Letting Go of the Bad:
Deficit in Maintaining Negative, but not Positive, Emotion in Bipolar Disorder

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Abstract

Bipolar disorder is a disorder of emotion regulation. Less is known, however, about the specific processes that foster the maintenance of such prolonged and intense emotions – particularly positive – over time in this disorder. We investigated group-related differences in the ability to maintain positive and negative emotion representations over time using a previously validated emotion working memory task (Mikels et al., 2005, 2008) among individuals with bipolar I disorder (BD; \( n = 29 \)) compared with both unipolar depression (MDD; \( n = 29 \)), and healthy control (CTL; \( n = 30 \)) groups. Results revealed that the BD group exhibited a selective deficit in maintaining negative – but not positive – emotions compared to both MDD and CTL groups. MDD and CTL groups did not significantly differ. These findings suggest that the heightened magnitude and duration of positive emotion observed in BD may, in part, be accounted for by difficulties maintaining negative emotions.

*Keywords:* emotion, emotion regulation, working memory, bipolar disorder, depression
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Bipolar disorder (BD) is a severe and chronic psychiatric disorder associated with functional and social impairment (Sanchez-Moreno, 2009; Faglioni, 2005) and has been ranked as one of the top ten causes of worldwide disability. Importantly, diagnostic criteria (American Psychiatric Association, 2000) for BD centrally features abnormally elevated or positive mood. Recent empirical evidence further confirms the notion that difficulties regulating positive emotion are a core feature of BD (e.g., Gruber, 2011; Gruber, Harvey & Purcell, 2011; Johnson, Gruber, & Eisner, 2007). Few empirical studies, however, have delineated precisely what underlying mechanisms might maintain heightened positive mood in BD.

Emotion Disturbance in Bipolar Disorder

There is burgeoning interest in the study of emotion regulation and psychopathology (e.g., Kring & Sloan, 2010). Unfortunately, the dysregulation of positive emotion has been left relatively unexplored (e.g., Dillon & Pizzagalli, 2009; Gruber, Mauss, & Tamir, 2011). Making progress in this domain is particularly important for studying bipolar disorder (BD), diagnostically featured as a disorder involving disturbances in positive emotion. Building empirical work based in affective science methodologies have shed insight into describing the emotional profile of individuals with BD, suggesting it is uniquely characterized both by heightened positive emotional reactivity and difficulty with positive emotion regulation (e.g., e.g., Gruber, 2011a; 2011b). Specifically, BD has been associated with a greater magnitude of positive emotion reactivity in response to (i.e., liking), and in anticipation of (i.e., wanting), positive or rewarding stimuli (e.g., Alloy et al., 2009; Gruber, 2011a; Johnson, 2005). These
increases in positive emotion reactivity are evident after controlling for baseline mood and current symptoms, suggesting that it may be a trait-like marker of BD. First, individuals at risk for, and diagnosed with BD, self-report greater positive affect in response to neutral photos (M’Bailara et al., 2009), at the prospect of earning rewards (Meyer, Johnson, & Winters, 2001), and in response to emotionally evocative films (Gruber, Johnson, Oveis & Keltner, 2008; Gruber, Harvey & Purcell, 2011). Moreover, several studies suggest that people with BD exhibit prolonged emotional responses to positive stimuli. For example, one study by Farmer and colleagues (2006) reported prolonged elevations in self-reported positive affect relative to controls (Farmer et al., 2006). Another self-report study found that those with BD demonstrate a self-reported tendency to dwell on positive feelings and thoughts for a prolonged duration, referred to as positive rumination (Gruber, Eidelman, Johnson, Smith, & Harvey, 2011; Johnson, McKenzie, & McMurrich, 2008). Finally, BD participants continue to exhibit heightened startle eyeblink magnitude following the presentation of positive photos compared to people with major depressive disorder and healthy controls (Forbes et al., 2005). Experience-sampling studies further reveal increased positive mood across daily life events in those falling in the BD spectrum (Hofmann & Meyer, 2006; Lovejoy & Steuerwald, 1995). Importantly, physiological data converges with self-reported data to suggest that people with BD also exhibit increased psychophysiological correlates of positive emotion (i.e., respiratory sinus arrhythmia) in response to a variety of positive stimuli, including films, photos, and memories (Gruber, 2011a; 2011b; Gruber et al., 2008). Neuroimaging studies further suggest that BD patients exhibit increased activity in the amygdala and putamen (Lawrence et al., 2004) as well as the orbitofrontal cortex (Elliott et al., 2004) – brain regions typically associated with emotional salience and reward -- in response to positive photos. In sum, behavioral work suggests that
individuals with BD exhibit a heightened initial positive emotion response, and that this heightened positive emotional response persists across stimuli classes and for extended durations, as compared to healthy controls.

Findings have been less conclusive regarding observable negative emotion difficulties in BD. Specifically, research investigating BD patients’ reactivity to negative emotional stimuli reveals few, if any, differences. People at risk for, and diagnosed with, BD do not appear to differ from healthy controls in their experiential, behavioral, cognitive, or psychophysiological responses to negative failure feedback (Stern & Berrenberg, 1979; Ruggero & Johnson, 2006), interpersonal criticism (Cuellar, Johnson, & Ruggero, 2009), negative photos (Sutton & Johnson, 2002), and challenging math tests (Depue et al., 1985). Studies of neural response to negative emotional stimuli in BD provide mixed evidence. For example, Yurgelon-Todd et al. (2000) found that female (but not male) inter-episode bipolar participants exhibited greater amygdala activation in response to viewing sad facial stimuli relative to controls. Taken together, there has not been suggestive evidence to date that individuals with BD exhibit increased negative emotion responding. It has been suggested that observed negative emotion differences between BD and healthy controls appear to be best accounted for by current depressive symptom severity as opposed to a more trait-like marker of the disorder (e.g., Johnson, Gruber, & Eisner, 2007).

Taken together, these studies suggest that people with BD exhibit heightened and prolonged positive, but not negative, emotional responding across different types of contexts. However, models of emotion regulation emphasize that emotion regulation not only involves decreasing and increasing emotions as has been studied in the context of BD – but also maintaining emotions (e.g., Gross, 1998). Maintenance of emotions – also referred to as affective working memory – is defined as a constellation of processes that maintain the subjective
experience of emotion in order to guide goal-directed behavior, even in the absence of the original stimuli or elicitor (Mikels, Reuter-Lorenz, Beyer, & Fredrickson, 2008; Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005). To experimentally isolate and measure emotion maintenance, Mikels et al. (2008) developed a task in which participants view emotion-eliciting pictures and are instructed to maintain their subjectively experienced emotion. This task has been used to isolate domain specific emotion maintenance process in healthy adults (Mikels et al., 2008), aging adults (Mikels et al., 2005), and schizophrenia patients (Gard, Cooper, Fisher, Genevsky, Mikels & Vinogradov, 2011). With respect to schizophrenia, Gard and colleagues demonstrated emotion maintenance disruption, suggesting the importance of emotion maintenance in understanding the etiology and maintenance in clinical disorders. However, emotion maintenance has not been empirically tested in mood disorders including BD.

The Present Investigation

The present investigation aims to isolate one putative mechanism that may underlie and foster the maintenance of heightened positive emotions in BD; namely, emotion maintenance (i.e., affective working memory). In this vein, we tested two competing hypotheses. The first hypothesis (positive magnification) predicted that individuals with BD would demonstrate enhanced affective working memory ability, or emotion maintenance, for positive emotions specifically, but not for negative emotions. This hypothesis was based upon prior work demonstrating that individuals with BD exhibit increased positive emotion across contexts (cf. Gruber, 2011a; 2011b) and an increased attentional bias towards positive stimuli (e.g., Leyman et al., 2009; Trevisani, Johnson, & Carver, 2008). The second hypothesis (negative minimization) predicts that individuals with BD would demonstrate diminished affective working memory for negative, but not positive, emotions. This hypothesis was grounded in findings demonstrating
that those with BD do not consistently demonstrate differences in negative emotion response (Johnson et al., 2007), exhibit impaired recognition of negative facial expressions (Lembke & Ketter, 2002), and fail to demonstrate attentional biases towards negative stimuli (Elliott, Rubinsztein, Sahakian, & Dolan, 2000). We note that these hypotheses are not mutually exclusive, however.

Method

Participants

All participants were recruited as part of a larger study on emotion and mood from the greater New Haven, CT area community. Participants included 29 individuals diagnosed with BD type I, currently remitted for an average of 14.93 months ($SD = 18.38$). Two comparison groups were also recruited upon which to compare BD-specific findings. This included a healthy control (CTL) group comprising 30 individuals who did not meet current or past criteria for any DSM-IV-TR Axis I disorder (First, Spitzer, Gibbon, & Williams, 2007), and a clinical comparison group of 29 individuals with major depressive disorder (MDD) in remission for an average of 34.31 months ($SD = 28.19$). All three groups were currently remitted (i.e., not in a current manic, depressed, or mixed mood phase) in order to examine more trait-like patterns of emotion control independent of current mood phase. Exclusion criteria included report of a history of severe head trauma, stroke, neurological disease, severe medical illness (e.g., autoimmune disorder, HIV/AIDS), or current alcohol or substance abuse in the past six months. Demographic and clinical characteristics are listed in Table 1.

Measures of Clinical Functioning

Diagnostic evaluation. Diagnoses were confirmed using the Structured Clinical Interview for DSM-IV by licensed clinical psychologists, graduate students, and a trained
research coordinator (SCID-IV; First et al., 2007). A subset \( n = 21 \) of digitally videotaped interviews were rated by an independent reviewer. Ratings matched 100% \((\kappa = 1.00)\) of primary diagnoses for the BD \( n = 9 \), MDD \( n = 8 \), and CTL \( n = 4 \) groups.

**Mood symptoms.** Current symptoms of mania were measured using the Young Mania Rating Scale (YMRS; Young, Biggs, Ziegler, & Meyer, 1978). Current symptoms of depression were measured using the Inventory of Depressive Symptomatology (IDS-C; Rush, Gullion, Basco, Jarrett, & Trivedi, 1996). The YMRS is an 11-item, clinician-rated measure of current manic symptoms with scores ranging from 0 to 60, with scores \( \geq 7 \) represent clinically significant manic symptom levels. The IDS-C is a 30-item, clinician-rated measure of current depressive symptoms with scores ranging from 0 to 84, with scores \( \geq 11 \) represent clinically significant depressive symptom levels. Current remitted mood status (i.e., neither manic, depressed, nor mixed mood state) for all groups was verified according to SCID-IV criteria and cutoff scores on the YMRS \((\leq 7)\), and IDS-C \((\leq 11)\). Intra-class correlations (ICCs) for absolute agreement between the original interviewer and an independent rater for approximately one-third of participants \( n = 23 \) were strong for both the YMRS \((= 0.98)\) and IDS-C \((= 0.98)\).

**Measures of Cognitive Functioning**

Similar to prior studies on affective working memory (e.g. Mikels et al., 2005; Gard et al., 2011), two facets of baseline cognitive functioning were measured, including working memory and general intellectual functioning.

**Working memory.** Participants were administered the letter-number sequencing subtest of the Wechsler Adult Intelligence Scale-IV (WAIS-IV; Pearson, 2008). In the Letter-Number sequencing subtest, participants are read aloud a series of increasingly long lists of randomly ordered numerical digits and alphabetical letters. After the list is read aloud, participants are
asked to verbally repeat back all numbers (in numerical order) first, followed by all letters (in alphabetical order). This subtest takes approximately 10 minutes to administer. Raw scores (ranging from 0 to 21) were calculated as the total number of trials correct, from which WAIS-IV age-normed scaled scores were computed.

**General intellectual functioning.** The Shipley Institute of Living Scale (SILS; Shipley, 1986) was included as a conventional measure of general intellectual functioning in adults. The vocabulary subtest of the SILS was administered, consisting of 40 multiple-choice questions in which the participant is asked to select one of four words closest in meaning to the target word. This subtest is stipulated to rely on verbal reasoning skills including reading ability, verbal comprehension, acquired knowledge, long-term memory, and concept formation. Scores range from 0-40. Time to complete the SILS vocabulary subtest is approximately 10 minutes.

**Affective Working Memory Task**

The design and procedures for the negative and positive emotion maintenance tasks were based on those used by Mikels et al. (2005; 2008), as depicted in Figure 1. Images were drawn from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999) as well as additional images acquired by Mikels et al. (2008). The task required participants to compare the emotional intensity of two visual images that differed in their emotional intensity, which were individually rated on 1 (*none at all*) to 7 (*a great amount*) scale.

Images were chosen based on the previously validated emotion affective working memory tasks (Mikels et al. 2005; 2008), derived from both the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1999) and Mikels et al. (2008). Specific images were grouped into pairs based on valence, such that 20 positive valenced image pairs formed the positive condition (i.e., 40 positive photos total), and 20 negative valenced image pairs (i.e., 40
negative photos total) formed the negative condition. Several considerations were made to ensure that the positive and negative conditions were equivalent in emotion intensity. First, pictures were selected using the normative ratings reported in Mikels et al. (2008). From this, the overall intensity of the 40 negative images was 3.71 ($SD = 0.68$) and the overall intensity of the 40 positive images was 3.68 ($SD = 0.64$). Second, both the positive and negative conditions counterbalanced the emotional intensity order of the image pairs, such that in each condition half of the trials had the second image being of a higher emotional intensity than the first; and for the other half of trials, the second image was lower in intensity. The emotional intensity order of the images in a pair was randomly distributed within trials. Third, both the positive and negative conditions were created to be equally difficult. For each valence condition, we divided the pairs by their intensity similarity: 10 highly similar pairs (emotional intensity difference of 0.85 or less for the negative trials and 0.80 or less for the positive trials; i.e., difficult trials) and 10 highly dissimilar pairs (emotional intensity difference of 1.03 or more for the negative trials and 1.02 or more for the positive trials; i.e., easy trials). The image pair similarity was randomly distributed within the trials. Thus, the positive and negative conditions were matched for emotional intensity, image pair order, and image pair difficulty. As such, we feel the positive and negative conditions were equivalent in emotional arousal and it is unlikely the arousal ratings of the conditions biased the findings.

The task parameters were the same for all trials across both conditions: an image was presented for 5 s (target), immediately followed by a retention interval with a fixation cross (3 s), a second probe image for (5 s), and picture rating (variable). Participants were told that in each trial they would view an emotion-eliciting image and that they should let their feelings occur naturally. After the image disappeared, participants were instructed to maintain their gaze on a
fixation cross and to sustain the feeling at the same intensity that they felt while viewing the first image. After the delay, participants viewed a second image of a different intensity (based on the ratings reported by Mikels et al., 2008) and were instructed to experience the emotions elicited by this second image. After viewing the second image, participants rated whether their feelings from the second image had a higher or lower emotional intensity compared with their feelings from the first image in the pair. Individual trials were separated by an inter-trial interval fixation cross.

Also following the procedures of Mikels et al. (2005; 2008), for half of the trials in each subset (10 pairs), the second image presented was higher in emotional intensity than the first, and for the remaining pairs (the other 10 pairs), the second image was lower in intensity. The emotional intensity order of the images in a pair was randomly distributed within trials. Following the procedures of Mikels et al. (2005), to make the tasks sufficiently difficult, for each valence condition, we divided the pairs by their intensity similarity: 10 highly similar pairs (emotional intensity difference of 0.85 or less for the negative trials and 0.80 or less for the positive trials; i.e., difficult trials) and 10 highly dissimilar pairs (emotional intensity difference of 1.03 or more for the negative trials and 1.02 or more for the positive trials; i.e., easy trials).

Emotion maintenance task trials were completed in two blocks, a positive trial block and a negative trial block, in counterbalanced order. Pairs of images (either positive-positive or negative-negative) were presented randomly within each block. After performing the maintenance tasks, participants viewed all positive and negative images presented during the experiment and were instructed to provide intensity ratings for each image on a scale of 1 (not at all) to 7 (extremely).

Procedure
After obtaining informed consent, trained clinical psychology faculty, graduate students, or trained post-baccalaureate researchers administered the SCID-IV, YMRS, IDS-C, and the cognitive measures. The task was completed in an individual testing room in front of a 26” high-resolution Sony computer monitor. Participants were initially oriented to the Affective Working Memory task verbally by the experimenter, and were then self-guided through the remainder of the task using computerized software (MediaLab v2008, Atlanta, GA). Once the experiment ended, participants completed a series of questionnaires, including the SILS. Participants were debriefed and compensated for their participation.

**Data Analysis Strategies**

First, we examined whether our emotion maintenance scores were normally distributed using the Kolmogorov-Smirnov test. Both the negative and positive maintenance conditions met this criterion for all three groups separately (all $Z_s < 1.01$, $p > .26$). Second, we tested whether there were group differences in the baseline working memory task. Note BD and CTL groups differed, but these scores were not meaningfully associated for any group with accuracy scores in the positive ($r_s < 0.19$) or negative ($r_s < 0.35$) maintenance conditions ($p_s > .05$). Thus these scores were not included in subsequent analyses. Third, we found no main effects for order ($p_s > 0.30$) or gender ($p_s > 0.39$) for all main variables. Fourth, following the procedures used by Gard et al. (2010), we used the post-task intensity ratings to create idiographic-based accuracy scores on each trial. Specifically, using each individual participant’s intensity rating for each picture in a pair, we computed a maintenance percent accuracy score for each task separately for each participant. We coded each maintenance trial according to the subjective ratings provided by the participants as to the correct higher or lower intensity designation. For example, for a given pair, if a participant rated the emotional intensity of image A as “6” and image B as “5”, the correct
maintenance response for that pair was coded with image B as lower than image A. For the maintenance accuracy score, then, if that participant responded that image B was lower than image A, their response was coded as correct. An average accuracy score was then calculated for each participant.

Results

Demographic and Clinical Characteristics

As seen in Table 1, BD, MDD, and CTL participants did not significantly differ with respect to age, gender, ethnicity, or education (ps > .28). Not surprisingly, BD and MDD groups scored lower on global functioning than the CTL group. Although all groups scored below YMRS (≤ 7) and IDS-C (≤ 11) cutoffs, BD and MDD participants scored higher than CTL participants on the IDS-C (ps < .01). The groups also differed on the baseline working memory measure, such that BD participants scored lower than both the CTL and MDD participants. Groups did not differ in general intellectual functioning on the SILS.

Main Analyses

Given our differential a priori predictions for positive versus negative emotion maintenance, we examined each condition separately using two one-way ANOVAs (as recommended by Keppel & Zedeck, 1989). A Greenhouse-Geisser correction was used when assumptions for sphericity were not met and adjusted F and p values are reported. Effect sizes are reported as partial eta squared (\(\eta^2_p\)). All reported p values are two-tailed.

As seen in Table 2, no group differences emerged for the maintenance of positive emotions, \(F(2, 85) = 0.03, p > .95, \eta^2_p = 0.001\). However, a significant group difference was detected between the groups in the maintenance of negative emotions, \(F(2, 80) = 3.33, p < .05, \eta^2_p = 0.08\). Planned contrasts revealed that the performance of the BD group was significantly
lower in negative emotion maintenance compared to both MDD and CTL groups, $t(51) = 2.21$ and $t(54) = 2.21$ ($p$'s < .05), respectively.

**Secondary Analyses: Potential Confounds**

We examined two potential confounds; current mood symptoms and baseline working memory. First, given that BD is associated with deficits in working memory (e.g., Clark et al., 2005), we examined if performance on the emotion maintenance task was meaningfully predictive of performance on the WAIS-IV working memory task. For the BD group, baseline working memory did not correlate with either negative or positive maintenance, $r = 0.03$, $p > 0.89$ and $r = 0.16$, $p > 0.40$, respectively. We thus opted not to include working memory as a covariate in our analyses.

Second, given that the BD and MDD groups scored higher in subsyndromal depressive symptoms (IDS-C), we examined whether observed group differences were influenced by depressive symptoms. Once again, IDS-C scores did not correlate with negative maintenance (BD: $r = -0.21$, MDD: $r = -0.03$, CTL: $r = 0.13$, $ps > .29$) or positive maintenance (BD: $r = -0.21$, MDD: $r = -0.25$, CTL: $r = -0.03$, $ps > .21$) for all groups. Thus, IDS-C score was not included as a covariate in our analyses. This decision was further supported by two conceptual reasons. First, controlling for current symptoms violates important statistical assumptions, as they are intended to minimize within group variability, not between group variability, especially where group status is not randomly assigned. Second, all groups scored well below the clinical threshold scores on all symptom measures suggesting minimal variability in depressive symptoms (Table 1). We suggest that future studies compare BD and MDD participants who score high and low on symptom measures to properly examine the relative influence of symptoms on emotion regulation.


**Discussion**

BD is fundamentally a disorder of emotion dysregulation. Indeed, a growing body of work has focused on delineating precisely how emotion is disrupted in this severe and chronic mood disorder (e.g., Gruber, 2011; Johnson, 2005; Phillips & Vieta, 2007). However, it remains less clear what potential mechanisms may underlie, and give rise to, heightened mood states – particularly positive – in this disorder. The present investigation represents three important areas of strength. First, this study is one of the first to use a rigorous experimental approach adopting a previously validated affective working memory task to examine potential mechanisms that may underlie and foster the maintenance of heightened positive emotions in BD. Second, this study adopted a transdiagnostic approach (Harvey et al., 2004) to examine emotion maintenance not just in comparison to a healthy control group, but also in comparison to a second clinical comparison group of individuals diagnosed with a history of major depressive disorder. As such this study enabled us to tease apart which aspects of emotion maintenance disturbance were disorder-specific to BD versus more transdiagnostic features of mood disorders generally. Third, we systematically measured several potentially important confounds – including symptom severity, baseline working memory, and general cognitive functioning – to rule out other potential explanations for the observed findings.

**Limitations and Future Directions**

Our findings should be interpreted within the confines of several limitations. First, although the images used in the present study are standardized and reliable elicitors of emotions, it may be argued that the results may not be generalizable to everyday emotional encounters in the lives of BD patients. It will thus be important for future paradigms to assess more ecologically valid stimuli that are both dynamic in nature and personally salient and possibly
more engaging. Second, the maintenance of positive emotion was assessed broadly, and as such it is unclear whether differences might emerge for specific positive emotions related to reward striving and achievement, implicated in BD (Gruber & Johnson, 2009). Related, it will be important for future work to consider how these findings contribute to the broader literature suggesting the relative independence of positive and negative affect processes, including maintenance of these distinct affective states (e.g., Diener & Emmons, 1984). Third, the present study did not include a specific experimental control condition upon which to directly compare the obtained study results (i.e., brightness maintenance condition; Mikels et al., 2005; 2008). However, we note that such results are unlikely to be accounted for by a deficit in maintenance processes more generally for several reasons. For example, our results suggested a specific valence difference in negative but not positive emotion maintenance. Moreover, given the separability of emotion maintenance from more general maintenance processes previously studied (e.g., Mikels et al., 2005; 2008) we would not expect a general working memory deficit to explain the current results. Additionally, the lack of a correlation between the baseline working memory task and the emotion maintenance tasks in the BD group further indicates that performance of the emotion maintenance task is independent of working memory processes used in the non-emotional baseline task. Fourth, we did not exclude BD participants on the basis of comorbidities or medication status. Although this may represent a more ecologically valid sample, it leaves unclear whether the presence of comorbid disorders or medication might account for observed group differences or lack thereof. Future research might include a control group that is matched on the same comorbid conditions, as well as random assignment of BD individuals on different medication classes (e.g., antidepressants, mood stabilizers, anxiolytics). Finally, this study was cross-sectional and so could not address hypotheses regarding how
deficits in negative emotion maintenance may predict the onset of heightened emotion responding in the short-term, and mood relapse in the long-term.

**Implications for Bipolar Disorder and Emotion**

Despite these caveats, the present investigation provides important insights into underlying mechanisms associated with positive emotional disturbance in a severe and chronic psychiatric disorder. Specifically, the present investigation isolated a specific process of interest – emotion maintenance, also referred to as affective working memory – in order to examine which cognitive processes are involved in maintaining online representations of affective content.

Results from the present study supported a ‘negative minimization’ account of affective working memory in BD. Specifically, participants diagnosed with BD exhibited selective deficits in negative (but not positive) emotion maintenance compared to both CTL and MDD comparison groups. Importantly, the MDD and CTL groups did not differ from each other suggesting that negative emotion maintenance deficits are a disorder-specific feature of BD, as opposed to a more transdiagnostic feature of mood disorders generally. These results are consistent with findings suggesting that individuals with BD exhibit impaired recognition of negative – but not positive – facial expressions (Lembke & Ketter, 2002) and fail to demonstrate attentional biases for negative stimuli more generally (Elliott et al., 2000). Such findings suggest that heightened positive emotion in BD may be accounted for, in part, by an inability to maintain competing negative emotions in working memory that may serve to decrease positive mood. In other words, the absence of negative emotional representations in one’s current mind may lead an otherwise transient positive thought or feeling to instead last longer and at a greater degree. The ability to hold on to and maintain negative emotional representations in working memory also serves an
important survival function, keeping our attention alerted to potential dangers and assisting in modulating positive emotions that may not adaptively match a given context. A deficit in negative emotion maintenance in BD may thus signal an even greater sign of trouble for this population, as negative emotions may serve to help down-regulate the overly positive and intense positive moods characteristic of BD.

These findings stand in contrast to a ‘positive magnification’ view of emotion maintenance in BD that suggests that prolonged and intense positive emotions in BD are fueled by focused efforts to maintain positive emotions. However, our findings appear consistent with two central empirical findings in BD. Specifically, one line of work has documented an increased attention bias towards positive stimuli (e.g., Trevisani et al., 2008). Another line of work documents heightened positive rumination – or dwelling on the causes and consequences of one’s positive feelings – in BD (Gruber et al., in press; Johnson et al., 2008). We propose that our findings are not only consistent with these facts but may actually help explain them. That is, it is possible that difficulty holding onto negative emotions may be explained by a tendency to attend selectively to positive stimuli, and actively focus one’s regulatory efforts towards dwelling on the causes of one’s positive feelings. This apparent bias towards attending to and ruminating over positive emotion may actually come at the expense of maintaining accurate representations of negative emotions; focusing on positive feelings perhaps allows letting go of too many negative feelings in BD, or too soon.
References


Table 1

Demographic and Clinical Participant Characteristics

<table>
<thead>
<tr>
<th></th>
<th>BD</th>
<th>MDD</th>
<th>CTL</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (Yrs)</td>
<td>30.28 (8.76)</td>
<td>31.32 (11.32)</td>
<td>31.45 (9.13)</td>
<td>$F = 0.13$</td>
</tr>
<tr>
<td>Female (%)</td>
<td>66%</td>
<td>64%</td>
<td>68%</td>
<td>$\chi^2 = 0.08$</td>
</tr>
<tr>
<td>Caucasian (%)</td>
<td>90%</td>
<td>90%</td>
<td>90%</td>
<td>$\chi^2 = 6.54$</td>
</tr>
<tr>
<td>Education (Yrs)</td>
<td>15.02 (2.31)</td>
<td>15.21 (2.26)</td>
<td>15.95 (2.41)</td>
<td>$F = 1.30$</td>
</tr>
<tr>
<td>YMRS</td>
<td>1.97 (1.94)</td>
<td>1.44 (1.53)</td>
<td>1.17 (1.05)</td>
<td>$F = 2.03$</td>
</tr>
<tr>
<td>IDS-C</td>
<td>4.17 (3.25)</td>
<td>4.93 (2.67)</td>
<td>2.00 (1.98)</td>
<td>$F = 9.55^*$</td>
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<tr>
<td>GAF</td>
<td>75.38 (5.98)</td>
<td>78.86 (7.02)</td>
<td>88.00 (3.03)</td>
<td>$F = 40.60^*$</td>
</tr>
<tr>
<td>Working Memory</td>
<td>10.48 (3.24)</td>
<td>12.45 (2.85)</td>
<td>12.30 (3.16)</td>
<td>$F = 3.66^{**}$</td>
</tr>
<tr>
<td>SILS</td>
<td>32.10 (3.96)</td>
<td>33.34 (4.14)</td>
<td>33.37 (2.95)</td>
<td>$F = 1.11$</td>
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<td>Age at Onset (yrs.)</td>
<td>16.03 (6.72)</td>
<td>16.22 (7.57)</td>
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<td>-</td>
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<tr>
<td>Illness Duration (yrs.)</td>
<td>14.28 (9.88)</td>
<td>15.12 (10.38)</td>
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<td>-</td>
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<tr>
<td># (Hypo)manic Episodes</td>
<td>9.09 (13.16)</td>
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<td>-</td>
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<td># Depressive Episodes</td>
<td>13.04 (18.00)</td>
<td>5.74 (7.68)</td>
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<td>-</td>
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<td># Psychotropic Medications</td>
<td>2.00 (1.58)</td>
<td>0.61 (0.88)</td>
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<td>-</td>
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<tr>
<td># Comorbid Disorders</td>
<td>0.58 (1.05)</td>
<td>0.72 (1.03)</td>
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</tr>
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</table>

Note: BD = Bipolar disorder group; MDD = Major depressive disorder group; CTL = Healthy control group; YMRS = Young Mania Rating Scale; IDS-C = Inventory of Depressive Symptomatology-Clinician Rating; GAF = Global assessment of functioning; WAIS-IV = Letter-number sequencing working memory subtest from WAIS-IV; SILS = Shipley Institute of Living Scale; # of Psychotropic Medications = the number of psychotropic medications currently taken (
including anticonvulsants, lithium, neuroleptics, anxiolytics, stimulants, antidepressants, and sedative-hypnotics); # Comorbid Disorders = the number of current DSM-IV-TR Axis I comorbidities (including panic disorder, agoraphobia, social phobia, specific phobia, obsessive-compulsive disorder, generalized anxiety disorder, hypochondriasis, body dysmorphic disorder, binge-eating disorder, and bulimia). Mean values are displayed with standard deviations in parentheses where applicable.

*p < .001; ** p < .05
### Table 2

*Group Differences in Positive and Negative Emotion Maintenance Accuracy*

<table>
<thead>
<tr>
<th></th>
<th>BD</th>
<th>MDD</th>
<th>CTL</th>
<th>Statistic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive Accuracy</td>
<td>86.1% (14.9)</td>
<td>86.7% (9.2)</td>
<td>86.8% (7.6)</td>
<td>$F = 0.03$</td>
</tr>
<tr>
<td>Negative Accuracy</td>
<td>82.5% (11.2)</td>
<td>88.9% (9.7)</td>
<td>88.9% (10.3)</td>
<td>$F = 3.33^*$</td>
</tr>
</tbody>
</table>

*Note:* BD = Bipolar disorder group; MDD = Major depressive disorder group; CTL = Healthy control group. Scores refer to accuracy rated on a 0-100% scale.

* $p < .05$
Figure Caption

*Figure 1.* Affective Maintenance Task Overview.
Figure 1

Negative Maintenance Task

Positive Maintenance Task
Footnotes

1 For these analyses, five participants were unable to complete the negative maintenance task (3 BD & 2 MDD participants).