stimuli. This implies that the positive bias among non-dysphoric individuals may have resulted from longer average glance durations when viewing positive stimuli (see Table 1).

Recognition Accuracy

For recognition accuracy (d′), a 4 (valence: dysphoric, aversive, positive, neutral) × 2 (dysphoria group: dysphoric, non-dysphoric) repeated measures ANOVA examined whether dysphoria groups differed in recognition for words from each stimulus category. The valence main effect, $F(3, 153) = .18$, $P = .90$, partial $\eta^2 = .00$, and its interaction with dysphoria group, $F(3, 153) = .44$, $P = .44$, partial $\eta^2 = .02$, were both non-significant. Further, the main effect of dysphoria group was also non-significant, $F(1, 51) = .65$, $P = .80$, partial $\eta^2 = .00$. Thus, recognition of word stimuli did not differ for dysphoria groups (see Table 1).

Mediation Analyses

The final set of analyses examined whether glance duration mediated the relationship between dysphoria status and time spent viewing positive stimuli. Further, although above analyses indicated that dysphoria status did not significantly predict recognition accuracy, we also examined whether time spent viewing positive stimuli influenced recognition accuracy regardless of dysphoria status. Path analysis was used to test these possibilities. Several indices are often used to determine quality of path model fit. Among the most commonly used are: χ^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 acceptable (see Kline 1998). These criteria were used in the present study.

Our initial model examined whether average glance duration for positive stimuli mediated the association between dysphoria group and percent time viewing positive stimuli. Dysphoria group status was coded 0 for non-dysphoric and 1 for dysphoric. We posited a direct effect from dysphoria group to average fixation duration for positive stimuli, and a direct effect from average fixation duration to percent time viewing positive words. Further, we also modeled a direct effect from percent time viewing positive words to recognition accuracy (d′) for positive

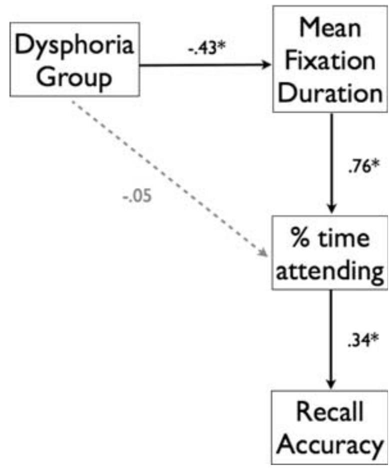

Fig. 2 Path model examining associations among dysphoria status, mean fixation duration for positive words, percentage of total time attending to positive words, and recognition accuracy for positive words. *Note*: The *solid lines* between observed variables were tested in the initial model. In a subsequent model, the *dashed line* was added to the initial model

words. This model had very good fit χ^2 ($N = 53$, $df = 3$) = 1.01, $P = .78$, CFI = 1.00, SRMR = .02. Depression group was significantly inversely associated with average fixation duration, which in turn was positively associated with percent time viewing positive words. Time spent viewing positive words was positively associated with recognition accuracy (see Fig. 2). The indirect effect of dysphoria group on recognition accuracy via mean fixation duration and percent time viewing positive words ($\beta = .11$) was also significant, using criteria identified by Cohen and Cohen (1983).[2] This model explained 11.6% of the variance in recognition accuracy for positive words, 17.1% of the variance in mean fixation duration for positive words, and 57.9% of the variance for percent time viewing positive words (see Fig. 2).

We then tested a second model, examining whether adding a direct effect from dysphoria group to percent time viewing positive words would improve model fit. The addition of this direct effect did not significantly improve model fit $\Delta\ \chi^2 = .29$. Further, the direct effect from dysphoria status to percent time viewing positive words was not significant (see dashed line, Fig. 2). This indicates that average fixation duration for positive stimuli fully mediates the association between dysphoria group status and percent time attending to positive stimuli.

Discussion

Depression is thought to be characterized by selective attention and memory bias for emotional information. Although a number of studies have examined attentional and memory biases independently, the current study concurrently examined selective attention and recognition for emotionally valenced word stimuli in stably dysphoric and non-dysphoric individuals. Eye tracking methodology was used to study selective attention for positive, aversive, dysphoric, and neutral word stimuli presented simultaneously for 10 s. Signal detection theory analyses examined accuracy of incidental recognition for stimuli presented during eye tracking. Finally, path analyses tested linkages between selective attention and recognition of word stimuli.

Non-dysphoric individuals demonstrated an attentional bias towards positive information, whereas dysphoric individuals lacked this positive bias. Compared to dysphoric individuals, non-dysphoric individuals spent more time viewing positively valenced words. Further, non-dysphoric individuals spent more time viewing positive information than all other types of information, whereas dysphoric individuals viewed stimuli equally. This bias towards positive word stimuli among non-dysphoric participants was related to longer mean fixations but not number of fixations. These results are consistent with previous work that also identified a positive bias was absent in people experiencing dysphoric mood (Kellough et al. 2008; Sears et al. 2010). In addition to a lack of positive bias, our results were consistent with previous work (e.g., McCabe and Gotlib 1995; Gotlib et al. 1988), showing that dysphoric individuals viewed emotionally valenced stimuli in an unbiased fashion.

In contrast to our results, however, other eye tracking studies have documented selective attention for mood congruent stimuli (Kellough et al. 2008; Eizenman et al. 2003). For instance, although Kellough et al. (2008) found the absence of a positive bias, they also found clinically depressed individuals spent more time viewing sad stimuli than non-depressed individuals. Similarly, Eizenman et al. (2003) found a similar bias for dysphoric stimuli. One possible explanation is that previous eye tracking studies recruited individuals who were diagnosed with a clinical episode of depression (Kellough et al. 2008; Eizenman et al. 2003), whereas participants in our study had elevated symptoms of depression but were not interviewed for the presence of major depressive disorder (MDD). Another eye tracking study of dysphoric individuals also reported that

[2] An indirect effect is the product of the direct effects that comprise the indirect effect pathway. Although exact significance tests are available for indirect effects involving up to three variables, Cohen and Cohen (1983) suggested that a reasonable proxy for exact significance tests for indirect effects involving four or more variables is whether each of the constituent direct effects are significant. If each direct effect is significant, as in our case, Cohen and Cohen (1983) suggested that the indirect effect is also likely significant. However, these effects tend to be small, given that the indirect effect size is a product of multiple direct effects.

non-dysphoric individuals had greater selective attention for positive stimuli than dysphoric individuals and that these groups did not differ for time spent viewing negative stimuli (Sears et al. 2010). It is possible that the absence of a protective bias is associated with milder forms of depression and that selective attention for negative stimuli occurs as depressive symptoms become more severe or chronic. Future work should consider directly comparing selective attention among participants who are clinically depressed, stably dysphoric, and never depressed to better understand how these biases unfold across a range of depressive symptoms.

In contrast to selective attention, no significant dysphoria group differences were observed for incidental recognition of stimuli presented during the attention task. Both groups recognized the stimuli with similarly high accuracy. This finding is consistent with previous research that did not show differences in memory between dysphoric and non-dysphoric individuals despite differences in selective attention (Koster et al. 2009), yet it is also inconsistent with previous research documenting enhanced memory for mood congruent stimuli often observed among depressed individuals (Matt et al. 1992).

One possible explanation for our lack of an association between dysphoria and memory bias may be our use of a recognition task. Hertel (2000) suggests that memory biases are most robust when the task is less structured, such as a free recall task. Although we set no constraints on the initial viewing of stimuli, recognition is inherently more constrained than free recall. This may have limited our ability to detect dysphoria group memory differences. Indeed, it is interesting that the least constrained task (eye tracking) produced the most robust dysphoria group differences. Further, the recognition task occurred immediately after eye tracking, reducing the opportunity for memory of word stimuli to decay. The brief period between presentation of stimuli and subsequent incidental recognition may have contributed to relatively high accuracy rates (80–90% correct). The relative ease of this recognition task may have also contributed to the lack dysphoria group differences for the recognition task. It will be important for future work to determine whether recognition biases are associated with depression severity and whether memory biases become more or less pronounced over time.

Given that the scope of information processing is limited, sustained attention to a stimulus may enhance encoding of the attended stimulus and subsequent recall (Chun and Turk-Browne 2007). Consistent with this idea, our results indicate that time spent attending to positive stimuli predicted recognition accuracy of those stimuli. Individuals who had longer average fixation duration for positive stimuli spent more total time viewing positive stimuli and had more accurate recognition of positive stimuli. This suggests that greater sustained attention for positive information in non-dysphoric individuals may serve to "protect" the individual by increasing the likelihood of later retrieval of positive stimuli. The absence of this protective attentional bias in dysphoria, in turn, may serve to maintain sad mood by decreasing future accessibility to positive information.

Although the relation between dysphoria and recognition was relatively small, this study is the first to identify attentional mediators through which dysphoria may affect memory for positive stimuli. However, it should be noted that associations observed between attention and recognition were correlational. Experimentally manipulating attention with cognitive training may be a fruitful direction for future work to further clarify causal relations among these cognitive processes. Notably, non-depressed individuals can be trained to allocate their attention toward emotionally valenced stimuli, which in turn increases vulnerability to experience negative emotion (MacLeod et al. 2002). Further, repeated attention training away from dysphoric stimuli can reduce depressive symptoms over time (Wells and Beevers 2010). It seems plausible that training depressed individuals to attend to positive stimuli may facilitate recall of positive information, which may also facilitate mood improvement. Additional work that examines the effect of manipulated attention on memory is clearly warranted.

Summary

Study findings indicate that dysphoria is characterized by the absence of a protective attentional bias for positive stimuli that is typically observed among non-dysphoric individuals. Although there was no direct association between dysphoria and incidental recognition of stimuli presented during eye tracking, path analyses revealed that average fixation duration and total fixation time for positive stimuli predicted subsequent incidental recognition. Thus, dysphoria is inversely associated with biased attention for positive stimuli, which in turn predicts individual differences in recognition of positive stimuli. These results provide new insight into how attention and memory processes operate within dysphoria. Such information may help inform development of novel interventions designed to prevent escalation of dysphoria into more severe and chronic forms of depression.

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