

Risk for Mania and Positive Emotional Responding: Too Much of a Good Thing?

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Although positive emotion research has begun to flourish, the extremes of positive emotion remain understudied. The present research used a multimethod approach to examine positive emotional disturbance by comparing participants at high and low risk for episodes of mania, which involves elevations in positive emotionality. Ninety participants were recruited into a high or low mania risk group according to responses on the Hypomanic Personality Scale. Participants' subjective, expressive, and physiological emotional responses were gathered while they watched two positive, two negative, and one neutral film clip. Results suggested that participants at high risk for mania reported elevated positive emotion and irritability and also exhibited elevated cardiac vagal tone across positive, negative, and neutral films. Discussion focuses on the implications these findings have for the diagnosis and prevention of bipolar disorder, as well as for the general study of positive emotion.

Keywords: mania risk, bipolar disorder, positive emotion, vagal tone

When you're high it's tremendous. . . feelings of ease, intensity, power, well-being, financial omnipotence, and euphoria pervade one's marrow. (Jamison, 2004, p. 67)

Recent advances in affective science have begun to highlight the nature and function of positive emotion (Fredrickson, 1998; Shiota, Keltner, & John, 2006; Tracy & Robins, 2004). Positive emotions help individuals form long-term interpersonal commitments (Gonzaga et al., 2006; Keltner & Haidt, 2003) and enable the individual to broaden and build cognitive and social resources vital to healthy adaptation (Fredrickson, 1998; Tugade & Fredrickson, 2004). However, abnormalities in positive emotion, in terms of extremes and deficits, remain less well understood.

One route to studying the extremes of positive emotion is to study those at risk for mania, which as suggested in the quote above, is a condition characterized by an abnormally and persistently elevated or irritable mood (American Psychiatric Association, 2002). By pinpointing how positive emotion is altered in people at risk for mania—a central aim of the present study—insights are gained with respect to likely maintenance factors, social effects, and potential pharmacological interventions for the prevention of mania (Gruber & Keltner, 2007; Keltner & Kring,

1998). Yet the emotional core of mania, which involves elevated positive emotion, has only recently garnered attention (e.g., Johnson, 2005; Johnson, Gruber, & Eisner, 2007).

Mania Risk and Abnormalities in Positive Emotion

How is risk for mania associated with abnormalities in positive emotion? To answer this question, one needs to assess whether risk for mania covaries with abnormalities in positive emotion across different valences of stimuli (positive, negative, neutral), modalities of emotion (subjective, physiological, expressive), and distinct kinds of positive emotion (reward, achievement, prosocial). Framed in this way, a continuum of possible abnormalities in positive emotion could be associated with risk for mania. On one end of this continuum is the possibility that risk for mania is related to excesses in positive emotion specific to a certain valence of stimuli, modality of measurement, or subset of positive emotions. On the other end of the continuum, one might observe that the risk for mania is reflected in an overall amplified positive emotionality, evident across differently valenced stimuli, measurement modality, and kinds of positive emotion.

Concerning eliciting stimuli, two contrasting theoretical perspectives on risk for mania and positive emotion have emerged. One perspective suggests that mania risk is associated with a specific kind of positive emotion abnormality—elevation in positive emotional response to positive or reward-related stimuli (although see Chang et al., 2004; Lennox, Jacob, Calder, Lupson, & Bullmore, 2004). In support of this view, two studies have demonstrated that people at high risk for mania reported more excitement and joy at the prospect of earning rewards in their daily lives when compared with healthy controls (Meyer, Johnson, & Winters, 2001). Similarly, after success feedback, people at high risk

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for mania, relative to controls, demonstrated increased self-confidence, a self-ascription related to certain positive emotions (Johnson, Ruggero, & Carver, 2005). When viewing positive static photos of peaceful landscapes and pleasant imagery, individuals at risk for mania exhibit increased startle attenuation, an indirect marker of positive affect (Sutton & Johnson, 2002). Furthermore, in response to static photos of human smiles, neuroimaging studies have revealed that bipolar patients, compared with nonpatients, showed increased activity in the amygdala and putamen (Lawrence et al., 2004) as well as the orbitofrontal cortex (Elliott et al., 2004), regions implicated in emotion and reward (Rolls, 2000). Taken together, these studies suggest that risk for mania may only be associated with elevated responses to positively valenced or reward-related stimuli.

Alternatively, limited evidence suggests that those at risk for mania show elevated positive emotional responding to a variety of emotional stimuli, and not just positive, reward-related stimuli. That is, two studies using experience sampling methodology suggest heightened positive affect (PA) regardless of context among participants at high risk for mania (Hofmann & Meyer, 2006) and those exhibiting bipolar spectrum disorders (Lovejoy & Steuerwald, 1995). Other experience sampling studies, however, failed to find such differences among at-risk bipolar offspring (Jones et al., 2006) and participants with a history of mania (Myin-Germeys et al., 2003).

All studies noted, however, converge on the general claim that risk for mania is associated with abnormalities in positive emotion. The studies to date, however, do not clarify whether the extremes of positive emotion associated with mania are specific to certain types of stimuli, modalities of emotion response, and distinct types of positive emotion, or whether they generalize across the realm of positive emotion.

A Multi-Method Approach in the Study of Positive Emotion and Risk for Mania

How might one begin to more precisely characterize the relationship between positive emotionality and risk for mania? First, it is important to assess responses to a variety of emotionally evocative stimuli, both positive and negative. Prior studies have tended to focus on either single positive elicitors, such as reward feedback (Johnson, Ruggero, & Carver, 2005), or collapsed measures of emotional response across several positive elicitors, as in the experience sampling studies or studies that assess emotional responses across collections of positive photos (e.g., Elliott et al., 2004; Lawrence et al., 2004; Sutton & Johnson, 2002).

Second, all previous studies have tended to assess only one or two channels of emotional response, with most studies focused on self-reported emotion and neuroimaging measures. Emotions, however, are multimodal phenomena, involving experiential, behavioral, and physiological responses (e.g., Lang, 1979). This raises the question of whether risk for mania generalizes beyond subjective emotion to the expressive and physiological components of emotion.

Third, in all of the studies described above, self-reported positive affect was measured indirectly through a single global positive affect measure, most typically with the positive affect (PA) subscale of the PANAS (Watson, Clark, & Carey, 1988). Affective scientists have begun to differentiate between positive emotions

associated with the pursuit of rewards, such as joy (Fredrickson, 1998); achievement, such as pride (Tracy & Robins, 2004); and those that promote prosocial attachment and connection, such as compassion (Shiota, Keltner, & John, 2006). No study to date has examined whether the positive emotional profile associated with risk for mania is specific to reward and achievement-focused positive emotions compared with prosocial positive emotions or whether mania risk generalizes to elevations across all specific positive emotions.

Finally, it is important to ascertain whether irritability, which is considered an important feature of mania (American Psychiatric Association, 2000), is part of the emotional profile of those prone to mania. Although negatively valenced, irritability is noteworthy for its close relationship to the emotion of anger, which is associated with similar left hemispheric activation as positive emotion states (Harmon-Jones & Allen, 1998), and approach behavior in the pursuit of goals (e.g., Carver, 2004; Panksepp, 1998). These conceptual similarities between irritability/anger and positive emotion suggest that irritability may be part of the emotion profile of mania. Likewise, mania involves an unusually strong drive to pursue goals and rewards; obstructing reward or goal pursuit may trigger irritability in those at risk for future manic episodes (Johnson, 2005). Consistent with this reasoning, Harmon-Jones and colleagues (2002) recently documented that increased left cortical responsivity to an anger-eliciting task regarding a proposed tuition increase was found in undergraduates at risk for mania. For these reasons, we also explored irritability in the present study guided by the expectation that irritability may also be elevated, along with positive emotion, in those at risk for mania.

The Present Investigation

In the present study, we used a multimethod approach to examine the nature of positive emotional disturbances among young adults with high and low risk for mania as assessed with the Hypomanic Personality Scale, a well-validated scale (Eckblad & Chapman, 1986) that has been shown to robustly predict the onset of mania episodes even over a 13 year period (Kwapil et al., 2000). We measured these individuals' self-reports of positive and negative emotional experience, positive and negative facial behavior, and three types of autonomic responses (vagal tone, heart rate, skin conductance) in response to two positive (happy, pride), two negative (sad, disgust), and one neutral (nonemotional) film clip. We compared the emotional profiles of people at risk for mania to an appropriately matched low-risk comparison sample. This methodological approach enabled us to ascertain whether risk for mania was associated with positive emotional responding across different types of emotional stimuli, channels of emotional responding, and classes of positive emotions, or instead is a more specific positive emotional disorder restricted to certain kinds of stimuli, measures of emotion, or kinds of positive emotion.

Method

Participants

Participants were 90 young adults drawn from the university community who participated for partial fulfillment of a course requirement. Participants were selected from an original sample of

over 1,400 who completed a prescreening survey for the Hypomanic Personality Scale (HPS; Eckblad & Chapman, 1986), a measure of risk for mania. Based on previously validated high and low mania risk cutoffs (Eckblad & Chapman, 1986; Kwapil et al., 2000), we selectively recruited two groups: a high-risk group (HPS ≥ 33 ; standard score of 1.82 or higher) and a low-risk group (HPS ≤ 21 ; standard score of 0.5 or lower). Using the aforementioned cutoffs, 36 participants were recruited into the high-risk group and 54 participants constituted the low-risk group. Notably, of the original sample of 1,400, only 3.2% ($n = 48$) actually met criteria for our high-risk group, and thus special efforts were made to recruit high-risk participants. As evident in Table 1, high and low-risk participants did not differ with respect to age, $F(1, 88) = .52, p = .47$; years of education, $F(1, 88) = .17, p = .68$; ethnicity $\chi^2(6, N = 90) = 5.38, p = .37$; or gender $\chi^2(1, N = 90) = 1.88, p = .17$.

Participant Selection Measure

Risk for mania. The HPS (Eckblad & Chapman, 1986) is a self-report questionnaire with high internal consistency ($\alpha = .86$ in the present study) and predictive validity for the onset of manic episodes. The HPS consists of 48 true-false items capturing episodic shifts in emotion (“I often feel excited and happy for no apparent reason” and “I often have moods where I feel so energetic and optimistic that I feel I could outperform almost anyone at anything”), behavior (“I often get into excited moods where it’s almost impossible for me to stop talking” and “there are often times when I am so restless that it is impossible for me to sit still”) and energy (“I very frequently get into moods where I wish I could be everywhere and do everything at once” and “I often get so happy and energetic that I am almost giddy”).

Several studies suggest that high scorers on the HPS generalize to clinical samples of those diagnosed with bipolar disorder. First, previous research indicates that high scores on the HPS correlate with clinical diagnoses of bipolar disorder (e.g., Eckblad & Chapman, 1986) and current mania symptoms (Klein, Lewinsohn, &

Seeley, 1996). In these studies, 78% of undergraduates who scored above the high-risk cutoff reported experiencing hypomanic episodes, and 25% actually qualified for a *DSM-IV* diagnosis of bipolar disorder (Eckblad & Chapman, 1986). Second, in one study, participants who scored above the high-risk threshold were found to have an increased risk for the development of manic episodes (25% compared with 10%) at a 13-year follow up assessment (Kwapil et al., 2000). Third, in the present study, only 3.2% of the entire surveyed pool of over 1,400 students actually met criteria for inclusion in the high-risk group, a prevalence rate similar to that found in Eckblad and Chapman’s survey (2.6%) of over 1,500 university-drawn participants and to epidemiological rates concerning the annual (1.4%) and lifetime (2.1%) prevalence of bipolar disorder in the general population (Merikangas et al., 2007).

Clinical Characteristics

Current symptoms of mania. Current symptoms of mania were assessed using the Altman Self-Rating Mania Index (ASRM; Altman, Hedeker, Peterson, & Davis, 1997), a five-item self-report inventory with scores ranging from 5 to 25. Scale items include rating the severity of the following five items in the past week, including heightened cheerfulness (“I feel happier or more cheerful than usual all of the time”), inflated self-confidence (“I feel more self-confident than usual all of the time”), reduced need for sleep (“I can go all day or night without any sleep and still not feel tired”), talkativeness (“I talk constantly and cannot be interrupted”), and excessive activity level (“I am constantly active or on the go all the time”). These items load onto a single component in factor analyses that is highly correlated with both clinical interview and self-report measures of mania (Altman, Hedeker, Peterson, & Davis, 2001). Scores ≥ 14 indicate clinically significant levels of current manic symptoms.

Current symptoms of depression. The Beck Depression Inventory (BDI; Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), a 21-item self-report measure, was used to measure current depression symptoms. BDI scores below 9 indicate no depressive symptoms and scores above 20 reflect moderate to severe depression (Kendall, Hollon, Beck, Hammen, & Ingram, 1987).

Medication status. Participants were asked to report (yes or no) whether or not they were currently taking any psychotropic medication and to provide the name of the medication if so. Two high-risk participants reported taking medication (both antidepressants) and none of our low-risk participants reported taking any medication.

Procedure

All participants completed written informed consent procedures before taking part in the study. Experimental sessions took place in a well-lit, sound- and temperature-controlled laboratory room. Film stimuli were presented approximately 2 feet away from participants on a high-resolution 17” computer monitor. A remotely controlled video camera was situated unobtrusively in front of the participant to record facial behavior. Upon arrival, the experimenter attached the physiological recording devices to the participants. Participants then rested for a 10-min acclimation period before watching the neutral film. After the neutral film,

Table 1
Demographic and Clinical Characteristics for High and Low Mania Risk Groups

	Group	
	High risk ($n = 36$)	Low risk ($n = 54$)
% female	79%	61%
Age	20.28 (2.60)	19.96 (1.52)
Years of education	14.61 (1.08)	14.72 (1.28)
Ethnicity (n)		
Asian	14	24
Caucasian	12	20
Latino/a	6	3
African-American	1	0
Other	3	7
HPS score*	37.64 (2.66)	13.29 (5.22)
BDI score	9.31 (6.36)	9.52 (10.17)
ASRM score*	7.61 (3.65)	4.69 (3.23)
Psychotropic medication (n)*	2	0

Note. HPS = Hypomanic Personality Scale; BDI = Beck Depression Inventory; ASRM = Altman Self-Rating Mania Index. * $p < .05$.

participants filled out a self-report emotion-rating questionnaire for the neutral film. Next, the two positive (happy, pride) and two negative (sad, disgust) films were presented. The four emotional films were presented in counterbalanced order without regard to valence. Before each film clip, participants read a message on the computer screen informing them to watch the film clip carefully. After each film clip, there was a 2-min pause while participants completed the emotion questionnaire. Then, over an intercom to the experimenter in another room, participants described out loud any “thoughts or feelings that were running through [their] mind while watching the film clip.” At the end of the experiment, physiological sensors were disconnected, and participants were thoroughly debriefed.

Emotion-Eliciting Stimuli

Film clips known to reliably elicit emotion were selected based on recommended criteria (e.g., Rottenberg, Ray, & Gross, in press) as well as validation evidence from our own laboratory. For the present study we included two positive clips (happy, pride), two negative (sad, disgust), and one neutral (nonemotional) film clip. The happy film clip lasted 150 seconds and depicted figure skater Sarah Hughes winning the Olympic gold medal and her excitement as she learned the results. The pride film clip lasted 140 seconds and was extracted from a University of California, Berkeley recruitment video sent to incoming undergraduate students depicting various scenes of the campus, university symbols, and well-known professors praising the university and its students. The sad film clip was 170 seconds and depicted a young boy watching his father die and responding with denial and intense crying. The disgust film clip lasted 60 seconds and depicted a man digging through a clogged, feces covered toilet while gagging. Lastly, the neutral film clip lasted 90 seconds and depicted a nondescript household scene with a man and woman.

Measurement of Three Channels of Emotional Response

Emotional experience. After each film clip, participants filled out a questionnaire in which they were asked to rate “the extent to which you experienced the following emotion while you were watching the film” for four positive and five negative emotions on a scale ranging from 0 (*not at all*) to 5 (*very much*). For positive emotions, this included four emotions associated with reward pursuit (happiness, joy), achievement (pride), and social connection (compassion). Participants also reported on their experiences of four well-studied negative emotions (fear, sadness, irritability, and disgust) and two self-conscious negative emotions (embarrassment, shame). Global positive and negative emotion composites were computed by averaging scores for the four positive emotions and the six negative emotion terms for each film clip. Irritability was also analyzed separately from the negative composite for theoretical reasons noted above. Cronbach alpha for our positive emotion composite was $\alpha = .93$ across all films and $\alpha = .85$ for our negative emotion composite across all films.

Facial expression. Facial expressions were recorded unobtrusively by two remotely controlled video cameras. Videotaped recordings of participants’ behavior were coded for three positive and five negative emotional displays using the Emotion Facial Action Coding System (EMFACS; Ekman & Rosenberg, 1997), a

modified version of the Facial Action Coding System (FACS; Ekman, Friesen, & Hager, 2002). EMFACS is an anatomically based system for coding specific units of visible facial muscle movements corresponding to prototypical emotion expressions. *Positive emotion displays* coded included *happiness* (the presence of AU6 [cheek raiser], AU12 [lip corner puller]), *amusement* (AU6, AU12 + laugh vocalization), and, following the recent work of Tracy and Robins (2004), *pride* (AU6, AU12, AU53 [head raise]). *Negative emotion displays* coded included *sadness* (AU6, AU15 [lip corner depressor]), *fear* (AU1 [inner brow raiser], AU2 [outer brow raiser], AU4 [eyebrow furrow]), *anger/irritability* (AU4 [eyebrow furrow], AU5 [upper lid raiser], AU 23 [lip tightener] or AU24 [lip press]), and *disgust* (AU9 [nose wrinkler], AU10 [upper lip raiser], AU26 [jaw drop], AU29 [jaw thrust]). To identify the most expression-rich portions of each film clip, two FACS-certified coders and authors of this paper (JG and DK) observed each film clip and chose the two most emotionally evocative 7- to 10-second segments to code (e.g., when the young boy begins to cry at his father’s death in the sad film). These two segments for each film clip were coded across every participant.

Two graduate students who had completed 80 to 100 hours of training and received FACS certification coded all of the emotion displays. To establish reliability, both coders independently coded approximately one third ($n = 40$) of the participants. Interrater reliability for this subset of participants was high, with intraclass correlations (ICC; Shrout & Fleiss, 1979) for absolute agreement between coders ranging from 0.86 to 0.95, with an average interrater agreement of 0.92. Given the high interrater reliability, we computed average values between the two coders for this subset of participants, and divided the remaining participants evenly between both coders. For analyses, the two coded segments for each individual emotion display were averaged. A positive behavior composite included the average score across happiness, pride, and amusement facial displays whereas a negative behavior composite included the average score across sadness, fear, disgust, and anger facial displays. Facial displays of anger/irritability were also analyzed separately from the negative behavior composite. According to standardized FACS scoring, an emotional expression received a score from 1 (“trace”) to 5 (“marked”). If a participant did not express a facial display to an individual film clip, they were assigned a score of 0 (“absent”).

Autonomic physiology. Electrodermal and cardiovascular responses were assessed continuously using the VU-AMS ambulatory monitoring system, a lightweight device worn as a belt around the shoulder (de Geus, Willemsen, Klave, & van Doornen, 1995). A response button on the recording device enabled the synchronization of physiological data with the onset and offset of each film clip. All signals were sampled at a frequency of 1,000 Hz. Beginning 10 seconds into each film, the first 90 second epoch of physiological data was extracted from continuous recordings for each film.¹ Physiological data from each of these epochs were inspected offline for recording errors and uncorrectable artifacts. Four participants were excluded from analysis of the physiological data because of equipment failure. For each film, averages for the following physiological variables were computed for analysis.

¹ Given that the disgust film was under 90 seconds, the first 60 second period was extracted for physiological analysis.

Cardiac vagal tone. Recent empirical studies suggest that elevated levels of cardiac vagal tone may be a psychophysiological marker of positive emotionality (e.g., Beauchaine, 2001; DiPietro, Porges, & Uhly, 1992). More specifically, the vagus nerve serves as a parasympathetic brake to heart rate. During inspiration, cardiac vagal control is inhibited, and the heart period (distance between R-spikes) becomes smaller; during expiration, cardiac vagal control is potentiated, and the heart period increases. Cardiac vagal tone is commonly assessed by examining patterns of variability in heart rate. Increased variability across expiration- and inspiration-related heart periods reflects greater vagal control of the heart. Vagal tone was calculated as the root mean of successive squared R-R intervals (r-MSSD; e.g., Neumann, Waldstein, Sollers, Thayer, & Sorkin, 2004).

Heart rate. Heart rate, multiply influenced by both sympathetic and parasympathetic branches of the autonomic nervous system, was assessed as a general index of autonomic arousal. Electrocardiogram recordings were obtained with three pre-jelled 1 3/4" diameter disposable vinyl electrodes placed in a modified Lead I configuration upon skin abraded with alcohol preparation pads (Stern, Ray, & Quigley, 2001). VU-AMS AMSCOM software was used to calculate interbeat interval (in milliseconds) from the EKG signal that was converted to continuous heart rate.

Skin conductance level. Absolute skin conductance level (SCL) was assessed as a relatively direct and undiluted representation of sympathetic nervous system arousal (Dawson, Schell, & Filion, 2000), typically associated with negative emotion (Levenson, 1992). SCL was obtained by passing a constant-voltage between two Ag/AgCl electrodes positioned on the palmar surface of the middle phalanx of the first and third fingers of the nondominant hand. Five mm electrode collars were used to control for recording area, and 0.5% saline electrolyte paste was used as a conductant.

Results

Overview of Analyses

Given the loose coupling of emotional responses (e.g., Lang, 1979; Mauss et al., 2005) and our interest in the relation between mania risk and modality of response, we organized our analyses around each modality of response (i.e., self-reported experience, facial expressions, and autonomic physiology). We used univariate repeated-measures analysis of variance (ANOVAs) to test whether individuals prone to mania showed greater self-reports and facial expressions of emotion than comparison participants. Given the more exploratory nature of our physiology measures, including our hypotheses about vagal tone, omnibus tests of our autonomic physiological response modality used multivariate repeated-measures MANOVAs across cardiac vagal tone, heart rate, and skin conductance. In all of these analyses, the primary between-subjects variable was group status (high risk, low risk) and the within-subjects variable was film type (neutral, happy, pride, sad, disgust). When differences between groups emerged for self-reported affect, emotion behavior, or physiology, we conducted follow up analyses to examine the source of difference. Where appropriate, a Greenhouse-Geisser correction was used when assumptions for sphericity were not met, and adjusted F and p values are reported. All p values reported are two-tailed.

Preliminary Analyses

As would be expected in the present study, high-risk participants reported significantly higher scores on the HPS compared with low-risk participants, $F(1, 89) = 653.87, p < .001$. Although only one high-risk participant actually reported clinically significant levels of current manic symptoms on the ASRM, one sees in Table 1 that high-risk participants generally reported higher levels of manic symptoms compared with low-risk participants, $F(1, 89) = 15.44, p < .001$. High and low-risk participants did not differ on current levels of depression symptoms on the BDI, $F(1, 89) = .01, p = .92$.

Preliminary analyses examined whether gender, film order, or previous exposure to any of the films influenced the three channels of emotional responding (experiential, behavioral, and psychophysiological). Across the entire sample, there were no significant main effects or interactions for film order or whether participants had previously seen any of the films (all $ps > .10$). Analyses including gender as an independent variable found no differences in the subjective, expressive, or physiological responses of females and males to the five film clips.

Mania Risk-Associated Differences in Emotional Responding

Emotional experience. We conducted three separate repeated measures ANOVA for the positive (PA) composite, negative (NA) composite, and irritability. The ANOVA for PA (a composite of happy, pride, joy, and compassion) yielded a main effect for film: not surprisingly, positive films elicited higher levels of PA than negative or neutral films, $F(4, 352) = 65.35, p < .001$. There was a significant effect of group status, $F(1, 88) = 11.55, p = .001$, but no Group X Film interaction, $F(4, 85) = 1.29, ns$. In other words, the high-risk group reported elevated positive emotion in response to all film clips, and not to any specific film clip, relative to the low-risk group (see Figure 1). To clearly examine whether differences between groups were not accounted for by differences in reactivity to a specific film but were evident in increased positive emotionality across all films we created change scores as an index of emotional reactivity. Indeed, change scores created by subtracting participants' reports of PA to the happy, pride, sad or disgust film from their PA response to the neutral film, confirmed that

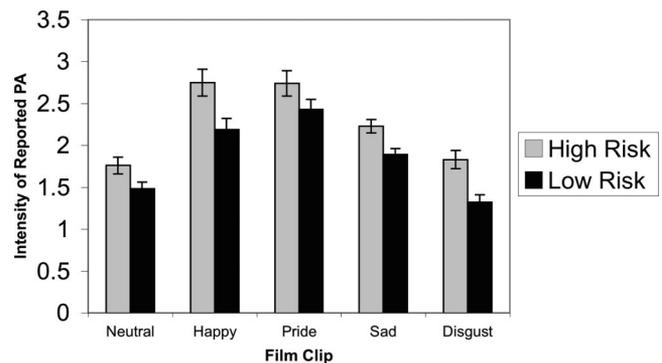


Figure 1. Reported positive emotion across all film clips.

there were no group differences in reactivity to any of the specific film clips (all p s < .10).

To examine which specific positive emotions were driving the observed group differences in overall positive emotion across films, a series of 2×5 repeated measures ANOVAs were conducted across all film clips for each positive emotion (happy, joy, pride, compassion). Compared with the comparison participants, high-risk participants reported higher levels of all four of the positive emotions across all films (all p s < .05). There were also no Film X Group interactions for any of the reported positive emotions.

Parallel analyses for the negative emotion composite (NA) also revealed a main effect for film, $F(4, 352) = 83.21, p < .001$: not surprisingly, negative clips elicited higher levels of NA than positive or neutral clips. Here we observed no group main effect, $F(1, 88) = 1.02, ns$, nor a Group X film interaction, $F(4, 352) = 1.02, ns$. High-risk participants reported similar levels of NA as low-risk participants (Figure 2).

Analyses of irritability revealed a significant main effect for group, $F(1, 80) = 7.04, p = .01$, but no Group X film interaction, $F(4, 77) = 1.22, ns$. In other words, high-risk participants also reported greater irritability across all film clips compared with low-risk participants.

The findings from the analyses of self-report measures suggest that people at high risk for mania report elevated levels of a variety of positive emotions across all films. More specifically, these group differences were observed across positive and negative films, and across three kinds of positive emotion—reward-related, achievement-related, and prosocial—suggesting that the risk for mania is associated with elevated subjective positive emotion across stimuli and kind of positive emotion. Furthermore, high-risk participants also reported increased irritability across all films. These findings are more consistent with the perspective that the risk for mania is associated with extreme levels of positive emotion, as well as approach-oriented states independent of valence, across stimuli.

Facial behavior. Given that the distribution of FACS-coded facial behavior data were positively skewed and leptokurtotic, square-root transformations were performed to normalize the distribution. We conducted two repeated-measures ANOVAs for positive and negative facial behavior composites. Separate analyses for anger/irritability displays could not be conducted given the extremely low base rate of such displays.²

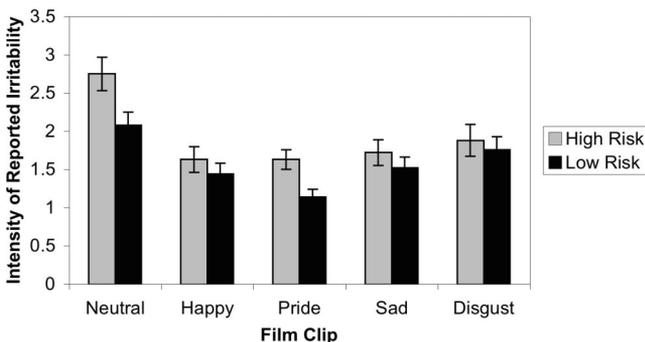


Figure 2. Reported irritability across all film clips.

The repeated measures ANOVA for positive facial behavior yielded a main effect for film: positive films elicited higher levels of positive facial behavior than the two negative films or the neutral film, $F(4, 240) = 31.62, p < .001$. Here, however, neither the main effect for group, $F(1, 60) = .02, ns$, nor Group X Film interaction, $F(4, 240) = 2.35, ns$, was significant.

The repeated-measures ANOVA for negative facial behavior yielded a similar pattern of findings. Again, the main effect for film was significant, $F(4, 240) = 49.31, p < .001$, revealing that negative films evoked more negative facial expressions compared with positive or neutral films. However, neither the group main effect, $F(1, 60) = .61, ns$, nor Group X Film interaction, $F(4, 240) = .40, ns$, was significant. In sum, participants at high risk for mania did not express different levels of positive or negative emotion in their facial behavior compared with low-risk participants.

Physiology. We first examined whether the low and high-risk groups differed in resting physiological levels, using a 90 second prefilm baseline during which participants were instructed to remain seated and fill out some questionnaires while they acclimated to the physiological apparatus. At rest, the high-risk group demonstrated significantly higher resting vagal tone than did the low-risk group, $F(1, 85) = 5.84, p < .05$. No group differences between the high and low-risk participants were found for heart rate, $F(1, 85) = 2.94, ns$, or skin conductance, $F(1, 85) = 1.33, ns$.

We next examined participants' physiological responses during the videos. A repeated measures MANOVA conducted on vagal tone, heart rate, and skin conductance level yielded main effects for film, $F(4, 672) = 3.42, p < .05$, physiology measure, $F(2, 672) = 490.63, p < .001$, and a film X physiology interaction, $F(8, 672) = 3.36, p < .01$. These effects were qualified by a significant physiology X group interaction, $F(2, 672) = 4.33, p < .05$. There was no higher order three-way interaction between film, physiology, and group status. To identify the source of the physiology X group interaction, we conducted three one-way repeated measures ANOVAs separately for the cardiac vagal tone, heart rate, and skin conductance level.

The one-way ANOVA for cardiac vagal tone yielded a main effect for group, $F(1, 84) = 4.56, p < .05$, but did not yield a main effect for film or a Group X film interaction. This analysis revealed that the high-risk group exhibited higher vagal tone levels across all film clips, including the neutral and negative films clips, mirroring the results found between the high and low-risk groups during the 90 second rest period (see Figure 3). To further examine this issue, we computed vagal reactivity scores for the happy, sad, neutral, disgust, and pride films by subtracting participants' baseline vagal tone from their vagal tone during each video. Results indicated no significant group differences in vagal reactivity during any of the films (all p s > .05). Thus, the high-risk group's higher vagal tone across film clips seems to reflect a stable individual difference that holds across distinct emotionally evocative stimuli.

² Of the entire total anger displays exhibited, three were coded a "1" intensity and two were coded a "2" intensity. These occurred during the neutral, pride and disgust film. Thus, the stimuli did not sufficiently elicit anger displays that could be analyzed.

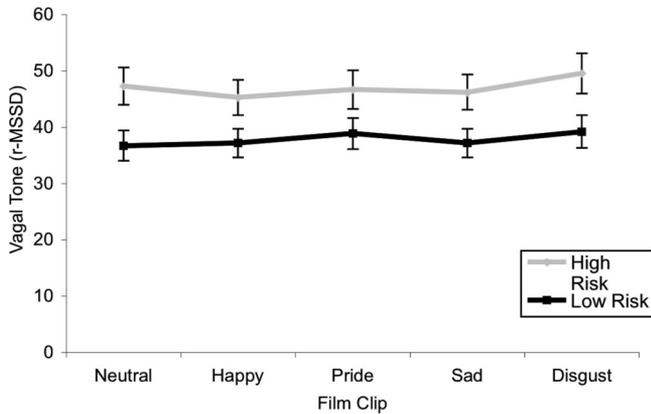


Figure 3. Cardiac vagal tone levels across all clips.

The one-way ANOVA for heart rate yielded a main effect for film, $F(4, 336) = 11.04, p < .001$, suggesting that our neutral and disgust films were associated with increased heart rate compared with our positive (happy, pride) and sad films. However, there were no significant group main effects, $F(1, 84) = 2.26, ns$, nor a significant Group X Film interaction, $F(1, 336) = .68, ns$. Similarly, the one-way ANOVA for skin conductance level yielded a main effect for film $F(4, 336) = 8.63, p < .001$. Again, there were no significant group main effects, $F(1, 84) = 1.56, ns$, nor Group X film interactions, $F(4, 336) = .77, ns$.

In summary, although high-risk participants exhibited elevated vagal tone, a parasympathetic marker of positive emotion, across all films there were no group differences in heart rate or skin conductance level. Thus, associations between mania and autonomic response were specific to vagal tone level.³

Secondary Analysis: Are Differences in Emotion Due to Current Symptomatology or Medication Status?

We next addressed whether the observed group differences in positive emotion and irritability were a trait-like marker of those at risk for mania, and not just a state-dependent byproduct of levels of current mood symptoms and medication status.⁴ To statistically determine whether the observed differences in self-reported positive emotion experience and elevated cardiac vagal tone were influenced by current clinical symptoms or medication status, we reanalyzed these significant group-related findings controlling for current symptoms of mania, depression, and whether or not participants were currently taking psychotropic medication. We did this by conducting seven ANCOVAs for each of our significant results, one for self-reported positive emotion composite (PA), four for each of the discrete positive emotions (happy, joy, pride, compassion), one for self-reported anger, and one for vagal tone.

Results of these analyses were generally consistent with those reported previously. Specifically, the ANCOVA for the self-reported positive composite continued to yield a main effect for group status $F(1, 85) = 7.08, p < .01$. When controlling for current symptoms and medication status, individuals in the high-risk group still tended to report elevations in reward-oriented (joy, happy) achievement-focused emotion (pride), with all $ps < .05$, but no longer reported greater levels of compassion. Furthermore,

Table 2
Participant Self-Reports of Discrete Positive Emotions Averaged Across All Clips

	Group		F value
	High risk (n = 36)	Low risk (n = 54)	
	M (SE)	M (SE)	
Positive, reward-focused			
Joy	2.33 (.12)	1.87 (.10)	8.29**
Happiness	1.98 (.10)	1.60 (.08)	8.21**
Positive, achievement-focused			
Pride	2.09 (.10)	1.81 (.08)	4.22*
Positive, prosocial-focused			
Compassion	2.54 (.11)	2.25 (.09)	3.75
Negative, approach-oriented			
Irritability	1.92 (.10)	1.59 (.08)	7.04*

Note. Values reported reflect the 5-point rating of the self-report scale. Results reflect values after controlling for current symptoms and medication status.

* $p < .05$. ** $p < .01$.

high-risk participants continued to exhibit elevated irritability across all films ($p < .05$) (see Table 2). When controlling for current symptoms and medication status, compared with control participants, those at risk for mania tended to show elevated cardiac vagal tone, $F(1, 81) = 3.47, p = .066$. These results suggest that participants in the high-risk group experienced elevated positive emotion, and they exhibited heightened vagal tone in a trait-like manner, independent of current symptom severity.

Discussion

Mania, a core criterion of bipolar disorder, is defined by excessive and disruptive positive emotionality as well as irritability. The study of people at risk for mania presents two conceptual opportunities. A first is to characterize the specific positive emotion dysfunctions in mania. The data from the present investigation address whether mania is associated with generalized excesses in positive emotion, or amplified positive emotion only in response to positive, reward related stimuli. The second opportunity is to further understand the nature of positive emotion more generally. Studies mapping self-report measures of individual differences onto emotional response, as in studies of shyness, neuroticism, autism, the hostile individual, or anxiety disorders, have revealed critical insights regarding *negative* emotions such as fear, anger, and self-conscious emotions (e.g., Harker & Keltner, 2001; Heerey et al., 2003; Schwartz, Snidman, & Kagan, 1999).

³ We examined cardiac vagal tone, heart rate, skin conductance level during a 90 second prefilm acclimation period and obtained a similar pattern of effects.

⁴ We controlled for medication status given that two of our high-risk participants were on psychotropic medications, and given evidence suggesting that many pharmacological treatments for bipolar patients (e.g., mood stabilizers such as lithium, SSRIs, and atypical antipsychotics) alter neural reactivity to emotionally relevant stimuli (e.g., Lawrence et al., 2004; Yurgelon-Todd et al., 2000).

The present study is the first to use a multimethod approach to examine emotional responding in people at high risk for mania in response to varied stimuli, channels of emotional responding, and across classes of positive emotion. People at risk for mania reported greater levels of different positive emotion and irritability across neutral, positive, and negative film clips, consistent with previous studies linking mania to elevated positive emotional experience. Our findings also dovetail with recent work highlighting the importance of considering approach-oriented emotions such as irritability in models of risk for mania (Harmon-Jones et al., 2002). Participants at risk for mania also showed elevated vagal response, but not differences in heart rate or skin conductance, across all five film clips. These findings are consistent with recent work suggesting that elevated vagal tone may serve as an autonomic marker of positive emotionality (e.g., DiPietro, Porges, & Uhly, 1992). Although elevated vagal tone reactivity has also been conceptualized as a marker of emotion regulation (e.g., Butler, Wilhelm, & Gross, 2006), our study did not adequately assess the effortful regulation of emotion in response to the films. Future studies are needed to disentangle these two affective functions potentially subserved by vagal tone.

The positive emotion and irritability associated with risk for mania, therefore, is not purely a subjective, self-report phenomenon, nor can the positive emotion profile of mania be attributed to the semantic overlap in the HPS (Eckblad & Chapman, 1986) items capturing risk for mania (e.g., "I feel happy for no reason") and positive emotion experience to the film clips. Taken together, these results suggest fairly clearly that risk for mania is associated with an excess in positive emotionality across stimuli, rather than an amplified positive emotionality that is tied to a specific type of stimulus or kind of emotion (Johnson, Gruber, & Eisner, 2007).

Implications for the Study of Mania and Bipolar Disorder

The results from the present study diverge from the perspective that risk for mania is associated with elevated positive emotion only in response to positively valenced or reward stimuli (e.g., Johnson, 2005; Sutton & Johnson, 2002). Rather, our results suggest that mania is associated with elevated positive emotion regardless of stimulus condition. What might account for these contrasting results? Future research is warranted to tease apart whether differences in emotional responding exist between at risk and clinically diagnosed bipolar samples, and examining differences between tonic and phasic emotional responses.

Methodological differences, in particular the induction and measurement of emotion, may also, in part, explain why the pattern of results observed in the present study diverges from previous research. Studies that have generated support for the perspective that mania is associated with elevated responding to positive stimuli and reward have not directly measured emotion, but rather, asked whether participants chose a more difficult task (Johnson et al., 2005), exhibited heightened self-confidence (Johnson et al., 2005; Stern & Berrenberg, 1979), or exhibited elevated neural reactivity (e.g., Lawrence et al., 2004; Yurgelou-Todd et al., 2000) to positive stimuli. The emotionally evocative stimuli in the present study also differed from those used in previous research.

At the same time, we should note that our more specific analyses of positive emotions, after controlling for current symptoms, begin to lend some preliminary support to the notion that amplified

activity in what are thought of as reward systems may play a role in the types of positive emotions experienced by those at risk for mania (e.g., Meyer et al., 2001). Specifically, after controlling for current symptoms, our high-mania risk group tended to report relative elevations in reward and achievement-focused positive emotions of joy and happiness as well as irritability, which has been conceptualized as the outcome of thwarted goal pursuit (Carver, 2004), but not elevations in emotion states thought to foster social connection, such as compassion. To the extent that people prone to mania show an unusual imbalance in the ratio of self-serving versus prosocial emotions, they are likely to have greater difficulties establishing and maintaining long-term, cooperative relationships (Kessler, Walters, & Forthofer, 1998).

Though not a central focus of the current study, it is notable that the high- and low-risk samples did not differ in negative emotional responses that were unrelated to approach, which included sadness, fear, embarrassment, and shame. They also showed similar levels of negative emotion in the face. Furthermore, people at risk for mania did not differ from the comparison sample in their sympathetic autonomic reactivity (skin conductance) or overall level of autonomic arousal (e.g., heart rate) that often covaries with negative emotion (e.g., Levenson, Ekman, & Friesen, 1990). This pattern of results concerning negative emotion extends recent work suggesting that when people with bipolar disorder are tested during fully asymptomatic periods, negative emotional reactivity is not present (e.g., Johnson et al., 2007). Rather, studies that have documented increased reactivity to negative stimuli have tended to assess people with bipolar disorder when depressive symptoms were present.

Although people at risk for mania reported greater positive emotion experience compared with controls, they did not show increased positive facial expressions. This is surprising given that prominent and well-validated mania symptom severity scales refer to unusual emotional expressivity, such as excessive "joking," "laughter," and "exuberant speech" (Bech, 2002) as well as more "animated" gestures and behavior (Young et al., 1978). Whereas our reliance on asocial means of inducing emotion (watching film clips) may have limited emotional expressivity, it may also be the case that those at risk for mania exhibit an incoherence, or lower degree of entrainment, among experiential and behavioral emotion response components. A lack of coherence among emotion response components is not a new theme in emotional disorders (Gruber & Keltner, 2007). In fact, prior research has documented a similar lack of coherence in schizophrenia (e.g., Kring & Neale, 1996) and potentially major depression (Rottenberg et al., 2002) such that outward facial behavior did not match the intensity of self-reported emotional experience. Clearly, further research utilizing more socially engaging stimuli and sophisticated methodology to assess coherence among emotional responses (e.g., Mauss et al., 2005) is needed to examine the tantalizing possibility that disjunction between the experiential and expressive components of emotion characterizes people at risk for mania.

Implications for the Study of Positive Emotion

The present study contributes to an emergent field of positive emotion by adding insights from a sample at risk for extreme episodes of positive emotion. First, the present study provides supportive evidence for a potential physiological marker of posi-

tive emotion, elevated vagal tone (e.g., Eisenberg et al., 1996). Elevated parasympathetic activity has traditionally been implicated in cardiovascular recovery from negative emotions (e.g., Fredrickson & Levenson, 1998). However, more recently researchers have begun to investigate the role of parasympathetic activation in the physiological profiles of positive emotions. This work is supported by anatomical studies of the autonomic nervous system (Janig, 2003) and recent findings linking increased vagal tone to prosocial attachment (e.g., Porges, 1995, 1998, 2007), resiliency to stress (Fabes & Eisenberg, 1997), and to trait and state experiences of positive emotion (e.g., DiPietro, Porges, & Uhly, 1992). Low levels of resting vagal tone, in contrast, are associated with major depression, a disorder characterized by deficits in positive emotion (Dalack & Roose, 1990).

The findings of the current study dovetail with these recent findings: heightened vagal tone across all films was characteristic of individuals at risk for mania, who were identified by the self-reported tendency to experience extreme levels of positive emotion, confidence, and approach-related activity. The current findings cannot be described as simply a recovery from a previous high-arousal or negative state, given the lack of observed differences in heart rate and skin conductance level, respectively, between the high and low-risk groups. In fact, a recent study by Cohen and colleagues (2003) found that patients with bipolar disorder exhibited higher levels of resting vagal tone. Taken together, these findings implicate elevated vagal tone in positive emotional experience.

Second, the present study begins to question whether too much positive emotion can be maladaptive for the individual. In other words, how is the positive emotion of disorders like mania functionally distinct from adaptive levels of heightened experiences of positive emotion (e.g., Diener & Seligman, 2002)? Just as high levels of negative emotions can lead to undesirable outcomes in externalizing disorders in children (e.g., Keltner, Moffitt, & Stouthamer-Loeber, 1995) and across anxiety disorders (e.g., Kring & Bachorowski, 1999), how might heightened levels of positive emotion lead to undesirable outcomes? Previous research has suggested that high levels of positive affect are indicative of risk for mania (Bagby, 1996; Lovejoy & Steuerwald, 1995) and predict increases in mania symptoms over time (Strakowski, Stoll, Tohen, Faedda, & Goodwin, 1993). Given the link between enhanced positive emotionality and risk for symptom relapse, it will be important for future studies to document whether elevated positive emotion levels are associated with increased social, occupational and functional impairment in both clinical and nonclinical populations and how this diverges from adaptive levels of positive emotion.

Future Directions

As further research maps how the risk for mania covaries with positive emotion, it will open up the possibility for examining which strategies those at risk for mania or diagnosed with bipolar disorder use to decrease positive emotions. Lam and colleagues (e.g., Lam, Wong, & Sham, 2001) found that many patients report reducing positive social interaction and goal-oriented activity, seeking quiet environments, and obtaining sleep to down-regulate overly positive moods. In treatment development work, patients with a history of mania have been asked to consider which calming

strategies they tend to use, and to gather data on how well these strategies tend to work for them using self-monitoring forms. If patients find that their own strategies are not fully effective, clinicians and patients work together to refine and test these strategies during session, and then monitor their effectiveness outside of the sessions (Johnson et al., 2005). Although the down-regulation of positive emotion is not typically discussed in emotion regulation models (e.g., Gross, 1998), this study suggests it may be an important focus in mania. For example, research by Feldman, Joormann, and Johnson (in press) found that undergraduates who responded to positive moods by thinking about how well they would do in the future were more likely to report mild symptoms of mania. Thus, cognitive tendencies to dwell on and amplify positive stimuli may actually intensify risk for further episodes. We hope that future research on positive emotion and clinical disorders continues to bear insights about positive emotion and its extremes; indeed, when it may be too much of a good thing.

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