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ORIGINAL ARTICLE

Emotion Regulation of Goals in Bipolar Disorder and Major Depression: A Comparison of Rumination and Mindfulness

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Abstract Progress towards goals is intertwined with emotional responding, yet little is known about how emotions are regulated during this process. This is especially pertinent in disorders characterized by emotional and goal dysregulation, such as bipolar disorder (BD) and major depressive disorder (MDD). The current study experimentally examined the influence of two emotion regulation strategies—rumination and mindfulness—on emotional responding to goal striving among individuals with BD, MDD, and a healthy control group. Participants visualized a future unattained goal and then engaged in a maladaptive (rumination) or adaptive (mindfulness) induction while experiential and autonomic responses were measured. Across participants, ruminating on a future goal was associated with increased negative and positive emotion and elevated cardiovascular arousal. Compared with ruminating, mindfulness was associated with increased positive emotion and parasympathetic responding. Ruminating on goals appears to exacerbate emotional reactivity while being mindful of one's goals is beneficial in healthy and clinical samples.

Keywords Emotion regulation · Goals · Rumination · Mindfulness · Mood disorders

Bipolar disorder (BD) and Major depressive disorder (MDD) are severe and chronic mood disorders involving core disruptions in emotion regulation (Gruber 2011b; Rottenberg 2005). Both are also associated with goal dysregulation, including overzealous and hyperactive goal striving in BD (e.g., Johnson 2005) and hypoactive and blunted goal striving in MDD (Dickson and MacLeod 2004). Disruptions in striving towards unattained goals are critically implicated in the onset and maintenance of symptoms in these disorders (Alloy et al. 2009; Kasch et al. 2002). However, less is known about how these individuals manage emotional responses in the context of thinking about their goals. The current study experimentally examined how instructed emotion regulation strategies might influence emotional responding when thinking of future goals in BD and MDD.

Emotion Disturbance in BD and MDD

Individuals with BD and MDD are both characterized by abnormal patterns of emotional reactivity (Gruber 2011b; Rottenberg 2005). For BD, converging lines of work demonstrate that individuals at risk for, and diagnosed with, BD exhibit greater positive emotional reactivity compared to controls (Gruber 2011b; Johnson 2005). Individuals with remitted BD exhibit greater subjective positive emotion (Gruber 2011b) and greater physiological reactivity to positive stimuli, such as increased respiratory sinus arrhythmia (RSA; a putative measure of positive emotion; Kok and Fredrickson 2010; Oveis et al. 2009). Importantly, these heightened positive emotional states have been found to predict increased manic symptom severity in BD (Gruber, Culver et al. 2009).

By contrast, there is a mixed literature on negative emotional reactivity in BD. For example, individuals at risk for or diagnosed with BD do not differ from controls in

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physiological responsivity to aversive photos (Sutton and Johnson 2002) or self-reported negative emotion to emotional films (Gruber et al. 2008). On the other hand, individuals with remitted BD display a negative response bias in an affective response inhibition task (Gopin et al. 2011) and demonstrate increased neural activation in response to negative emotional stimuli (Hassel et al. 2008; Yurgelun-Todd et al. 2000). Moreover, individuals with BD have elevated contradictory appraisals of negative and positive internal states compared with MDD or CTL groups (Kelly et al. 2011), highlighting the interactive effects of negative and positive emotional biases in BD.

MDD, on the other hand, is characterized by blunted emotional reactivity to both negative and positive stimuli (e.g., Bylsma et al. 2008). With respect to negative stimuli, currently depressed MDD individuals exhibit blunted subjective emotional responding (Rottenberg et al. 2002) and damped physiological (startle modulation and decreased RSA) responding to negative films (Kaviani et al. 2004; Rottenberg et al. 2003). MDD individuals also exhibit blunted subjective and physiological (event related potential (ERP); and startle) reactivity to positive words, photos, and film clips (e.g., Bylsma et al. 2008; Kaviani et al. 2004; Shestyuk et al. 2005) and blunted responsivity to rewards compared to healthy controls (Pizzagalli et al. 2008). Blunted subjective and physiological positive emotion reactivity is also associated with current depressive severity and worsened course of depression (Rottenberg et al. 2002).

Goal Regulation and Emotional Responding in BD and MDD

A robust literature in healthy populations suggests that emotional responding is related to, and also influences, pursuit of unattained goals in daily life. That is, positive emotions increase when progressing closer to a goal, and negative emotions increase when pursuit towards a goal is unsuccessful or thwarted (Carver and Scheier 1998). Furthermore, emotions and goal-pursuit bi-directionally influence one another in a recursive cycle (Louro et al. 2007). Given that emotional and goal responding interact while individuals progress towards their future unattained goals, it is important to understand the implications of these interactions in BD and MDD, disorders characterized by disturbed emotional responding and goal dysregulation.

BD is associated with overzealous pursuit of, and emotional reactivity to, goals (for review see Johnson 2005). For example, symptoms of mania in BD are associated with overly ambitious goals (Johnson et al. 2009) and higher expectations of accomplishing future goals (Meyer et al. 2004). BD is also associated with elevated emotional responses to goals. For example, after receiving false success feedback, individuals at risk for BD report increased self-confidence and goal striving compared with controls (Johnson et al. 2005; Stern and Berrenberg 1979). Finally, dysregulated goal striving is associated with greater risk for onset of manic symptoms in BD (Alloy et al. 2009; Johnson 2005; Nusslock et al. 2007). In sum, goal responding and emotion responding influence one another and are both associated with worsened clinical symptoms. Less is known though about how individuals with BD emotionally respond when thinking about, or visualizing, future, unattained goals, and how they regulate these emotional responses.

By contrast, MDD is associated with diminished pursuit of, and emotional responding to, future goals (Trew 2011). Depressive symptoms are related to having fewer approach related goals to strive towards (Dickson and MacLeod 2004) and depressed individuals exhibit decreased motivation to approach goals compared with controls (Kasch et al. 2002). Lower approach motivation in depressed individuals is also associated with longer time to recovery (Kasch et al. 2002; McFarland et al. 2006). In fact, a long line of research focuses on helping depressed individuals set appropriate goals and strive to achieve them (e.g., Jacobson et al. 2001). However, there is a gap in the literature examining how remitted MDD participants, who are not currently experiencing elevated depressive symptoms, emotionally respond to future goals. In sum, independent lines of research demonstrate that individuals with BD and MDD experience both dysregulated goal striving and emotional responding. Yet little is known about how these tendencies interact when imagining one's future goals and while trying to manage the emotional responses that arise.

Ruminative and Mindful Emotion Regulation

Literature examining emotion regulation has broadly categorized regulation strategies into two domains: "maladaptive," regulation strategies associated with high levels of psychopathology or distress, and "adaptive," regulation strategies associated with low levels of psychopathology or distress (e.g., Gross and Thompson 2007). An example of a generally maladaptive strategy is *rumination*, defined as the process of repetitively focusing on the causes and consequences of one's current affective state (Nolen-Hoeksema 1991). Ruminating on a current mood amplifies one's emotional state (be it a sad, angry, or happy emotional state). For example, ruminating over one's negative mood has been associated with increased severity of depression, anxiety, and eating disorders (e.g., Nolen-Hoeksema et al. 2007, 2008) and decreased well-being (Harrington and

Loffredo 2011). Conversely, ruminating in the context of a positive emotional state increases positive emotion and manic symptoms, while ruminating after a provocation is associated with increased anger and aggressive behavior (e.g., Nolen-Hoeksema et al. 2013). An example of an adaptive regulation strategy is *mindfulness*, defined as non-judgmental awareness and acceptance of one's current emotional state (Kabat-Zinn 1990). Mindfulness is associated with decreased symptoms and severity of depression, anxiety, and anger, increased well-being (Keng et al. 2011), lower rumination (Raes and Williams 2010), and more adaptive physiological responding (Ditto et al. 2006).

How are rumination and mindfulness implicated in BD and MDD? For rumination, a large body of work suggests greater negative rumination (i.e., ruminating in the context of negative moods) in remitted BD (Johnson et al. 2008) and current and remitted MDD (e.g., Just and Alloy 1997; Nolen-Hoeksema 2000). Increased positive rumination (i.e., recurrent and perseverative thoughts focusing on one's positive moods) is evident in individuals with remitted BD compared to those with MDD and controls (Johnson et al. 2008). Negative rumination predicts increased depressive symptoms in both BD and MDD (Feldman et al. 2008; Nolen-Hoeksema et al. 2008). Positive rumination is associated with elevated self-reported positive emotion in both BD and MDD (Edge et al. 2012; Gilbert et al. 2013), elevated hypomanic symptoms in healthy samples (Raes et al. 2009), and the onset of manic and depressive symptoms within a remitted BD sample (Feldman et al. 2008; Gilbert et al. 2013; Gruber et al. 2011). Although not studied within the context of BD and MDD, ruminating on unattained future goals highlights the discrepancy between one's current state and a desired future state (Martin et al. 2004; Martin and Tesser 1996). The experience of this discrepancy could lead to either action to reduce this discrepancy, increasing positive emotion and subsequently activating positive rumination, or continued negative and perseverative thinking on this discrepancy, increasing negative emotion, negative rumination, and inaction (Martin and Tesser 1996).

Mindfulness, by contrast, is associated with decreased depression severity. For example, Mindfulness-Based Stress Reduction (MBSR) and Mindfulness-Based Cognitive Therapy (MBCT) programs reduce the risk of depressive relapse and increase momentary positive emotions in those with remitted MDD (Geschwind et al. 2011; Hofmann et al. 2010) and BD (Williams et al. 2008). Furthermore, experimental mindfulness inductions decrease negative mood and increase positive mood among depressed and healthy adults (Broderick 2005; Erisman and Roemer 2010; Huffziger and Kuehner 2009). Importantly, higher trait mindfulness is associated with improved goal differentiation and pursuit (Crane et al. 2010). Taken together, this research suggests that rumination may be associated with maladaptive emotional responses to goals while mindfulness might be associated with adaptive goal regulation.

The Present Investigation

The present study experimentally examined the effects of ruminative and mindfulness emotion regulation strategies on goal visualization of future goals across remitted bipolar I (BD), remitted depressed (MMD), and non-psychiatric control (CTL) groups. We examined future goals to provide a first examination of how regulating emotions about one's goals may influence how individuals with goal dysregulation (BD and MDD) respond to unattained goals that they may be working towards. We focused on remitted BD and MDD participants to examine trait differences in emotion regulation to future goals to minimize the impact of current symptoms. Using a within-subjects design, participants were instructed to visualize a future goal. Next, they were asked to reflect on this goal while undergoing either a rumination or mindfulness induction in counterbalanced order. Although rumination is often compared with distraction inductions, we did not include the latter as previous studies have indicated mindfulness and distraction inductions show comparable effects on mood (Broderick 2005; Huffziger and Kuehner 2009). Moreover, although distraction is an effective emotion regulation strategy in the short-term, its' constant use may lead to avoidance of emotional experiencing. Thus, we employed a mindfulness induction to examine an adaptive comparison to rumination that may lead to more emotional acceptance (Kabat-Zinn 1990). Experiential and physiological responses were monitored during the experiment. Participants also completed several questions about their imagined goal and provided a written description of their goal at the end of the experimental session. These methods enabled the examination of two main aims:

Rumination and Mindfulness Differences

The first aim examined differences in emotional responses to visualizing goals from baseline to the rumination and mindfulness regulation conditions. We predicted that the rumination induction would be associated with greater subjective (i.e., positive and negative affect) and physiological (i.e., increased cardiovascular) emotional responding across all participants compared with baseline. This prediction was based on work indicating that rumination intensifies both positive and negative mood states, and occurs in response to unattained goals (Gruber, Harvey, et al. 2009; Martin and Tesser 1996; Nolen-Hoeksema

et al. 2008). This finding would suggest that rumination is associated with exacerbated emotional and physiological responding and may be maladaptive when thinking of goals. We also predicted that compared with baseline, the mindfulness induction would elicit specific subjective (i.e., positive affect) and physiological (i.e., increased parasympathetic) emotional responding across all participants. This was based upon work associating mindfulness with increased positive affect and parasympathetic activity among healthy adults (Ditto et al. 2006; Erisman and Roemer 2010; Huffziger and Kuehner 2009). This finding would suggest that mindfulness may be a subjectively and physiologically adaptive way to regulate emotional responding to goals.

Mood Disordered and Healthy Control Group Differences

The second aim was to examine group differences in emotion response across both emotion regulation conditions. For the BD group, we predicted greater increases in self-reported positive emotion and RSA compared to MDD and CTL groups, based on models of positive emotion disturbance in BD (Gruber 2011a). For the MDD group, we predicted decreased self-reported positive and negative emotion and decreased RSA compared to BD and CTL groups, supported by evidence indicating MDD patients exhibit blunted positive and negative emotional reactivity and inflexible RSA functioning (Rottenberg 2005, 2007). We did not predict group differences in cardiovascular arousal given that BD and MDD groups have not been found to differ from controls in cardiovascular responding (i.e., heart rate) while regulating emotional responses in prior research (Gruber, Harvey et al. 2009; Rottenberg et al. 2002).

Materials and Methods

Participants

Participants were 31 persons diagnosed with BD type I (currently remitted), 31 persons diagnosed with MDD (currently remitted) and 31 healthy non-psychiatric controls (CTL) with no current or past psychiatric disorders. Exclusion criteria included history of head trauma, stroke, neurological disease, autoimmune disorder, psychosis outside of a mood episode, or alcohol or substance abuse in the past 6 months. Demographic and clinical characteristics are listed in Table 1.

For the BD group, the average number of manic episodes was 11.40 (±20.30) and depressive episodes was 13.94 (±22.18), and for the MDD group, the average number of depressive episodes was 5.60 (±7.44). Psychotropic medications for the BD group included lithium ($n = 11$), anticonvulsants ($n = 13$), antidepressants ($n = 3$), neuroleptics ($n = 11$), anxiolytics ($n = 8$), stimulants ($n = 4$), and sedative-hypnotics ($n = 2$); and for the

Table 1 Demographic and clinical characteristics of bipolar (BD), depressed (MDD) and control (CTL) participants

	Group			Statistic
	BD ($n = 31$)	MDD ($n = 31$)	CTL ($n = 31$)	
Demographic				
Age	30.94 (9.82)	31.20 (10.97)	32.06 (9.02)	$F(2,89) = 0.11$
Female (%)	65	68	71	$\chi^2 = 0.30$
Caucasian (%)	90	90	90	$\chi^2 = 6.50$
Education (years)	14.98 (2.18)	15.16 (2.28)	16.0 (2.40)	$F(2,89) = 1.56$
Employed (%)	48	52	65	$\chi^2 = 11.60$
Married (%)	30	13	16	$\chi^2 = 18.97$[a]
Clinical				
YMRS	1.82 (1.94)	1.47 (1.63)	1.16 (1.71)	$F(2,89) = 1.05$
IDS-C	5.70 (3.55)	5.73 (3.07)	2.32 (2.31)	$F(2,89) = 12.94$[a]
GAF	75.68 (6.13)	79.13 (7.01)	87.74 (3.40)	$F(2, 89) = 36.67$[a]
Months remission	23.84 (52.38)	44.84 (53.65)	–	$t(60) = -1.56$
Illness duration	12.87 (10.55)	15.06 (10.47)	–	$t(60) = -0.81$

Mean values are displayed with standard deviations in parentheses where applicable *BD* Remitted bipolar I disorder participants, *MDD* remitted depressed participants, *CTL* control participants, *YMRS* Young Mania Rating Scale, *IDS-C* inventory to diagnose depression, *GAF* Global Assessment of Functioning Scale, *Months remission* number of months since most recent episode, *Illness duration* Number of years since onset of first episode

[a] $p < .05$

MDD group it included anticonvulsants ($n = 2$), antidepressants ($n = 10$), neuroleptics ($n = 1$), and anxiolytics ($n = 3$)[1]. BD participants had an average of 0.56 (±0.91) current comorbidities, including panic disorder ($n = 1$), agoraphobia ($n = 1$), social phobia ($n = 3$), specific phobia ($n = 4$), obsessive–compulsive disorder ($n = 3$), generalized anxiety disorder ($n = 3$), hypochondriasis ($n = 1$), body dysmorphic disorder ($n = 1$), and bulimia nervosa ($n = 1$). The MDD group had an average of 0.68 (±0.97) comorbidities, including panic disorder ($n = 2$), agoraphobia ($n = 1$), social phobia ($n = 7$), specific phobia ($n = 4$), obsessive–compulsive disorder ($n = 1$), generalized anxiety disorder ($n = 5$), and binge eating disorder ($n = 1$).

Measures of Clinical Functioning

Diagnostic Evaluation

Diagnoses were confirmed using the Structured Clinical Interview for DSM-IV Patient Version (First et al. 2007) administered by trained researchers. One-third ($n = 29$) of interviews were independently assessed and ratings matched 100 % ($\kappa = 1.0$) of primary diagnoses, and were high across all Axis I comorbidities ($\kappa_{mean} = 0.95$).

Mood Symptoms

Current symptoms of mania were measured using the Young Mania Rating Scale (YMRS; Young et al. 1978), an 11-item measure ranging from 0 to 60, with scores ≥7 representing clinically significant symptoms. Current symptoms of depression were measured using the Inventory of Depressive Symptomatology (IDS-C; Rush et al. 1996), a 30-item clinician-rated measure ranging from 0 to 84, with scores ≥11 representing clinically significant symptoms. Current remitted mood status for all groups was verified with the SCID-IV mood module (no mood disorder in the past month or longer) and YMRS (<7), and IDS-C (<11) cutoff scores for the past week.

Goal Characteristics and Task Engagement

We examined whether there were significant differences in the subjective beliefs about the visualized future goal, the content of the goal, and the engagement in visualizing this goal. For goal beliefs, participants rated the importance of, ability to accomplish, belief they could manage, and the realistic nature of their goal on a 1 (*not at all*) to 7 (*a lot*) scale. Furthermore, two coders blind to diagnostic status also coded a written description of the goal for degree of positive valence, negative valence, and ambitiousness of the goal on a 1 (*not at all*) to 5 (*extremely*) scale; as well as goal content categories including social, job, home, school, money, romantic or sexual, outdoors/vacation, recreation/hobby, or other (coded *yes/no*). For task engagement, participants rated how well they were able to engage in the task of visualizing their goal during the experiment and how vivid their mental images of their goal and the steps necessary accomplish it were, both measures using a 1 (*not at all*) to 7 (*a lot*) scale.

Multi-Method Measurement of Emotion Response

A multi-method approach was employed to measure emotion at experiential and physiological levels of analysis in order to obtain both self-report and biological indices of goal and emotion regulation. Data across channels were measured across three experimental periods: a Baseline period (60 s)[2], Rumination condition (300 s) and Mindfulness condition (300 s).

Positive and Negative Affect

Self-reported positive affect (PA) and negative affect (NA) were assessed using the 10-item short form of Positive and Negative Affect Schedule (PANAS; Watson et al. 1988). Participants rated all items on a 1 (*very slightly*) to 5 (*extremely*) scale and items were summed to create a PA ($\alpha_{mean} = 0.90$) and NA ($\alpha_{mean} = 0.83$) composite.

Physiology

Physiological data were recorded continuously at 1,000 Hz using a Mindware multi-channel chassis device (BioNex 50-3711-08 Mindware Technologies, Gahanna, OH). Artifacts and recording errors were corrected offline using Mindware v3.0.8 software and values ±3.0 standard deviations were deemed outliers and Winsorized (<3 % of all data). Two physiological measures assessed cardiovascular arousal and parasympathetic responding.

[1] Levels of each class of medication were recorded using the Somatotherapy Index (Bauer et al. 1997) for both the BD and MDD groups who were taking psychotropic medications. Specifically, bivariate correlations were conducted within each group separately, as well as a combined clinical group (both BD and MDD), between the intensity of medication dose equivalency and the emotion response dependent variables (i.e., both subjective and physiological responding and goal expectancy). Results did not reveal significant correlations between medication dosage across different medication classes and emotion response variables during the experimental induction.

[2] The physiological baseline was a combined average of the two counterbalanced 60 s baseline periods prior to the onset of the Rumination and Mindfulness conditions separately. Baseline self-reported emotion was assessed once at the beginning of the experimental session.

Heart Rate (HR)

Heart rate was assessed as a general index of cardiovascular activity. ECG recordings were obtained with two prejelled Ag–AgCl snap disposable vinyl electrodes placed in a modified Lead II configuration. A MindWare ECG amplifier, using a bandpass filter of 0.5–100 Hz (and a 60 Hz notch filter), was used and the ECG signal was converted to R-wave intervals (interbeat intervals [IBIs]), which were converted to beats per minute.

Respiratory Sinus Arrhythmia (RSA)

RSA was employed as a noninvasive index of parasympathetic nervous activity. RSA is purportedly associated with positive emotion (Oveis et al. 2009), psychological flexibility (Kashdan and Rottenberg 2010) and emotional well-being (Kok and Fredrickson 2010). RSA was derived from a power spectral analysis of high frequency heart rate variability (0.12–0.14 Hz Bernston et al. 1997). Specifically, a 4 Hz (250 ms) time series was derived by interpolation from the derived IBI series mentioned above (Bernston et al. 1995), and the series was detrended by the second order polynomial to minimize non-stationaries in the data (Litvack et al. 1995). The residual series was then tapered with a Hamming window and a Fast-Fourier Transform (FFT) was applied to the resampled R–R intervals using Mindware HRV Module (v3.0.8, Mindware Technologies, Inc., Gahanna, OH). RSA was quantified as the integral power within the respiratory frequency band (0.12–0.40 Hz), which is equal to the statistical variance of the time series within that band.

Experimental Goal Expectancy

In addition to measuring emotional responding during the regulation inductions, we also wanted to experimentally assess cognitions of goal achievement expectancy. To measure future goal achievement during the experimental paradigm, participants predicted future success on an unrelated task following each goal-visualization and emotion regulation induction. Participants were told they would be later completing a hand-eye coordination task and that their performance on this task was associated with "intelligence and athletic ability." Participants were asked to rate their expected success on this task on a 0 (*not at all successful*) to 100 (*completely successful*) scale at the end of each of the two emotion regulation inductions (i.e., immediately after the mindfulness induction and immediately after the rumination induction). This question was used to measure predicted future success and has previously demonstrated that individuals at high risk for BD show elevated expectancies compared with low risk individuals (Johnson et al. 2005; Stern and Berrenberg 1979).

Procedure

After obtaining informed consent, the SCID-IV, YMRS and IDS-C were administered. Physiological sensors were then attached and participants were seated in a $6' \times 7'$ copper-shielded experimental room in front of a $26''$ Samsung computer monitor. Participants were oriented to the task verbally by the experimenter, and then self-guided through the experiment using computerized software (MediaLab v2008, MediaLab, Inc., Atlanta, GA, USA).

Using a within-subjects design, participants completed both the Rumination and Mindfulness conditions in counterbalanced order. Previous research has effectively utilized a within-subjects design to examine emotional and physiological ruminative versus reflective processing in a BD population (Gruber, Harvey et al. 2009). Prior to each induction, a resting physiological baseline period (60 s) was acquired where all participants were instructed to remain seated and still. Next, participants were instructed to identify and visualize a future goal using the following instructions: *I will now ask you to imagine something that you have dreamed of pursuing. That is, something you would like to, or hope to, achieve one day. Please take a few moments right now to think about things you have really wanted to pursue or aim to achieve. As you think about these future goals, try to identify one that is clear in your mind that you would feel motivated to pursue and accomplish. This goal can be large or small, easy or difficult. It might be something you could pursue as soon as tomorrow, or, something you dream of pursuing in another life.* Participants were given 90 s to visualize their goal. Following the goal visualization, participants completed the Rumination or Mindfulness induction (300 s each). Next, they self-reported current affect and goal expectancy items. The Rumination and Mindfulness conditions were separated by a cognitive distractor task lasting approximately 300 s (i.e., Digit Symbol Copy Task; Weschler 1997).

For the Rumination condition, participants were instructed to continue thinking about their future goal while self-guiding through the previously validated manipulation (Lyubomirsky and Nolen-Hoeksema 1993). Specifically, participants heard out loud and read on the computer screen up to 20 rumination prompts including, "why you react the way you do" and "think about your level of motivation right now." For the Mindfulness condition, participants were instructed to continue thinking about their future goal while they self-guided through the previously validated manipulation (Kuehner et al. 2009). Specifically, participants heard out loud and read on the computer screen up to 20 mindfulness prompts including, "let your thoughts and feelings pass by without judging them" and "as best you can, accept your present experience simply as it is." For

both conditions, participants were told to spend as long as they wanted on each prompt. Once finished, participants typed a brief written description of the imagined goal, completed manipulation check items, and were compensated.

Results

Demographic and Clinical Characteristics

As evident from Table 1, the BD, MDD and CTL participants were similar across all demographic variables. All groups scored below the standardized cutoffs on the YMRS ($\leq$7) and IDS-C ($\leq$11), although the BD and MDD groups scored higher on subsyndromal IDS-C scores compared with the CTL group.

Preliminary Analyses

First, we examined potential group differences in emotion response variables during a resting baseline (see footnote 1). No baseline group differences emerged (*ps* > .05) with the exception of NA $F(2,90) = 7.03$, $p = .001$. Follow-up pairwise analyses revealed that the CTL group ($M = 7.51$, $SD = 0.96$) reported lower NA than both the BD ($M = 9.10$, $SD = 2.14$) and MDD groups ($M = 9.3$, $SD = 2.61$), yet the BD and MDD groups did not differ in baseline NA (*ps* > .05). Given this difference, we included baseline emotion responding as a within-subjects factor in subsequent analyses. Second, we examined potential group differences in physiological responding during the goal-induction and found no group differences for either HR or RSA (*ps* > .05). Fourth, we examined whether our primary outcome variables were normally distributed using the Kolmogorov–Smirnov test. One variable did not meet this criterion (i.e., NA; $Z > 5.5$; $p < .05$) and thus natural log transformations were performed to normalize these variables for the main analysis. Non-transformed values are presented for ease of interpretation.

Goal Characteristics and Task Engagement

Means and standard deviations of goal characteristics and task engagement are presented in Table 2. For personal goal characteristics, groups did not significantly differ in the importance of, ability to accomplish, or the realistic nature of the visualized goal (*ps* > .05). However, the BD group reported lower beliefs that they could effectively manage their goal compared to both MDD and CTL groups, $F(2, 90) = 11.67$, $p = .0001$, $\eta_p^2 = 0.80$. The MDD and CTL groups did not differ on the perceived ability to manage of their goal (*ps* > .05). For coded goal features, two coders demonstrated reliable agreement ($ICC_{mean} = 0.86$). Groups did not significantly differ on coding of negative valence, ambition of the goal, or any of the nine goal content codes (*ps* > .05). However, the BD group's goal was coded as less positively valenced than the CTL group, $F(2,90) = 4.38$, $p = .02$, $\eta_p^2 = 0.95$. The MDD group did not differ from the CTL or BD groups (*ps* > .05). The three groups did not significantly differ in task engagement or in how vivid their mental image of the goal and the steps towards the goal (*ps* > .05).

Table 2 Goal characteristics and task engagement across participants

	Group		
	BD	MDD	CTL
Goal Characteristics (reported)			
Importance	6.00 (1.34)	6.07 (1.15)	5.87 (1.26)
Ability to accomplish	5.10 (1.49)	5.50 (1.17)	5.84 (1.13)
Inability to manage	3.97 (2.08)[b]	2.50 (1.33)	2.10 (1.22)
Realistic nature of goal	5.17 (1.56)	5.53 (1.50)	5.87 (1.06)
Goal content (coded)			
Positive valence	3.13 (0.94)[a]	3.23 (0.68)	3.68 (0.65)
Negative valence	1.50 (0.86)	1.37 (0.56)	1.19 (0.40)
Ambition	2.83 (0.87)	2.83 (1.02)	3.13 (1.06)
Social-related (%)	0	0	3
Job-related (%)	46	40	48
Home-related (%)	7	3	13
School-related (%)	7	13	3
Money-related (%)	3	3	0
Romantic-related (%)	7	0	7
Outdoors/vacation-related (%)	6	7	3
Recreation-related (%)	3	27	23
Other (%)	16	03	0
Task engagement			
Engaged in visualization	5.63 (1.07)	5.63 (1.38)	5.71 (1.30)
Vivid mental image	5.07 (1.36)	5.43 (1.48)	5.35 (1.43)

Mean values are displayed with standard deviations in parentheses. *BD* remitted bipolar I disorder participants, *MDD* remitted depressed participants, *CTL* control participants, Goal characteristic and task engagement variables self-reported from 1 (*not at all*) to 7 (*a lot*); Goal Content coded by two independent raters from 1 (*not at all*) to 5 (*extremely)*

[a] $p < .05$; BD versus CTL groups

[b] $p < .05$; BD versus MDD and CTL groups

Overview of Main Analyses

We first tested the effects of gender and condition order by performing eight separate 2 (gender or condition order) × 3 (Condition: baseline, rumination, mindfulness) repeated measures ANOVA for each emotion variable (NA, PA, HR, RSA). To test hypothesized analyses, we performed separate 3 (Group: BD, MDD CTL) × 3 (Condition: Baseline, Rumination, Mindfulness) factorial

ANOVAs for each emotion variable (NA, PA, HR, RSA), similar to prior research (e.g., Rottenberg et al. 2002). When assumptions for sphericity were not met, adjusted Greenhouse–Geisser F and p values are reported. Bonferonni-adjusted tests were used for follow-up analyses. See Table 3 for means and standard deviations.

Gender and Condition Order Differences

Gender

There were no main effects of gender for NA, $F(1,88) = 0.12$, $p = .73$, $\eta_p^2 = 0.001$, PA, $F(1,92) = 0.95$, $p = .33$, $\eta_p^2 = 0.01$, HR, $F(1,80) = 2.70$, $p = .10$, $\eta_p^2 = 0.03$, or RSA, $F(1,79) = 0.22$, $p = .64$, $\eta_p^2 = 0.003$. There were also no significant Gender × Condition interactions for NA, $F(1.68,176) = 1.41$, $p = .25$, $\eta_p^2 = 0.02$, PA, $F(2,184) = 0.45$, $p = .64$, $\eta_p^2 = 0.005$, HR, $F(1.86,160) = 0.09$, $p = .92$, $\eta_p^2 = 0.001$, or RSA, $F(2,158) = 1.21$, $p = .30$, $\eta_p^2 = 0.02$. As such, gender was not included as a covariate in subsequent analyses.

Table 3 Subjective emotion, physiological, and goal expectancy responses across participants by condition

	Emotion and goal responding by condition				
	PA	NA	HR	RSA	Goal
BD					
Baseline	11.73 (4.48)	8.89 (1.99)	73.53 (11.07)	5.88 (1.53)	
Rumination	12.83 (5.45)	10.37 (3.99)	74.92 (10.30)	5.80 (1.63)	58.53 (28.01)
Mindfulness	12.73 (4.84)	8.59 (2.49)	73.97 (10.81)	6.08 (1.58)	59.57 (24.17)
MDD					
Baseline	11.93 (3.53)	9.14 (2.56)	72.32 (7.43)	6.15 (1.13)	
Rumination	14.30 (5.30)	10.62 (3.49)	72.70 (7.84)	6.06 (1.13)	70.73 (16.19)
Mindfulness	13.97 (5.05)	9.41 (3.02)	71.71 (8.55)	6.31 (1.23)	72.00 (16.64)
CTL					
Baseline	12.58 (4.36)	7.52 (0.96)	73.04 (10.28)	6.23 (0.94)	
Rumination	14.48 (5.42)	8.51 (1.81)	74.33 (11.60)	6.18 (1.23)	73.48 (22.06)
Mindfulness	14.10 (5.04)	8.03 (1.43)	73.59 (10.20)	6.37 (1.04)	73.55 (22.17)

Mean values are displayed with standard deviations in parentheses. *PA* positive affect, *NA* negative affect, *HR* heart rate (measured in beats per minute), *RSA* respiratory sinus arrhythmia, *BD* remitted bipolar I disorder participants, *MDD* remitted depressed participants, *CTL* control participants; *Goal* the mean predicted future success (goal expectancy) on an unrelated task rated from 1 (*not at all successful*) to 100 (*completely successful*)

Condition Order

There were no main effects of condition order (i.e., whether the mindfulness or rumination induction came first) for NA, $F(1,88) = 1.23$, $p = .27$, $\eta_p^2 = 0.01$, PA, $F(1,92) = 0.002$, $p = .96$, $\eta_p^2 = 0.00$, HR, $F(1,80) = 0.25$, $p = .62$, $\eta_p^2 = 0.003$, or RSA, $F(1,79) = 0.03$, $p = .87$, $\eta_p^2 = 0.00$. There were also no significant Condition Order × Condition interactions for NA, $F(1.69,176) = 1.50$, $p = .23$, $\eta_p^2 = 0.02$, PA, $F(2,184) = 0.31$, $p = .73$, $\eta_p^2 = 0.003$, HR, $F(2,160) = 0.70$, $p = .50$, $\eta_p^2 = 0.01$, or RSA, $F(2,158) = 1.50$, $p = .23$, $\eta_p^2 = 0.02$. As such, condition order was not included as a covariate in subsequent analyses.

Condition and Group Differences

PA

For PA, there was a main effect of Condition, $F(2,176) = 17.92$, $p = .0001$, $\eta_p^2 = 0.17$. There was no Group main effect, $F(2,88) = 0.66$, $p = .52$, $\eta_p^2 = 0.02$, and no significant Group x Condition interaction, $F(4,176) = 0.74$, $p = .56$, $\eta_p^2 = 0.02$. For the Condition main effect, pairwise comparisons revealed that the Rumination ($M = 13.87$, $SD = 5.38$) and Mindfulness ($M = 13.60$, $SD = 4.96$) conditions were associated with greater PA compared to Baseline ($M = 12.08$, $SD = 4.12$) ($ps = .0001$), and Rumination and Mindfulness conditions did not differ ($p = 1.00$).

NA

For NA, there was a main effect of Condition, $F(1.60, 134.17) = 13.26$, $p = .0001$, $\eta_p^2 = 0.14$; and a main effect of Group $F(2,84) = 5.52$, $p = .01$, $\eta_p^2 = 0.12$. There was no Group × Condition interaction, $F(3.19, 134.17) = 0.96$, $p = .42$, $\eta_p^2 = 0.02$. For the Condition main effect, pairwise comparisons revealed that the Rumination condition ($M = 9.79$, $SD = 3.29$) elicited more NA than the Baseline ($M = 8.48$, $SD = 2.05$) condition ($p = .0001$) as well as the Mindfulness ($M = 8.67$, $SD = 2.42$) condition ($p = .002$). The Mindfulness and Baseline conditions did not differ ($p = 1.00$). For the Group main effect, the MDD group reported higher NA ($M = 9.72$, $SD = 5.39$) than the CTL group ($M = 8.02$, $SD = 2.07$), ($p = .006$). The BD group ($M = 9.28$, $SD = 2.06$) did not differ from the CTL or MDD groups ($p = .068$, 1.00, respectively).

HR

For HR, there was a main effect of Condition, $F(2,152) = 4.53$, $p = .01$, $\eta_p^2 = 0.06$. There was no main effect of Group, $F(2,76) = 0.28$, $p = .76$, $\eta_p^2 = 0.01$, and

no significant Group × Condition interaction, $F(4,152) = 0.62$, $p = .65$, $\eta_p^2 = 0.02$ (p's > .05). For the Condition effect, pairwise-comparisons revealed greater HR in the Rumination ($M = 73.97$, $SD = 9.92$) compared to the Baseline ($M = 72.96$, $SD = 9.58$) condition ($p = .03$), however, the Mindfulness condition ($M = 73.08$, $SD = 9.80$) did not differ from the Baseline or Rumination conditions ($p = .97$, .07, respectively).

RSA

For RSA, there was a main effect of Condition, $F(2,150) = 4.13$, $p = .018$, $\eta_p^2 = 0.05$. There was no main effect of Group, $F(2,75) = 0.56$, $p = .572$, $\eta_p^2 = 0.02$; and no Group × Condition interaction $F(4, 150) = .06$, $p = .994$, $\eta_p^2 = .001$. For the Condition main effect, pairwise comparisons revealed that Mindfulness ($M = 6.26$, $SD = 1.29$) was not associated with increased RSA compared with the Baseline ($M = 6.09$, $SD = 1.23$) condition ($p = .189$), but was associated with increased RSA compared to Rumination ($M = 6.01$, $SD = 1.34$) condition, ($p = .006$). Rumination and Baseline did not differ ($p = 1.00$).

Because RSA magnitude can be influenced by respiratory frequency (e.g., Grossman et al. 1991), we carefully examined the potential influence of respiration on both within and between-group findings. First, we conducted one-way ANOVAs to examine whether the three groups differed on mean respiratory frequency. Results did not reveal a main effect of Group on respiratory frequency across the task, $F(2,71) = 0.92$, $p = .40$, $\eta_p^2 = .02$, nor was there a significant Group × Condition interaction for respiration rate, $F(2.43, 86.30) = 0.70$, $p = .53$, $\eta_p^2 = .02$. Nonetheless, we more fully assessed the influence of respiration on RSA analyses by conducting three separate linear regressions examining whether respiration rate significantly predicted RSA for the Baseline, Rumination condition, and Mindfulness condition. Specifically, for each of the three conditions predicting RSA, we entered respiration rate in step 1, group status as a dummy code in step 2 (i.e., BD or CTL, MDD or CTL), and an interaction term in step 3 (i.e., Respiration rate × BD group status, Respiration rate × MDD group status). Results suggested that respiration rate significantly predicted RSA for the Baseline condition ($\beta = -0.51$, $p = .003$) and Rumination condition ($\beta = -0.54$, $p = .002$) across all participants. Respiration rate did not significantly predict RSA for the Mindfulness condition ($\beta = 0.10$, $p = .64$). None of the group variables or interaction terms were significant predictors of RSA. These results suggest that respiration rate did significantly predict RSA levels during the Baseline and Rumination condition. Thus, we performed subsequent analyses with and without respiration rate included as covariate.

When covarying for respiration rate during the baseline and rumination conditions, the main effect of Condition was no longer significant, $F(2,146) = 0.58$, $p = .56$, $\eta_p^2 = .008$. However, results appeared to be trending in the same direction and pairwise comparisons of conditions using a Bonferroni correction revealing a significant difference between the rumination and mindfulness induction ($p = .005$).

Experimental Goal Expectancy

For experimental goal expectancy on an unrelated task, there was no main effect of Condition, $F(1,88) = 0.34$, $p = .559$, $\eta_p^2 = 0.004$ however there was a main effect of Group $F(2, 88) = 4.18$, $p = .018$, $\eta_p^2 = 0.09$. We found no Group × Condition interaction, $F(2,88) = 0.08$, $p = .927$, $\eta_p^2 = 0.002$. For the Group effect, the BD group ($M = 59.05$, $SD = 20.99$) reported less predicted future success than the CTL ($M = 73.52$, $SD = 21.0$) group ($p = .026$) but did not differ from the MDD ($M = 71.36$, $SD = 20.99$) group ($p = .076$). The MDD and CTL groups did not differ ($p = 1.00$).

Secondary Analyses: Symptom Severity

Given the observed group differences in IDS-C scores (Table 1), we examined the role of symptom severity by running all analyses controlling for current symptoms of depression. Two results no longer reached significance after controlling for IDS-C, including the Group main effect for NA, $F(2,82) = 1.67$, $p = .195$, $\eta_p^2 = 0.04$; and the Condition main effect for HR, $F(2,148) = 2.07$, $p = .130$, $\eta_p^2 = 0.03$.

Discussion

Our goals and emotions are intertwined and interact in our everyday lives to give rise to behavior and decision-making. The present study's findings demonstrate how two well-studied emotion regulation strategies differentially influence emotional responding when visualizing one's future goal among individuals with BD, MDD, and healthy controls.

Rumination and Mindfulness Differences

Consistent with our predictions, all participants reported increased NA, PA and exhibited elevated HR during the rumination condition compared with baseline. This increase in overall emotional arousal (both subjectively and physiologically) is consistent with prior work demonstrating an emotion-amplifying effect of rumination on a

variety of emotion states (Nolen-Hoeksema et al. 2013). Such findings also extend prior work by demonstrating that rumination may amplify emotion intensity specifically in response to goal visualization. This emotional amplification in response to goals potentially occurs in two ways, first that ruminating increases positive feelings via anticipating the accomplishment of one's goals and second, that rumination perhaps also increases negative feelings by highlighting the discrepancy between one's current state and the perceived goal state (Martin and Tesser 1996). Stated differently, rumination appears to exacerbate the normative interaction between emotions and goals (Carver and Scheier 1998; Martin et al. 2004) and this appears to generalize across both healthy and mood-disordered populations.

The simultaneous increase in positive and negative emotion associated with ruminating about goals may be helpful in motivating healthy individuals to prioritize and take action towards pursuing and accomplishing goals (Carver and Scheier 1998). On the other hand, this positive and negative emotional enhancement may be especially maladaptive for individuals with BD, whose interpretation of such mixed valence states may lead to increased mood symptoms (Mansell et al. 2007) and possibly utilization of conflicting emotion regulation strategies in attempt to soothe such opposing emotional states (Gruber et al. 2011; Kelly et al. 2011). For individuals with MDD, the increase in positive emotion while ruminating over a goal is somewhat counterintuitive given that rumination typically exacerbates negative mood in depressed individuals (Nolen-Hoeksema et al. 2008). Importantly, this demonstrates that rumination is not a specific negative emotional amplifier, per se, but may function as a more general emotion amplifier depending on the content and affective quality of the information being ruminated about. The literature examining rumination in the context of positive emotion suggests some conceptual overlap of positive rumination with savoring, defined as mentally reflecting and elaborating on recent positive situations and anticipating future positive situations (Bryant 2003; McMakin et al. 2010). Unlike research finding positive rumination to be maladaptive (e.g., Bijttebier et al. 2011; Gruber et al. 2011), savoring positive emotions and thoughts appears to be generally adaptive (e.g., Tugade and Fredrickson 2007) and has even been utilized in clinical interventions for depression (McMakin et al. 2010). Future work would greatly benefit from parsing out whether ruminating on and savoring positive emotional states are distinct constructs and understanding role context and individual difference factors play in determining when and how these regulation strategies may be adaptive or maladaptive.

The mindfulness induction demonstrated increased PA from baseline and increased parasympathetic activity (RSA) compared with ruminating. This momentary increase in PA is consistent with prior work demonstrating the ameliorating subjective mental health benefits of longer mindfulness interventions (e.g., Crane et al. 2010; Teasdale et al. 2000). Although it cannot be determined whether rumination decreased RSA or mindfulness increased it because neither significantly differed from baseline, the significant condition differences are consistent with work demonstrating RSA to be indicated in mindfulness and a physiological marker of adaptive emotional responding (Kok and Fredrickson 2010; Oveis et al. 2009). These findings importantly extend this work by experimentally demonstrating the momentary benefits of mindfulness of future goals in both healthy and clinical samples. Compared with the rumination induction, all groups demonstrated elevated parasympathetic activity and elevated positive affect, however, did not demonstrate differences in cardiovascular activity or negative affect (as evidenced in the rumination condition). These results are particularly intriguing in the BD and MDD groups, both of which are typically marked by dysregulated positive emotion and RSA functioning (e.g., Gruber et al. 2008; Rottenberg 2007). Mindfulness appears to be an adaptive regulation strategy that individuals with BD and MDD can effectively employ when thinking about future goals. Considering recent treatment development focused on goal dysregulation specifically for BD (Johnson and Fulford 2009; Nusslock et al. 2009), mindfulness may be an adaptive component to clinical interventions focused on goal regulation and emotion regulation in this population. However, in order to extend these findings to clinical interventions, future work should focus on the longer-term outcomes of repeated practice of mindfulness of one's goals.

It should be noted that increasing PA in the mindfulness condition might be construed as potentially maladaptive for individuals with BD, who already experience elevated positive emotional reactivity associated with symptom severity (Gruber, Culver et al. 2009; Gruber et al. 2008). However, because individuals with BD did not demonstrate overly elevated levels of positive affect or RSA compared with the MDD and CTL groups, this potentially indicates that momentary experiences of being mindful may lead to more balanced levels of positive affect and physiological responding in individuals with BD.

Mood Disordered and Healthy Control Group Differences

Contrary to hypotheses, we did not find any group differences in emotion response across both emotion regulation conditions following goal-visualization. A couple potential interpretations are possible. First, the current study examined emotion response following visualization of a future

unachieved goal versus an already achieved goal. Most work in BD has examined emotion response *after* an initial goal-attainment event or when progress towards a goal is already high (Fulford et al. 2010; Meyer et al. 2004) or in MDD after a previous loss or goal-failure (Nolen-Hoeksema et al. 2008). As such, sufficient emotional responses may not have been triggered, preventing our ability to detect subtle group differences. Future work examining emotion response and regulation at different temporal stages of goal striving is warranted. Second, the current study primarily focused on remitted BD and MDD groups whose responsivity to goal visualization may have been dampened or obscured because of minimal current symptoms. Future work examining emotion regulation of goals across manic and depressed mood phases in both disorders is warranted.

We did, however, find a pattern of group differences in the BD group specifically for goal-relevant cognitions. Self-reported characteristics about one's visualized future goal revealed that the BD group provided a less positive future goal, they described the visualized goal as one they had fewer beliefs they could effectively manage, and following both regulation inductions the BD group reported decreased confidence in associated future success. Such findings speculatively suggest the BD group might have more negative goal-relevant cognitions. Although counter to our initial hypotheses and previous literature (e.g., Johnson 2005), these findings are consistent with prior work indicating during remission, individuals with BD construe goals as unattainable, more stressful, and more difficult compared with healthy controls (Mansell and Pedley 2008; Meyer et al. 2004). Given these preliminary findings, future work would benefit from parsing apart when individuals with BD experience goals to be negative versus activating overconfidence and how emotion regulation strategies may influence goal-relevant cognitions.

Limitations and Future Directions

Findings form the present study should be interpreted within the confines of several limitations. First, although participants were instructed to continue thinking about their personal goal during the experiment, it is unclear to what extent they focused on their goal relative to their current emotional experience. Although we considered more frequent assessments of attention towards the visualized goal during the emotion regulation manipulations, we decided against this so as not to interrupt the previously validated induction procedures (Kuehner et al. 2009; Lyubomirsky and Nolen-Hoeksema 1993). Future studies could remedy this limitation by inserting prompted reminders for participants to continue thinking about their visualized goal while continuing to engage in emotion regulation strategies. Second, a control condition with no regulation instruction was not included and thus spontaneous regulation to goal visualization was not examined.

Third, we acknowledge that our sample sizes were relatively modest despite mirroring sample sizes typically reported in experimental psychopathology research (e.g., Chentsova-Dutton et al. 2007; Ehring et al. 2010; Gruber et al. in press). Effect sizes for main effects were larger than those of our interaction terms, signifying that sample size could be the driving force leading to a lack of significant results. Therefore, future studies would greatly benefit from larger sample sizes as the absence of interaction effects could simply be due to low statistical power in detecting these effects. Fourth, respiration rate did appear to influence the significance of the RSA findings, signifying that these findings should be interpreted with caution. However, results were still trending the same direction, demonstrating that future work would benefit from further investigation of the role of mindfulness in increasing RSA in clinical groups. Fifth, the sample consisted largely of female Caucasian participants and results may not generalize to a more diverse sample. Sixth, alternative emotion regulation strategies that might have been employed during the inductions were not assessed and may have been used concurrently. Seventh, it is unknown how previous yoga and mindfulness meditation practices influenced responding in the mindfulness condition. Future work would benefit by experimentally inducing a mindful state in both experienced and novice meditators/yogi's with clinical disorders to assess momentary differences in subjective and physiological responding. Eighth, the current study employed visualization of a future goal during a relatively brief laboratory induction. Thus, it will be important to understand whether these findings from brief laboratory inductions generalize to more naturalistic goal visualization and striving situations in everyday life. Ninth, the BD and MDD groups were not excluded on the basis of comorbidities to ensure a more ecologically valid sample. Although this represents one strength of the study, future studies would be helpful in examining how the presence of comorbid disorders influences goal regulation. Finally, although we examined associations between medication dosage and emotion response variables, we did not systematically control for the presence of medication. Given that an unmedicated bipolar sample is often unfeasible and unrepresentative, future studies with larger sample sizes and random assignment to different medication classes are warranted to examine the possible role of psychotropic medications on physiological responding (Licht et al. 2008).

Despite these limitations, this study provides an important step forward in understanding the connection between emotional responding and regulation when goal

striving in mood disorders. The present study is the first to our knowledge to experimentally examine the impact of individual emotion regulation strategies in response to goal-visualization among populations characterized by dysregulated goal regulation and emotion responding. Ruminating over future goals exacerbated subjective emotion and physiological arousal, while in comparison, being mindful of these same goals was associated with increased positive emotion and parasympathetic activity (RSA) across participants. These findings underscore the adaptiveness of being mindful of the present moment, especially in the face of planning and pursuing everyday goals.

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Conflict of Interest Kirsten Gilbert and June Gruber declare that they have no conflict of interest.

Informed Consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all patients for being included in the study. The Yale University institutional review board approved all study protocols and all participants involved in this study provided informed consent prior to completing any experimental tasks.

Animal Rights No animal studies were carried out by the authors for this article.

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