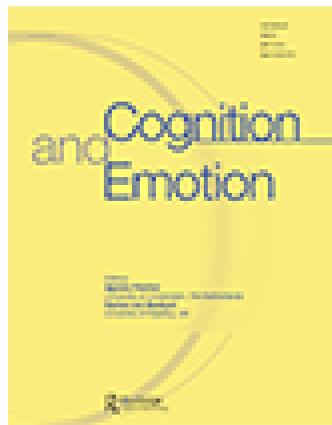


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Attentional bias in euthymic bipolar I disorder

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Little is known about the nature of the relation between information-processing biases and affective traits in bipolar disorder. The present study was designed to investigate whether attentional biases are evident in persons diagnosed with bipolar disorder when they are in a positive mood state, and whether biases are related to indices of emotion regulation and to prior history of mood episodes. Ninety adults diagnosed with bipolar I disorder and 81 controls with no lifetime mood disorder underwent a positive mood induction and then completed an emotion face dot-probe task; participants in the bipolar disorder group also completed a self-report measure of responses to positive affect. Attentional bias was not related to a diagnosis of bipolar disorder or to symptom severity. Consistent with hypotheses, analyses within the bipolar group indicated that greater dampening of positive affect related to significantly less attention paid to the positively valenced faces. Discussion focuses on the potential role of affective traits in shaping attentional bias in bipolar disorder.

Keywords: Attention bias; Bipolar disorder; Cognitive bias; Dampening.

Biases in cognitive processes such as attention and memory (“information-processing biases”) have been hypothesised to maintain anxiety and depressive disorders (Beck, 1976). Anxiety disorders and unipolar depression have both been found to be associated with attentional biases towards negatively valenced stimuli (Armstrong & Olatunji, 2012; Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Gotlib, Kasch, et al., 2004; Peckham, McHugh, & Otto, 2010). Attentional biases have also been found to predict the course of disorder (Beevers & Carver, 2003; Beevers, Lee, Wells, Ellis, & Telch, 2011), which has provided a foundation for

research examining attentional bias training as a clinical intervention (Hakamata et al., 2010). In contrast to depression and anxiety, relatively little research has been conducted examining attentional biases in bipolar disorders.

Applying information-processing models to bipolar disorder is particularly complicated because many people with bipolar disorder experience both depression and mania. Several studies of individuals in manic episodes have found a bias towards positive stimuli (Murphy et al., 1999) and problems with attentional control in the context of positive stimuli (García-Blanco, Perea, & Salmerón, 2013) in bipolar disorder. Investigators

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have also documented propensities towards overly positive cognitive styles in individuals with bipolar disorder during euthymic periods, including exaggerated confident attitudes about themselves and their future and a general profile of elevated sensitivity to reward (Johnson, Edge, Holmes, & Carver, 2012). Given this profile, one might expect individuals with bipolar disorder to show attentional bias towards positively valenced stimuli. Although evidence for this hypothesis has been mixed (García-Blanco, Salmerón, Perea, & Livianos, 2014; Leyman, de Raedt, & Koster, 2009; Jabben et al., 2012; Whitney et al., 2012), heterogeneity in study methodology and in mood state of participants makes it difficult to draw strong conclusions about the nature of positive biases in bipolar disorder.

The current study was designed to examine attentional biases in bipolar disorder while addressing three aspects of methodological variability in previous research. First, a number of studies of unipolar depression have documented mood-congruent effects of negative mood inductions on cognitive processing (Scher, Ingram, & Segal, 2005). In this context, some investigators have argued that biases may be easier to detect during a positive mood state in people with bipolar disorder. Indeed, some studies of bipolar disorder have documented a bias to attend to and detect positive stimuli in samples characterised by an elevated mood, assessed either during current manic states (Murphy et al., 1999) or after a positive mood induction (Roiser et al., 2009; Trevisani, Johnson, & Carver, 2008), but not when euthymic bipolar adults have been assessed in the absence of a positive mood induction (García-Blanco et al., 2014; Jabben et al., 2012). Following this literature, we reasoned that, compared with earlier dot-probe studies, reducing heterogeneity in mood state and specifically testing participants while in a positive mood state could enhance our ability to detect mania-congruent attentional biases.

Second, researchers have argued that facial stimuli provide a more sensitive index of information-processing biases than do words (Gotlib, Krasnoperova, Yue, & Joormann, 2004), and a

broader literature suggests the evolutionary importance of conspecific facial cues (e.g., Schmidt & Cohn, 2001). Consistent with this formulation, numerous studies using the dot-probe task with valenced faces have found attentional bias effects in studies of depression and anxiety disorders (Bar-Haim et al., 2007; Peckham et al., 2010). In studies of bipolar disorder, some investigators have found evidence of attentional abnormalities during the processing of valenced faces in currently depressed (García-Blanco, Perea, & Salmerón, 2013; Leyman et al., 2009) and currently manic adults (García-Blanco, Perea, & Salmerón, 2013), but not in bipolar individuals who are in euthymic states (García-Blanco, Perea, & Salmerón, 2013) or in adolescents with bipolar I disorder (Whitney et al., 2012). No study to date, however, has used the dot-probe task with faces as stimuli in adults with bipolar disorder. Within bipolar disorder, at least one study suggests that risk for the disorder is associated with increased sensitivity to facial expressions of happiness following a positive mood induction (Trevisani et al., 2008). Building on these findings, the present study assessed attentional biases to facial stimuli following a positive mood induction.

Third, a number of studies of attentional bias in unipolar depression and anxiety disorders have found that stimulus duration is important in determining whether attentional bias is observed in these populations (Bradley, Mogg, & Lee, 1997). In studies of unipolar depression, greater bias for negative emotion cues has generally been observed when stimuli are displayed for relatively long durations (i.e., at least 1 s; Bradley et al., 1997; Gotlib, Kasch, et al., 2004). Conversely, in studies of individuals with anxiety disorders, bias towards negative information is frequently observed at much shorter stimulus durations (i.e., <500 ms); though anxiety is associated with avoidance of negative cues presented for longer durations (Bögels & Mansell, 2004; Mogg, Bradley, & Williams, 1995). This literature suggests that, rather than a general bias towards negative information, specific forms of psychopathology shape attention to emotion cues in ways that vary according to stimulus duration. Very few studies of attention in bipolar disorder have manipulated

presentation time. Whitney and colleagues (2012) found no evidence of biased attention at either short or long presentation times in adolescents with the disorder, and a dot-probe study of students at risk for bipolar disorder found no evidence of attention bias at either subliminal or supraliminal presentation times (Rock, Goodwin, & Harmer, 2010). To our knowledge, no studies that have used the dot-probe task have examined the role of presentation time in adults diagnosed with bipolar disorder.

In addition to biases towards positive information, it is also important to consider the possibility of a bias towards negatively valenced stimuli in the 67–75% of people with bipolar disorder who have a history of major depressive episodes (cf. Cuellar, Johnson, & Winters, 2005). Negative cognitive styles, measured using self-report scales, have been shown to be related robustly to the severity of previous (Alloy, Reilly-Harrington, Fresco, Whitehouse, & Zechmeister, 1999) and current (Van der Gucht, Morriss, Lancaster, Kinderman, & Bentall, 2009) depressive symptoms among adults with bipolar disorder. In persons experiencing bipolar depression, findings of one study suggested a bias towards both negative and positive stimuli (Leyman et al., 2009), although other investigators have failed to produce this effect (Jabben et al., 2012; Jongen, Smulders, Ranson, Arts, & Krabbendam, 2007; Rubinsztein, Michael, Underwood, Tempest, & Sahakian, 2006). In the current study we examined history of depression as a predictor of positive and negative attentional biases in bipolar I disorder.

Finally, findings from several studies suggest that people with bipolar disorder show a bias *away* from positive words or reduced attention to positive images both while they are depressed (García-Blanco et al., 2014; Jabben et al., 2012; Jongen et al., 2007) and during euthymic states (Jongen et al., 2007). How might we understand a tendency to avoid emotionally relevant stimuli? In a series of studies, Mansell and colleagues found that many people with bipolar disorder experience their emotions as overwhelming and catastrophic (Mansell, 2006; Mansell & Jones, 2006). Persons with a diagnosis of bipolar disorder have been

found to engage in strategies to dampen and avoid even positive mood states (Edge et al., 2013; Johnson, McKenzie, & McMurrich, 2008; Gruber, Eidelman, Johnson, Smith, & Harvey, 2011). This type of response to emotion-relevant stimuli might help to explain a tendency for some persons with bipolar disorder to exhibit a bias away from positive stimuli. In considering avoidance, it is worth noting that dampening emotion does not appear to be universal in bipolar disorder, in that some individuals also engage in strategies to amplify positive emotion (Feldman, Joormann, & Johnson, 2008; Raes, Daems, Feldman, Johnson, & van Gucht, 2009). When present, dampening of positive affect does appear to be tied to lower quality of life, making this affective trait particularly important to understand (Edge et al., 2013). Despite the evidence that some people with bipolar disorder may engage in responses designed to avoid emotion-relevant stimuli and the heterogeneity in this profile, no research to date has considered whether information-processing biases are related to these tendencies. Increasingly, researchers studying depression (Joormann & D'Avanzato, 2010) and anxiety (Cisler & Koster, 2010) have hypothesised links between emotion regulation and information processing in mood and anxiety disorders. Taken together, the inconsistencies suggest that the considerable heterogeneity in depressive history and emotion-relevant traits may shape information-processing style among euthymic persons with bipolar disorder.

The current literature suggests that it is important (1) to reduce heterogeneity by testing all participants after inducing a positive mood; (2) to use facial stimuli; (3) to consider the effects of stimulus duration; and (4) to consider the role of depression history and dampening of positive affect as predictors of attentional biases. Therefore, in the current study we administered a positive mood induction procedure to participants and then carefully assessed attentional biases using the dot-probe task with facial stimuli, which is a well-validated measure that has not yet been used in studies of adults with bipolar disorder. We presented stimuli at durations of 1 s (similar to studies of unipolar depression) and 3 s (designed

to investigate maintenance of attention to positive and negative cues; cf. Joormann & Gotlib, 2007), and we assessed both history of depressive episodes and attitudes towards positive emotion.

We predicted that after a positive mood induction, people with bipolar disorder would show greater attention to happy faces than would control participants, and that depression indices within bipolar disorder (quantified by lifetime frequency of depressive episodes and current depressive symptoms) would predict greater bias towards sad faces. Regarding emotion regulation, we hypothesised that dampening of positive affect would predict reduced attentional bias for happy faces, whereas strategies to amplify positive affect would predict greater attentional bias for happy faces. Drawing on the unipolar depression literature, we predicted that biases would be more powerfully associated with bipolar disorder when stimuli were presented for relatively longer durations.

METHOD

Participants

The sample consisted of 90 adults diagnosed with bipolar I disorder and 81 control participants with no current or lifetime mood disorder diagnosis who were recruited in Miami and Palo Alto. Some data from this sample have been previously reported in other publications (Edge et al., 2013; Johnson, Carver, & Gotlib, 2012; Victor, Johnson, & Gotlib, 2011), however, the dot-probe paradigm results have not previously been published. We report how we determined our sample size, all data exclusions, all manipulations and all measures in the study. Study procedures were approved by the Institutional Review Board at the University of Miami and Stanford University. Participants were recruited through advertisements placed on the Internet, in newspapers and flyers, and at public transportations sites, as well as through local outpatient clinics within the Palo Alto, California and Miami, Florida communities. To be considered for the study, participants were required to be between 18 and 65 years of age and to have spoken English for at least 10 years. Exclusion

criteria included a history of medical conditions affecting central nervous system functioning (e.g., major head or brain injuries or degenerative CNS disorders); conditions that would interfere with independently and adequately completing self-report measures; and colour blindness.

The Structured Clinical Interview for DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1996) was used to assess diagnostic status. SCID interviewers were doctoral level graduate students who received extensive training in this instrument. Those who met diagnostic criteria for substance abuse or substance dependence within the past year, for a primary psychotic disorder during their lifetime, or for a mood episode secondary to a general medical condition were excluded. In addition, participants were excluded if they had undergone treatment involving ECT during the past 18 months. To facilitate examination of the influence of comorbid conditions, recruitment was stratified such that about half of participants with bipolar disorder met criteria for lifetime substance-related conditions and half for an anxiety disorder. To enhance the comparability of the bipolar and the control group, control participants with a lifetime history of anxiety disorders and those with a history of substance use disorders were strategically recruited through advertising in relevant centres (e.g., anxiety clinics and AA groups), as well as through targeted newspaper ads. To increase comparability, advertising for control participants was also conducted in unemployment and public benefit centres. Recruitment was targeted so that the bipolar and control groups were comparable in their mean age and gender ratio.

Measures

Somatotherapy Index

The Somatotherapy Index (Bauer, McBride, Shea, Gavin, Holden, & Kendall, 1997) is a 6-point scale that assesses treatment adequacy of psychotropic medications. This measure integrates information on dosage and adherence for current psychotropic medications.

Structured Clinical Interview for DSM-IV

The SCID (First et al., 1996) is the most widely used semi-structured diagnostic interview. Within the bipolar group, interviewers collected data about the number of depressive and manic episodes, as well as the age of onset of depressive and manic episodes. Before conducting SCID interviews, staff completed extensive didactic and role-play training, including multiple co-interviews and reliability assessments. Inter-rater reliability, based on a random sample of 10 audiotaped interviews, was good for depression ($k = 1.0$) and mania diagnoses ($k = 1.0$). Because estimates of number of depressive and manic episodes were not normally distributed, these data were recoded as: fewer than four episodes, four to six episodes or more than six lifetime episodes, and non-parametric correlations were conducted of these variables. An aggregate score was used to define lifetime presence of a substance use disorder (alcohol abuse, alcohol dependence, substance abuse or substance dependence). In parallel, a dichotomous score was calculated to index the lifetime presence of any anxiety disorder (generalised anxiety disorder, panic disorder, agoraphobia, social phobia, specific phobia, obsessive-compulsive disorder or post-traumatic stress disorder).

Bech-Rafaelson Mania Rating Scale

The Bech-Rafaelson Mania Rating Scale (BRMS; Bech, Bolwig, Kramp, & Rafaelson, 1979) is an 11-item interview designed to assess the severity of manic symptoms. Previous research has established that BRMS scores are strongly correlated with other indices of mania and distinguish individuals with mania from individuals not experiencing mania (Bech, 2008). Reliability was monitored throughout the study. Both inter-rater reliability (ICC = 0.93) and internal consistency (alpha = 0.94) were high.

The Modified Hamilton Rating Scale for Depression

The Modified Hamilton Rating Scale for Depression (MHRSD; Miller, Bishop, Norman, & Maddever, 1985) is a semi-structured interview designed to assess severity of depression symptoms. This modification of the Hamilton Rating Scale for Depression includes standardised probes and clear behavioural anchors to enhance reliability. A total score of 0–52 is obtained by summing the 17 items. Previous research has shown the MHRSD is a valid measure of depressive symptoms that is sensitive to change within unipolar depression (cf. Miller, Norman, & Keitner, 1989) and bipolar disorder (Johnson et al., 2008). In the current study, inter-rater reliability (ICC = 0.93) and internal consistency (alpha = 0.92) were high. Follow-up BRMS and MHRSD interviews were conducted by phone, which has been shown to be a sensitive and valid manner of gathering symptom severity information (Potts, Daniels, Burnam, & Wells, 1990; Simon, Revicki, & VanKorff, 1993). Due to a data entry error, BRMS and MHRSD scores for 15 participants were missing in the bipolar group. These scores were imputed before analyses were conducted.¹

Responses to Positive Affect scale

The Responses to Positive Affect (RPA) scale (Feldman et al., 2008) is a brief self-report measure designed to assess responses to positive mood that might dampen (e.g., “Remind yourself these feelings won’t last”) or amplify (e.g., “Think about how happy you feel”) positive feelings. The scale is based on the Responses Styles Questionnaire (RSQ; Nolen-Hoeksema & Morrow, 1991). Participants are asked to describe how they typically respond when feeling “happy, excited or enthused” on a series of 17 items. Responses range from 1 (“almost never”) to 4 (“almost always”). The scale yields three factor-analytically supported

¹ Correlations involving bias scores and MHRSD/BRMS scores were conducted both with the original data and with the imputed mood data; the direction and significance of effects were unchanged when imputed scores were used.

subscales: Dampening, Emotion Focus and Self-Focus. In two validation studies, each subscale of the RPA showed internal consistency values ranging from 0.69 to 0.79 (Feldman et al., 2008). The Dampening subscale has been found to be elevated among those with bipolar I disorder (Gruber et al., 2011) and to be correlated with lower quality of life in bipolar I disorder (Edge et al., 2013). For this study, we combined the Self- and Emotion-focused scales into an Amplification composite score, given that both relate to strategies that would be expected to intensify positive affective states, and that the two scales have little discriminant validity (Johnson & Jones, 2009). In the current study, internal consistency was good (Dampening $\alpha = 0.86$, Amplifying $\alpha = 0.84$).

Procedure

After an initial phone screen to review demographic, medical and preliminary psychiatric diagnostic eligibility criteria (described above), potentially eligible participants were scheduled for an individual face-to-face appointment to complete the SCID. If participants remained eligible for the study after the SCID interview, mood interviews (BRMS and MHRSD) were conducted. Participants returned for a second session to complete the information processing session. Within the bipolar group, those participants whose scores were in the symptomatic range according to standard cut-off scores were not scheduled for their cognitive session (greater than 6 for the BRMS and greater than or equal to 7 on the MHRSD). Study staff followed this subset of participants via monthly phone interviews until their mood stabilised. At a second session, participants completed the RPA self-report measure, mood ratings, a positive mood induction, a second set of mood ratings and then the dot-probe task.

Positive mood induction

Before completing the dot-probe task, all participants underwent a brief positive mood induction. Participants were instructed as follows: "Please

think about a great dream coming true. It can be any dream you want, whether you have ever thought about it before or not. While you think about this dream happening, music will play in the background". Musical choices were selected for this part of the study after extensive pilot testing to identify clips that consistently enhanced mood ratings: two Latin selections ("Vamos a Bailar" or "Bamboleo", each performed by the Gipsy Kings) and two Classical selections ("Allegro (Spring)", from *The Four Seasons*, by Antonio Vivaldi, and "Flute Quartet in G Major" by George Telemann). Participants were allowed to choose classical or Latin music based on their personal music preferences, and then one of the two selections for that music category was randomly selected and played. After listening to music for approximately 4 min, participants rated their mood. Participants who had not achieved a positive mood were asked to continue to listen to the music and focus on a dream coming true for an additional 4 min. Before and after the mood induction procedure, participants rated their current happiness, sadness, nervousness, alertness and confidence on a scale ranging from 1 ("Not at all") to 7 ("Extremely").

Dot-probe task

The dot-probe task is a measure of attentional biases that has been widely used in studies of mood and anxiety disorders. Drawing on the formulation that facial stimuli are more powerful and more naturalistic emotion-relevant cues than words, several researchers have recommended using facial stimuli for the dot-probe task in disorders (Bradley, Mogg, Falla, & Hamilton, 1998; Gotlib, Krasnoperova, et al., 2004). Participants completed 80 trials displayed on a 17-inch computer monitor, programmed with Eprime 1.0 (Psychology Software Tools, Pittsburgh, PA). For each trial, participants viewed one neutral facial expression and one valenced (happy or sad) facial expression of the same actor, arranged side by side on the screen. Images from 40 different actors were displayed twice during the course of the experiment (as in Joormann & Gotlib, 2007). Facial stimuli were colour photographs of actors

(20 male and 20 female, with an equal number of pictures from different races) drawn from the NimStim Face Stimulus Set (Tottenham et al., 2009). The face stimuli were 9 cm wide and 10 cm high, centred in the screen and separated by 13 centimetres of blank space. The duration of stimulus presentation (either 1 or 3 s, 40 trials of each type) was randomised throughout the trials. When the face stimuli disappeared, a dot appeared in the spatial location of either the emotional or the neutral face. Participants were instructed to respond as quickly and accurately as possible to the location of the dot by pressing a key labelled 'left' or 'right.' If a response was not detected within 5 s of the probe presentation, the trial was scored as an incorrect response. A fixation cross appeared for 1 s between each trial. Presentation time, valence of emotional face and dot location (left or right) were randomised throughout the task.

Before calculating bias scores, dot-probe data were cleaned according to procedures outlined in previous studies (cf. Joormann & Gotlib, 2007). Probe responses were examined for accuracy, and incorrect responses were excluded from further analyses (2% of all trials). Two participants were excluded based on high error rates (>25% of trials incorrect). To ensure that responses were based on actual response to probe location, response times of very short durations (<100 ms) were excluded, as were trials with reaction times (RT) greater than 2 standard deviations above the mean RT for that participant.

Four bias scores were calculated for each participant: bias scores for happy and sad faces at 1 and 3 s. To calculate bias scores, the average reaction time for trials in which the probe replaced an emotionally valenced face (emotion congruent trials) was subtracted from trials in which the probe replaced a neutral face (emotion-incongruent trials), using the following equation: Bias score = $\frac{1}{2} [(RpLe - RpRe) + (LpRe - LpLe)]$, in which, R = right, L = left, p = probe and e = emotion.

For example, "RpLe" then indicates reaction time for trials in which the probe appeared on the right side of the screen and the emotionally valenced face appeared on the left, and "RpRe" is the reaction time for trials in which the probe appears on the right and the emotionally valenced face also appears on the right. Thus, positive bias scores represent greater attention to that emotion at that duration of presentation (Mogg et al., 1995).

RESULTS

All analyses were conducted using SPSS, version 21.0. Normalcy of dependent variables was confirmed before conducting analyses, and alpha was set to .05.

Was the mood induction successful?

To evaluate the effectiveness of the mood induction, we first conducted a repeated-measures analysis of variance (ANOVA) with Group (bipolar or control) as a between-subjects factor and Time (pre/post mood induction) and Emotion (happiness, confidence, alertness, sadness, nervousness) as within-subjects factors.² Self-reported emotion (rated on the 7-point scale mentioned above) was the dependent variable. This analysis yielded significant main effects of Time, $F(1, 144) = 15.81, p < .001, \eta_p^2 = .10$, and Emotion, $F(4, 576) = 405.55, p < .001, \eta_p^2 = 0.74$, as well as significant interactions of Time and Emotion, $F(4, 576) = 22.73, p < .001, \eta_p^2 = 0.14$, and Group and Emotion, $F(4, 576) = 11.75, p < .001, \eta_p^2 = 0.08$. Neither the main effect of Group, $F(1, 144) = .01, p = .93, \eta_p^2 < .001$, nor the interaction of Time and Group, $F(1, 144) = 0.46, p = .50, \eta_p^2 = .003$, was significant, nor was the three-way interaction of Time, Emotion and Group, $F(4, 576) = 1.19, p = .32, \eta_p^2 = .01$. Regarding the significant effect of Time, participants reported an average increase in happiness of 0.64 points

² Pre-mood induction mood ratings were missing for 10 participants in the bipolar group and 16 in the control group due to a technology failure. Mood induction analyses are therefore based on 65 control participants and 81 participants with bipolar disorder. The primary ANOVA analysis of dot-probe scores was also repeated within this smaller group; results were entirely parallel to the primary results reported in the manuscript.

(SD = 0.99). Participants also reported feeling more confident (mean change = 0.46, SD = 1.15) and alert (change = 0.36, SD = 1.07) and less sad (mean change of -0.20, SD = 1.43) and nervous (change = -.39, SD = 1.35). These tests indicate that the mood induction was successful, and that bipolar and control individuals did not differ on overall response to the mood induction. A parallel analysis indicated that the choice of music was unrelated to mood ratings and did not interact with Time, Emotion or Group.

We also carefully examined distributions of happiness after the induction. On average, participants reported a post-mood induction rating of 5.49 out of 7 (SD = 1.18). Nonetheless, nine individuals reported post-mood induction that they had not achieved moderate happiness; parallel analyses excluding these individuals did not produce significant changes in the results, and variability within the mood scores post-induction was not significantly related to bias scores (all $r_s < .14$).

Are attentional bias scores confounded by demographic, comorbidity or treatment variables?

Before testing hypotheses, we considered potential demographic, clinical and treatment effects that might confound the results of this study. Bias scores were unrelated to gender, anxiety disorders or lifetime substance disorders, all $t_s < 1.49$, $p > .05$. Bias scores were also uncorrelated with age or education (see Table 1). Within the bipolar group, bias scores were not significantly correlated with lithium or antidepressant levels, mania severity (BRMS), number of manic episodes (SCID) or global assessment of functioning (GAF) scores (see Table 1). To assess the reliability of the dot-probe task, inter-trial intraclass correlations (with individual and trial as random factors) were calculated for each of the four primary bias scores for incongruent trials, adjusting for the individual's mean reaction time for the congruent trials within that condition. Because individuals differed in how many trials they successfully completed within each condition, we used only the first seven trials of each

Table 1. Bivariate correlations of dot-probe bias scores with demographic and clinical variables

	Happy bias score, 1 s	Happy bias score, 3 s	Sad bias score, 1 s	Sad bias score, 3 s
Age	-.04	-.08	-.13	.01
Years of education	.07	.08	-.03	-.09
<i>Bipolar only (n = 90)</i>				
Lithium dose	-.10	.05	.09	.09
Antidepressant dose	-.14	-.12	-.05	-.03
GAF score	.12	.10	-.09	-.10
BRMS score	-.16	-.10	-.06	-.13
Lifetime number of manic episodes	.07	.10	-.12	.13

Note: All test statistics are Pearson correlations with the exception that number of manic episode effects were tested with a non-parametric correlation. None of the variables was significantly related to dot-probe bias scores.

BRMS, Bech-Rafaelsen Mania Score; GAF, global assessment of functioning.

condition for these analyses. Intraclass correlations were low: 1-s negative, ICC = 0.50; 3-s negative, ICC = 0.45; 1-s positive, ICC = 0.63; 3-s positive, ICC = 0.34. Although low correlations are expected with a small number of trials, these estimates are somewhat higher than the alpha coefficients observed in previous reliability studies of the dot-probe task (Schmukle, 2005; Staugaard, 2009).

Do bipolar disorder and control groups differ in attentional biases?

To examine group differences on the dot-probe task, we conducted a 2 (Group: bipolar or control) \times 2 (Duration: 1- or 3-s presentation time) \times 2 (Valence: sad, happy) mixed-model ANOVA, with dot-probe bias scores as the dependent variable. This analysis did not yield significant main effects for Group, $F(1, 169) = .002$, $p = .96$, $\eta_p^2 < .001$, Duration, $F(1, 169) = .07$, $p = .79$, $\eta_p^2 < .001$, or Valence, $F(1, 169) = .001$, $p > .99$, $\eta_p^2 < .001$. Moreover, Group did not interact with

Table 2. Correlations of current and lifetime depression with dot-probe bias scores among participants with bipolar disorder

	Happy bias score, 1 s	Happy bias score, 3 s	Sad bias score, 1 s	Sad bias score, 3 s
Lifetime depressive episodes	.00	-.03	.11	-.05
MHRSD	-.05	-.02	-.11	.08

Note: $N = 90$. All statistics shown are Pearson correlations, with the exception of lifetime depressive episodes (Spearman's Rho). MHRSD, Modified Hamilton Rating Scale for Depression.

Duration, $F(1, 169) = .001, p = .97, \eta_p^2 < .001$, or Valence, $F(1, 169) = .50, p = .48, \eta_p^2 = .003$, nor were the higher order interactions significant. Post-hoc calculations of achieved power (conducted with G-Power, Version 3.1.3) showed that this study was well-powered (power, $1 - \beta, = .97$) to detect effects in the small to medium-sized range (based on Cohen's $f = 0.15$). Within the bipolar and control groups separately, t -tests indicated that bias scores for each of the four conditions did not differ significantly from zero.

Relation of dot-probe bias scores with current mood symptoms, depression history and responses to positive affect within the bipolar group

Bivariate correlations indicated that current depressive symptoms (MHRSD) and number of lifetime major depressive episodes (determined from the SCID) were not significantly correlated with bias scores (Table 2). Higher scores on the Dampening subscale of the RPA scale were correlated with less attention to positive faces for the 3-s stimulus duration, while Amplification was unrelated to bias scores (Table 3). A Fisher's z -test of the difference between correlations of Dampening with attentional bias to happy faces at 1 and 3 s, however, showed that the magnitude of correlations was not statistically different ($p = .37$).

Table 3. Correlations of the RPA scale with dot-probe positive bias scores among participants with bipolar disorder

	Happy bias score, 1 s	Happy bias score, 3 s
RPA dampening	-.15	-.28*
RPA amplifying	.02	-.02

Note: $N = 90$. All statistics shown are Pearson correlations; tested against Bonferroni-corrected significance level of $p < .013$.

RPA = Responses to Positive Affect scale.

* $p < .01$

DISCUSSION

Previous studies of information-processing biases in bipolar disorder have yielded equivocal results. The current study provides one of the first examinations of information-processing biases in bipolar disorder using the well-validated dot-probe task with facial stimuli. The study was also designed to assess the nature of biases after a positive mood induction, a strategy that has been shown to magnify other positive emotional and cognitive profiles among individuals with, and people at risk for, bipolar disorder (Roiser et al., 2009; Trevisani et al., 2008). Finally, in addition to examining differences between bipolar and control groups, we considered the role of depression history, current mood state and attitudes towards emotion as potential correlates of bias scores. Other strengths of the study include the relatively large sample and the careful procedures used to test participants during euthymic periods and to consider confounds.

The current findings indicated that the bipolar and control groups did not differ significantly in bias towards emotionally valenced faces. The absence of significant group differences did not appear to be due to power limitations, given that the sample size was large and the effect sizes were quite small. Our findings extend previous research conducted without a mood induction to suggest that euthymic bipolar disorder is not related to positive attentional biases even when participants are tested in a positive mood state using facial

stimuli (e.g., García-Blanco et al., 2014; Jabben et al., 2012; Jongen et al., 2007). The present findings are also consistent with a recent study that used an anti-saccade task with valenced faces and found no evidence of impaired attentional control to positive faces in euthymic bipolar individuals (García-Blanco, Perea, & Salmerón, 2013). Across studies, therefore, a preponderance of evidence suggests that a positivity bias is not characteristic of euthymic bipolar disorder, regardless of current mood state.

In considering how the lack of a mood-congruent bias in the present sample compares to findings of previous studies, one possibility is that mood-congruent positive biases are related more robustly to symptoms of mania than to more transient and milder shifts in mood. The strongest evidence for mood-congruent shifts in cognitive processing seems to be documented in studies of currently manic samples (e.g., García-Blanco, Perea, & Salmerón, 2013; García-Blanco, Perea, & Livianos, 2013; Murphy et al., 1999). Given the relatively limited evidence of mood-congruent positive biases in euthymic bipolar disorder, it may be that the more extreme shifts into mania are necessary before positive cognitive biases are reliably observed in this population.

We also did not observe negative biases in the bipolar group, and there was no evidence that a negative bias was observed among those with a history of depression or higher levels of current sub-syndromal symptoms. Not only were effects not significant, but the direction of effects for several of the depression variables on bias towards negative faces was inconsistent with hypotheses. Although this contrasts with effects observed for a history of unipolar depression (Joormann & Gotlib, 2007), our findings are consistent with research on current bipolar depression in not observing a bias towards negative stimuli (García-Blanco et al., 2014; Jabben et al., 2012; Jongen et al., 2007; Rubinsztein, Michael, Underwood, Tempest, & Sahakian, 2006). Taken together, these findings indicate that early reports of the association between bipolar disorder and negative biases using the emotion Stroop task (Bentall & Thompson, 1990; French, Richards, & Scholfield, 1996; Lyon, Startup, &

Bentall, 1999) are difficult to replicate using the dot-probe task in bipolar disorder. Caution is warranted in interpreting these effects; however, in that the positive mood induction in the present study may have interfered with the expression of negative bias in previously depressed individuals.

Although we did not provide evidence that attentional biases are associated with bipolar diagnoses or depression history, we did find that attentional biases were correlated with responses to positive affect. Within the bipolar group, those who endorsed tendencies to dampen positive affect were significantly less likely to sustain their attention towards happy faces that were displayed for the longer duration of 3 s; this effect was within the small to medium range (Cohen, 1988). This effect appears to be unique to tendencies to dampen positive affect. In previous research, the tendency to dampen positive affect has been found to be related to poor outcomes in bipolar disorder (Edge et al., 2013; Gruber et al., 2011).

Attentional biases in bipolar disorder may not be universally present, but instead may be tied closely to emotion regulatory strategies. This might help explain the mixed findings regarding attention bias in bipolar disorder, as tendencies to dampen appear to vary with the severity and length of disorder (Edge et al., 2013). This is consistent with a broader framework that has begun to emerge with other psychopathologies, in which there appears to be an interactive relationship between cognitive bias and emotion regulation strategies (Cisler & Koster, 2010; Johnson, 2009; Joormann & D'Avanzato, 2010). Alternatively, other studies have reported biases away from positive stimuli during the depressive episodes of bipolar disorder (Jabben et al., 2012; Jongen et al., 2007), and depression has been linked to tendencies to dampen positive affect in both cross-sectional (Feldman et al., 2008; Raes et al., 2009) and prospective (Raes, Smets, Nelis, & Schoofs, 2012) studies. The current sample, while euthymic, showed some variability in sub-syndromal levels of depression; these symptoms, however, were unrelated to bias for positive stimuli. Thus, it is possible that multiple mechanisms could contribute to avoidance of positivity in

bipolar disorder: both dampening and depressive symptoms each could confer a tendency to avoid positive cues. In future studies researchers might examine how dampening and depression symptoms interact over time to predict avoidance of positive information.

It is noteworthy that greater use of dampening was associated with reduced bias for happy faces at 3 s, but not when the faces were displayed for a shorter duration (although the magnitude of this effect did not differ significantly for short versus long stimulus duration). We know little about the time course of positive attentional biases in bipolar disorder; few studies have used varied presentation times for cognitive bias paradigms in this population (see Rock et al., 2010; and Whitney et al., 2012, for exceptions). Speculatively, our finding that dampening of positive affect is particularly related to attention at longer stimulus durations suggests that dampening is a more effortful process.

Previous research on attention to positive stimuli provides some support for this hypothesis. In a large study of healthy undergraduate students completing a dot-probe task with happy and angry face pairs, participants who were specifically directed to focus attention on happy faces showed a positive bias only at 1250 ms presentations, but not at shorter presentation times (Johnson, 2009). In parallel, our findings could indicate that dampening may require enough time to recognise the valence of a positive stimulus, determine that it is appropriate to avoid this positive mood state and remove attention from the source of positivity. However, caution is warranted in interpreting the link between dampening and attention at the 3-s presentation time. Because the dot-probe task does not specifically index attentional focus across time, such as frequency of fixations to a given stimulus (cf. Armstrong & Olatunji, 2012), we cannot ascertain the extent to which specific components of attention may have shifted during the longer presentation time. Attentional paradigms with greater specificity, such as eye-tracking, are needed to test this effect; consequently, the present findings should be replicated with more sophisticated paradigms.

This process of disengaging attention from positive cues may relate to underlying beliefs about emotion in individuals with bipolar disorder. People with bipolar disorder have been found to endorse beliefs that positive emotions are catastrophic and overwhelming (Mansell, 2006; Mansell, Morrison, Reid, Lowens, & Tai, 2007, 2007), and these beliefs predict changes in symptoms over time (Dodd, Mansell, Morrison, & Tai, 2011). The current findings suggest that individuals with bipolar disorder who are concerned about their positive affect may avoid attention to positive stimuli as a means of mood regulation.

The findings of this study link dampening positive affect to shifting attention away from positively valenced faces in a laboratory paradigm. Researchers have suggested that people with bipolar disorder avoid positive stimuli in real life as well (Mansell et al., 2007). For example, many people with bipolar disorder report avoiding highly rewarding goals (Edge et al., 2013). More research is needed to examine the potential downsides of such strategies. Beyond links to outcomes, it is worth noting that the relationship between dampening positive emotion and turning attention from positive stimuli is consistent with a broader literature on reward dysregulation in bipolar disorder. People with bipolar disorder describe themselves as sensitive to reward and in laboratory studies; they appear more willing to exert effort to obtain rewards (see Johnson, Edge, et al., 2012 for review); and they demonstrate a unique neural profile of reward anticipation compared to those with depression (Chase, Nusslock, Almeida, Forbes, LaBarbara, & Phillips, 2013). They also appear to experience a greater deficit in cognitive control in the context of reward (Mueller et al., 2010), although reward sensitivity may be modulated by depression (Johnson, Edge, et al., 2012; Trost et al., 2014). Future research could examine the complex interplay of whether reward sensitivity, concerns about impulsivity and cognitive control during heightened reward, and emotion regulation strategies designed to down-regulate positive emotion are relevant for understanding attention to positive cues. Before considering implications of the current study, it is important

to note a number of limitations. Most significantly, the dot-probe task was administered only after a positive mood induction, and the absence of a pre-mood induction dot-probe assessments precludes assessment of whether a change in mood state actually influences attentional bias. The presence of the positive mood induction also limits our ability to determine how depression-related variables influence bias, as depressive effects could have been attenuated by state positive mood. In this context, however, mood did not appear to be a powerful contributor to attentional bias: neither symptom severity scores nor mood state ratings were correlated with bias scores within the bipolar group. A second limitation is the low observed reliability of the dot-probe task, perhaps related to the relatively small number of trials per condition, which might have contributed to the failure to identify group differences. In this regard, however, it is noteworthy that previous studies have reported even lower reliability of the dot-probe task (Schmukle, 2005; Staugaard, 2009), and yet dot-probe bias scores have often been found to effectively differentiate depressed and anxious groups from control groups (e.g., Bar-Haim et al., 2007; Peckham et al., 2010). Third, the present study did not include stimulus presentations of less than 1 s. Vigilance for negative information at these shorter stimulus durations has been found to be associated with anxiety symptoms (Bögels & Mansell, 2004), and anxiety diagnoses are prevalent in bipolar disorder (Simon et al., 2004). Fourth, investigators have posited that some attentional and mood regulation strategies become pronounced during manic states (Mansell et al., 2007), and some evidence suggests that attention is altered during mania (García-Blanco, Perea, & Livianos, 2013; García-Blanco, Perea, & Salmerón, 2013; Murphy et al., 1999); in the current study we examined these processes only during euthymic states. Finally, the large number of correlational analyses in this study increases the possibility of spurious findings; therefore, it is important that our finding that attention for positive information is correlated with dampening be replicated.

Despite these limitations, the current study provides several novel and important clarifications

to the literature on attentional biases in bipolar disorder. First, the findings suggest that euthymic persons with bipolar disorder may not demonstrate general biases to attend to either negative or positive stimuli, even after the induction of positive mood. One possibility is that bipolar disorder is not characterised by biases in attention to valenced stimuli. Nonetheless, before making this conclusion, future studies of attentional bias in bipolar disorder may benefit from the inclusion of idiosyncratic stimuli or stimuli that are directly theoretically relevant to bipolar disorder. Alternatively, aspects of cognition other than attention may be more relevant to bipolar disorder. For example, recent research points to deficits in cognitive control in the context of reward (Mueller et al., 2010), deficits in facial affect recognition (Hoertnagl et al., 2011), and after positive mood boosts, difficulties with set-shifting on emotion relevant tasks (Roiser et al., 2009), as important cognitive factors within bipolar disorder.

Second, the present study finds that the relatively normative profile of attention to emotionally valenced stimuli is not changed in the context of a more severe depression history or current mood features. In contrast to these null findings, attentional biases were distinctly related to the tendency to dampen positive moods, which has been shown to be common among persons with a severe history of bipolar disorder. Our findings suggest that self-reports of tendencies to dampen are associated with rapidly occurring, basic processes of how people shape their attention to positive information. Taken together, these findings highlight the importance of continuing to conduct research examining the intersection of emotion regulation and attention to emotion-relevant stimuli in bipolar disorder.

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