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Impulsivity Predicts the Onset of DSM-IV-TR or RDC Hypomanic and Manic Episodes in Adolescents and Young Adults with High or Moderate Reward Sensitivity

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Abstract

Background—A growing body of research suggests that bipolar disorders (BD) are associated with high impulsivity. Using a multi-method approach, the current study provided the first examination of the hypothesis that impulsivity would prospectively predict shorter time to onset of *DSM-IV-TR* or RDC hypomanic or manic episodes in a sample selected based on reward sensitivity, a biobehavioral trait shown to predict onset and course of BD.

Methods—163 participants with high reward sensitivity and 114 participants with moderate reward sensitivity were followed every six months for an average of 2.68 years. Participants completed the Barratt Impulsiveness Scale–Version 11 (BIS-11), Balloon Analog Risk Task (BART), Beck Depression Inventory, Altman Self-Rating Mania Scale, and an expanded Schedule for Affective Disorders and Schizophrenia (exp-SADS)–Lifetime Version at baseline and were followed prospectively with the exp-SADS–Change Version to assess onset of hypomanic or manic episodes and treatment seeking for mood problems.

Results—Cox proportional hazard regression analyses indicated that impulsivity as measured by a behavioral task (BART; OR = 1.04, $p = .03$) and a self-report measure (BIS-11 Attentional Impulsiveness subscale; OR = 1.16, $p = .01$) predicted shorter time to hypomania/mania onset, after controlling for baseline depressive and manic symptoms, family history of mood disorder, treatment seeking for mood problems, and reward sensitivity.

Limitations—The study was limited by non-comprehensive assessment of impulsivity and unknown generalizability to clinical samples.

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Conclusions—Impulsivity confers vulnerability to hypomania or mania. Future studies would benefit from considering how impulsivity can be integrated into existing biopsychosocial models of BD.

Keywords

impulsivity; hypomania; vulnerability; bipolar disorder

1. Introduction

Impulsivity, broadly defined as the tendency to act with little regard for consequences, is a complex, multidimensional construct relevant to numerous psychiatric conditions, such as bipolar disorders (BD) and impulse control disorders (Sharma et al., 2014). The field has little consensus on what constitutes impulsivity, as reflected by the fact that many researchers have developed their own theories and measures of impulsivity. On the one hand, personality researchers tend to conceptualize impulsivity as traits and measure them using self-report questionnaires, such as the Barratt Impulsiveness Scale Version 11 (BIS-11; Patton et al., 1995; Stanford et al., 2009). On the other hand, neurocognitive researchers tend to conceptualize impulsivity as states and measure them using behavioral tasks, such as the Balloon Analog Risk Task (BART; Lejuez et al., 2002) and Go/No-Go tasks (Wright et al., 2014). Self-report and behavioral measures of impulsivity appear to assess different facets of impulsivity. Therefore, it is unsurprising that they show weak correlations with each other (Sharma et al., 2014). However, they both independently predict daily-life impulsive behaviors, such as substance use, aggression, and gambling (Sharma et al., 2014).

Over the past decade, several lines of research have converged to suggest that impulsivity may play an important role in BD. Studies have reported that relative to healthy controls, self-reported impulsivity is elevated in all phases of BD (Newman and Meyer, 2014; Peluso et al., 2007; Saddichha and Schuetz, 2014; Strakowski et al., 2010), in unaffected relatives of bipolar probands (Henna et al., 2013; Lombardo et al., 2012; Wessa et al., 2015), and in people at risk for mania according to scores on the Hypomanic Personality Scale (Eckblad and Chapman, 1986; Giovanelli et al., 2013; Johnson et al., 2013). There is also evidence of increased impulsivity based on performance on behavioral task measures of impulsivity in individuals with BD (Edge et al., 2013; Lipszyc and Schachar, 2010; Wright et al., 2014). For example, a meta-analysis of Go/No-Go task performance suggested that individuals with BD showed the largest deficits in response inhibition, the ability to withhold a pre-potent response and a facet of behavioral impulsivity, among all psychopathologies (Wright et al., 2014).

In addition, studies have demonstrated that impulsivity is related to the course and outcome of BD. Specifically, self-reported impulsivity has been shown to mediate the association between BD and substance use problems (Alloy et al., 2009b), predict a longer time to recovery among inpatients with bipolar I disorder (Dawson et al., 2014) and an increased likelihood of conversion from milder forms of BD to bipolar I disorder (Alloy et al., 2012b). In BD, self-reported impulsivity is also associated with earlier age of illness onset (Swann et al., 2009), increased mood episode frequency (Kwapil et al., 2000; Swann et al., 2009),

mania severity (Najt et al., 2007; Swann et al., 2008, 2001), suicide attempts (Swann et al., 2009; Watkins and Meyer, 2013), poor quality of life (Victor et al., 2011), and functional impairment (Jiménez et al., 2012; Lombardo et al., 2012; Muhtadie et al., 2014). Impulsivity as measured by behavioral tasks also has been shown to be associated with mania severity (Strakowski et al., 2009) and suicidal behavior severity (Swann et al., 2005). It is plausible that impulsivity may partly account for the high rate of comorbidity between BD and other psychiatric disorders characterized by impulsivity, such as substance use disorders, intermittent explosive disorder, and attention-deficit/hyperactivity disorder (ADHD). It has been suggested that impulsivity may be a candidate endophenotype for BD (Lombardo et al., 2012; Wessa et al., 2015). Taken together, the mounting evidence highlights the relevance of impulsivity in BD.

Reward sensitivity, a construct that overlaps with but also differs from impulsivity according to factor analysis (Dawe et al., 2004), has provided one of the few models for the etiology of BD. According to the Behavioral Approach System (BAS) or reward hypersensitivity model of BD (Alloy et al., 2015, 2012a; Alloy and Abramson, 2010; Johnson et al., 2012b), an overly sensitive BAS, as reflected by hyperreactivity to goal- and reward-relevant cues, confers vulnerability to hypomania/mania and depression. The theory has received considerable support in the literature (Alloy et al., 2015). BAS sensitivity has been found to be elevated in people with BD according to self-report (Alloy et al., 2009a, 2008, 2006; Alloy and Abramson, 2010; Lam et al., 2004) and behavioral and psychophysiological measures (Harmon-Jones et al., 2008; Hayden et al., 2008; Sutton and Johnson, 2002). Longitudinal studies have shown that BAS hypersensitivity predicts intensification of mania over time (Johnson et al., 2012a; Meyer et al., 2001), conversion from milder forms of BD to bipolar I or II disorder (Alloy et al., 2012b), and first onset of BD (Alloy et al., 2012a).

To our knowledge, although some longitudinal studies have been conducted to examine the association between impulsivity and life events (Molz et al., 2013), substance use problems (Alloy et al., 2009b), conversion to bipolar I disorder (Alloy et al., 2012b), and time to euthymia in BD (Dawson et al., 2014), no studies have prospectively examined whether impulsivity predicts time to onset of hypomanic or manic episodes. The current study examined whether impulsivity, assessed with self-report or behavioral task measures, prospectively predicts time to onset of *DSM-IV-TR* or RDC hypomanic or manic episodes above and beyond the effects of characteristics that could influence time to onset of hypomania or mania, including baseline depressive and manic symptoms, family history of mood disorder, treatment seeking for mood problems over follow-up, and BAS sensitivity. Based on previous research demonstrating that high impulsivity appears to be concurrently associated with more severe manic symptoms (Najt et al., 2007; Swann et al., 2008, 2001), we hypothesized that higher baseline impulsivity would predict a shorter time to onset of hypomanic or manic episodes, after controlling for these other characteristics.

2. Methods

2.1 Participants and procedures

Participants in this study were drawn from the Teen Emotion and Motivation (TEAM) Project (Alloy et al., 2012a), which employed a prospective, behavioral high-risk design to

examine the BAS/reward theory of BD. They were selected via a two-phase screening procedure from the greater Philadelphia area (for more details, see Alloy et al., 2012a). In Phase I, 9,991 students (14–19 year olds) from Philadelphia School District public high schools and Philadelphia universities completed the Behavioral Inhibition System/BAS Scales (BIS/BAS; Carver and White, 1994) and the Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ; Torrubia et al., 2001). Students who scored in the top 15th percentile on *both* the BAS-Total (BAS-T) of the BIS/BAS and the Sensitivity to Reward Scale (SR) of the SPSRQ composed the high BAS group, and those who scored between the 40th and 60th percentiles on both of these measures composed the moderate BAS group. The final sample was representative of adolescents ages 14–19 in the Philadelphia area on characteristics including race, sex, and age. Among the 9,991 students screened in Phase I, 7.77% ($n = 776$) met criteria for the high BAS group and 4.04% ($n = 404$) met criteria for the moderate BAS group. Participants with low BAS sensitivity were excluded because low BAS sensitivity is associated with vulnerability to unipolar depression (Depue et al., 1987; Depue and Iacono, 1989) and a major aim of the TEAM Project was to examine vulnerability to first onset of BD based on the BAS/reward model of BD.

A random subset of high BAS and moderate BAS participants ($n = 390$) were invited to participate in the Phase II screening and were administered the mood and psychosis sections of an expanded Schedule for Affective Disorders and Schizophrenia Lifetime diagnostic interview (exp-SADS-L; Endicott and Spitzer, 1978) by interviewers blind to participants' BAS risk group status. The exp-SADS-L interview was expanded to allow for generation of both *DSM-IV-TR* (American Psychiatric Association, 2000) and Research Diagnostic Criteria (RDC; Endicott and Spitzer, 1978) diagnoses. In Phase II, parents provided written consent and adolescents provided written assent for those under the age of 18 and participants 18 or older completed their own written consent. Participants were excluded from the final sample if they met *DSM-IV-TR* and/or RDC criteria for a lifetime history of any psychotic disorder or were not fluent in English. Although Alloy et al. (2012a) indicated that participants were also excluded from the final sample if they met criteria for a BD (including a single hypomanic episode) prior to the date of the Phase I screening because the goal of Project TEAM was to predict first onset of BD, the goal of the current study was to predict new onsets of hypomanic or manic episodes, regardless of whether they were first onsets or recurrences. Thus, participants with a prior BD diagnosis were not excluded for the current study. Of the students who completed Phase II, seven were excluded due to history of psychotic disorder, and five were excluded due to poor English ability.

It is important to note that although Alloy et al. (2012a) also used the Project TEAM sample, there is no overlap between Alloy et al. (2012a) and the current study. Whereas Alloy et al. (2012a) only used the total score of BIS-11 to predict first onset of diagnosed BD, the current study uses the BART and the total score and three subscales of BIS-11 at baseline to predict new onsets of hypomanic or manic episodes, regardless of whether they were first onsets or recurrences.

After completing the screening procedures, participants completed the remainder of the exp-SADS-L, as well as several measures described below, at a baseline session. Participants then were followed prospectively for an average of 2.68 years ($SD = 1.07$ years). At follow-

ups, participants completed the exp-SADS Change Version (exp-SADS-C; Endicott and Spitzer, 1978) to assess the onset of episodes of hypomania/mania and treatment-seeking status. The sample for the present study consisted of 163 high BAS and 114 moderate BAS participants who completed the baseline assessment and at least one regular prospective assessment.

The demographic and clinical characteristics of participants and means and *SDs* of the measures used in the current study are presented in Table 1. The high and moderate BAS groups did not significantly differ on age, gender, race/ethnicity, family history of mood disorder, BIS-11 Nonplanning Impulsiveness, and BART score. Relative to participants with moderate BAS sensitivity, participants with high BAS sensitivity were more likely to seek treatment for mood problems and had significantly higher scores on the BAS-T, SR, BDI, ASRM, and the Attentional Impulsiveness and Motor Impulsiveness subscales and total scale of the BIS-11. Table 2 provides a summary of measures.

2.2 Measures

2.2.1. BIS/BAS Scales—The BIS/BAS Scales (Carver and White, 1994) are a widely used self-report questionnaire that assesses individual differences in sensitivity to threats and rewards. Participants responded to questions on a 4-point Likert scale ranging from *strongly disagree* to *strongly agree*. The BAS-Total (BAS-T) score is the sum of all the BAS items. Internal consistencies (α 's = .66-.76) and test-retest reliabilities (r 's = .59-.69) for the subscales are satisfactory (Carver and White, 1994). In the current study, the BAS-T demonstrated good internal consistency; α = .80.

2.2.2. SPSRQ—As described above, the SPSRQ (Torrubia et al., 2001) was used to select the high BAS and moderate BAS groups, along with the BIS/BAS Scale. The SPSRQ is composed of two subscales, sensitivity to reward (SR) and sensitivity to punishment (SP) with 24 “yes” or “no” questions in each. Both subscales have good internal consistency and retest reliability (Torrubia et al., 2001). Research also supports the construct validity of both the BIS/BAS and SPSRQ measures (Harmon-Jones and Allen, 1997; Heponiemi et al., 2004). In the current study, the SR and SP scales demonstrated good internal consistency with α 's = .76 and .84, respectively, and the SR subscale was correlated with the BAS-T (r = .40, p < .01) in our Phase I sample.

2.2.3. BIS-11—At baseline, participants completed the BIS-11 (Patton et al., 1995). The BIS-11 is a widely used self-report questionnaire for assessing impulsivity that yields three subscales: Attentional Impulsiveness, Motor Impulsiveness, and Nonplanning Impulsiveness. The Attentional Impulsiveness subscale captures difficulty with concentration and an intolerance of cognitive complexity (e.g., “I don’t pay attention”). The Motor Impulsiveness subscale assesses a tendency to take action impetuously (e.g., “I do things without thinking”). The Nonplanning Impulsiveness subscale measures a lack of future planning (e.g., “I am more interested in the present than the future”). The three subscales are moderately correlated, with r 's of .46-.53 (Stanford et al., 2009); internal consistency in an undergraduate sample was good (α = .82). The BIS-11 predicts risk-taking behaviors in high school and college students (Stanford et al., 1996) and has been

successfully used with people with BD (e.g., Swann et al., 2001). Internal consistency in the present study was good ($\alpha = .79$).

2.2.4. BART—The BART (Lejuez et al., 2002) is a computerized behavioral task that assesses impulsivity in a reward context. At the start of the BART, the computer screen displays a small balloon accompanied by a balloon pump, a reset button, a Total Earned display, and a second display labeled Last Balloon that denotes the points earned on the last balloon. Participants are informed that they must click on the pump to inflate the balloon; with each pump, the balloon was inflated by 1° and points were accumulated in a temporary bank. When balloons were pumped past their individual explosion points, the computer produced a bursting sound, and all points in the temporary bank for that balloon were lost. At any point during each trial, a participant could stop pumping the balloon and click the “Collect \$\$\$” button. This transferred all money from that trial to the permanent bank, while a slot machine payoff sound played. Each successive pump on any trial increased the amount to be lost due to an explosion and decreased the relative gain of any additional pump (Lejuez et al., 2002). A total of 30 balloons (trials) were completed. We analyzed the adjusted number of pumps across balloons (labeled as BART score). This adjusted value, defined as the average number of pumps on balloons that did not explode, is preferable to the unadjusted average because the number of pumps is constrained on trials with balloons that exploded, limiting between- participant variability in the unadjusted averages (Lejuez et al., 2002).

2.2.5. Altman Self-Rating Mania Scale (ASRM; Altman et al., 1997)—The ASRM is a 5-item self-report questionnaire that assesses manic symptoms, including inflated self-confidence, talkativeness, elation, reduced need for sleep, and excessive activity. For each symptom, participants choose the statement that best describes them in the last month on a 5-point Likert scale. Total scores demonstrate high correlation with both clinical interviews and other measures of mania (Altman et al., 2001). The ASRM has been used successfully to assess symptoms of mania and hypomania in individuals with, and at risk for, BD (Ng and Johnson, 2013; Savitz et al., 2008; Stange et al., 2012). The ASRM was used to assess symptoms of hypomania at Phase II. In the current study, it demonstrated good internal consistency ($\alpha = .75$).

2.2.6. Beck Depression Inventory (BDI; Beck et al., 1979)—The BDI is a 21-item self-report questionnaire that assesses the presence and severity of cognitive, motivational, affective, and somatic symptoms of depression. The BDI has been shown to be valid among student samples (Bumberry et al., 1978; Hammen, 1980). The BDI was administered at the baseline visit to assess current symptoms of depression; $\alpha = .87$.

2.2.7. Exp-SADS-L—During Phase II of the screening process, semistructured diagnostic interviews were conducted using the exp-SADS-L (Alloy et al., 2008), which assesses symptoms related to mood, anxiety, eating, psychotic, and alcohol and drug use disorders and ADHD over the lifetime. All interviews were conducted by extensively trained interviewers who were blind to participants’ BIS/BAS and SPSRQ and impulsivity scores (see Alloy et al., 2012a for training procedures). To obtain consensus diagnoses and monitor

inter-rater reliability, interviews were audiotaped. A three-tiered standardized review procedure was used for diagnostic consensus. Inter-rater reliability generated from 80 jointly rated interviews by this procedure was high ($K > .96$ for bipolar diagnoses) (Alloy et al., 2012a, 2008; Nusslock et al., 2012; Weiss et al., 2015).

2.2.8. Exp-SADS-C—The exp-SADS-C was used to obtain information about the occurrence, duration, and symptom severity of mood episodes at each follow-up (Alloy et al., 2012a, 2008; Francis-Raniere et al., 2006; Stange et al., 2015). The exp-SADS-C interviewers were blind to participants' BIS/BAS, SPSRQ, and impulsivity scores as well as their clinical diagnoses. Validity and inter-rater reliability of the exp-SADS-C for mood disorder diagnoses were strong ($K = .80$) (Francis-Raniere et al., 2006). It was expanded in the same ways as the exp-SADS-L (Alloy et al., 2012a, 2008; Weiss et al., 2015). A validity study showed that participants identified the dates of their symptoms on the exp-SADS-C compared to daily symptom ratings made over a four-month interval with greater than 70% accuracy (Alloy et al., 2008). The exp-SADS-C also was used to obtain information about participants' treatment seeking (medication or psychotherapy) during each follow-up period.

2.3. Statistical Analyses

Cox proportional hazard regression (survival) analyses were used to evaluate the hypothesis that impulsivity would predict a shorter time to onset of episodes of hypomania/mania. We utilized this analytic technique because it allows for different follow-up lengths, minimizes biases due to attrition, utilizes all available data at each time point, and takes into account censored or missing data (Willett and Singer, 1993). We entered impulsivity (BART and BIS-11 Attentional Impulsiveness, Motor Impulsiveness, Nonplanning Impulsiveness, Total) as the independent variable and time to onset of a (hypo)manic episode as the dependent variable. Baseline depressive and manic symptoms were entered as covariates to control for any effects of baseline mood symptoms on time to onset of hypomanic or manic episodes. Treatment seeking for mood problems during follow-up (no treatment, pharmacotherapy, psychotherapy, or both) also was entered as a covariate to control for the possibility that treatment might alter time to onset of hypomanic or manic episodes. Family history of mood disorder in first-degree relatives was included as a covariate to control for familial effects. We also included BAS risk group as a covariate to ascertain that any prediction of the onset of a hypomanic/manic episode by impulsivity was above and beyond the previously demonstrated effects of BAS sensitivity (Alloy et al., 2012a). If impulsivity was a significant predictor of time to hypomanic/manic episode onset, we re-conducted the relevant analysis controlling for additional possible confounds (i.e., history of ADHD and history of alcohol or drug use disorders).

3. Results

Main effects of predictors on time to prospective onset of (hypo)manic mood episodes are presented in Table 3. Consistent with our hypothesis, behavioral impulsivity as assessed by the BART predicted shorter time to the onset of hypomania/mania (Wald = 4.88, $p = .03$, OR = 1.04, 95% CI = 1.00–1.07). Fig. 1 displays the survival curves for (hypo)manic episode onset as a function of high versus low BART score (plotted using a median split).

Regarding self-reported impulsivity, total BIS-11 scores did not significantly predict time to onset of hypomania or mania (Wald = 1.03, $p = .31$, OR = 1.02, 95% CI = 0.98–1.07). When BIS-11 subscales were considered separately, neither Motor Impulsiveness (Wald = 0.04, $p = .84$, OR = 0.99, 95% CI = 0.91–1.09) nor Nonplanning Impulsiveness (Wald = 0.08, $p = .78$, OR = 1.02, 95% CI = 0.91–1.14) predicted time to onset of hypomania/mania. However, Attentional Impulsiveness significantly predicted time to (hypo)manic episode onset (Wald = 6.18, $p = .01$, OR = 1.16, 95% CI = 1.03–1.30), such that those with higher self-reported attentional impulsivity had shorter time to onset of a hypomanic or manic episode, even after controlling for the five covariates. The survival curves for high versus low attentional impulsivity (plotted using a median split) are presented in Fig. 2.

3.1 Potential confounds

To ascertain that the prospective associations between BART scores and Attentional Impulsiveness and shorter time to onset of hypomanic/manic episodes were not attributable to history of ADHD and history of alcohol and drug use disorders, we repeated the survival analyses including these two covariates. Controlling for them in addition to the five original covariates, BART scores (Wald = 4.471, $p = .034$, OR = 1.034, 95% CI = 1.002–1.067) and Attentional Impulsiveness (Wald = 6.224, $p = .013$, OR = 1.158, 95% CI = 1.032–1.300) still significantly predicted shorter time to onset of hypomanic/manic episodes.

4. Discussion

Although there is a growing body of literature that investigates the importance of impulsivity in BD, to our knowledge, no studies have examined whether impulsivity prospectively predicts time to onset of *DSM-IV-TR* or RDC hypomanic or manic episodes. Using survival analysis, we found that higher self-reported attentional impulsivity on the BIS-11 and greater behavioral risk-taking on the BART predicted a shorter time to the onset of hypomania/mania, controlling for depressive and (hypo)manic symptoms, family history of mood disorder, and BAS sensitivity status at baseline and treatment-seeking status over follow-up. The predictive effect was retained even after history of ADHD and history of alcohol and drug use disorders were controlled as additional covariates.

Our findings are consistent with prior studies demonstrating that facets of impulsivity, such as attentional impulsivity (Swann et al., 2008) and impulsive nonconformity (Chapman et al., 1984), are associated with manic symptoms and extend them to people with high or moderate BAS sensitivity and to the prospective occurrence of (hypo)manic episodes. The present study is the first to demonstrate that facets of impulsivity can predict time to onset of *DSM-IV-TR* or RDC (hypo)manic episodes.

We found that motor impulsivity, nonplanning impulsivity, and overall impulsivity as assessed by the BIS-11 did not significantly predict onset of (hypo)manic episodes. This is partially supported by the findings of Swann et al. (2008), which showed that overall and motor impulsivity, but not nonplanning impulsivity, were associated with manic symptoms concurrently. One possible explanation is that these facets of impulsivity may only be associated with manic symptoms, but not full-blown episodes. It is also possible that whereas these facets of impulsivity fluctuate with manic symptoms concurrently, they do not

provide vulnerability to increases in manic symptoms prospectively. Attentional Impulsiveness, the only BIS-11 scale found to predict onset of hypomania/mania in the current analyses, was also the only BIS-11 scale that showed elevation of scores in unaffected relatives of bipolar probands in a cross-sectional study conducted by Henna et al. (2013). Indeed, Henna et al. (2013) found that the unaffected relatives group exhibited a level of attentional impulsivity that was comparable to that of the BD group and the unipolar depression group and significantly higher than that of the healthy control group. Swann et al. (2009) also reported that elevated attentional impulsivity was the only BIS-11 scale associated with early onset of BD. Evidence across these studies suggests that relative to other facets of impulsivity, attentional impulsivity may be a particularly important risk factor for the development of hypomania or mania. Taken together, attentional impulsivity may be considered a particularly promising candidate endophenotype for BD.

In combination with previous empirical work, the current findings suggest that the onset of hypomania or mania may be explained by an integrated vulnerability-stress and stress generation model, in that people with BD may have a pre-dispositional vulnerability for impulsivity that interacts with life events/stress generated by impulsivity to contribute to the onset of hypomania/mania. This model is corroborated by previous research reporting that impulsivity predicts generation of life events/stress hypothesized to trigger recurrences of mood episodes (Molz et al., 2013), that life events/stress negatively affect the course of BD (Alloy et al., 2005; Johnson, 2005), and that impulsivity is elevated in unaffected relatives of bipolar probands (Henna et al., 2013; Lombardo et al., 2012; Wessa et al., 2015) and in people with BD across mood states (Newman and Meyer, 2014).

It is important to highlight that impulsivity predicted hypomanic or manic episodes, even when controlling for BAS sensitivity. This is similar to previous research demonstrating that relative to other facets of BAS sensitivity, the impulsivity-related aspect of BAS sensitivity (e.g., fun-seeking) or impulsivity itself seem to be more important predictors of progression to bipolar I disorder from milder forms of disorder (Alloy et al., 2012b), and prospective substance use problems in BD (Alloy et al., 2009b).¹ Future research is needed to disentangle the relationship between impulsivity and BAS sensitivity and to examine which facets of these constructs are most important for the onset, course, and outcome of BD.

The current study has several methodological strengths. These include the use of a longitudinal sample not recruited from a clinic population at risk for BD based on reward sensitivity, a multi-method, multi-measure assessment approach, semistructured diagnostic interviews, standardized criteria, diagnosticians blind to the impulsivity levels of participants, a conservative statistical analysis approach, relatively long overall follow-up period, and relatively short follow-up assessment intervals, which conferred high sensitivity for the detection of mood episodes during follow-up.

¹Alloy *et al.* (2012b) indicated that impulsivity, but not BAS sensitivity, significantly predicted conversion to bipolar I disorder controlling for baseline mood symptoms, length of follow-up, treatment-seeking status, and family history of bipolar disorder. Alloy *et al.* (2009b) reported that BAS sensitivity no longer mediated the relationship between bipolar disorder and substance use problems controlling for impulsivity, whereas impulsivity continued to mediate the relationship controlling for BAS and BIS sensitivities.

Despite these methodological strengths, it is also important to note the limitations of the study. First, we did not assess all facets of impulsivity. Future studies should examine whether other facets of impulsivity, such as positive or negative urgency, or the tendency to behave rashly in response to strong positive or negative emotions (Cyders et al., 2007; Muhtadie et al., 2014; Whiteside and Lynam, 2001), also predict a shorter time to hypomania/mania onset. Second, our study included mostly high school or university students, and thus, whether these findings would generalize to community, non-clinical populations is unknown. Third, family history of mood disorder was obtained indirectly by interviewing the participants rather than their relatives. Fourth, a relatively small number of participants had a prospective onset of hypomanic or manic episodes. Fifth, although the current study had a relatively short follow-up assessment interval, it is acknowledged that hypomania is difficult to diagnose accurately. Sixth, it is also important to note that we did not control for borderline personality disorder in the analyses, which may be a confounder of the prospective association between impulsivity and (hypo)manic episodes. Finally, we did not examine the mechanisms by which impulsivity might affect the course of bipolar disorder. Some theorists suggest that cognitive deficits and sleep disturbance may underlie the effects of impulsivity in BD (Harvey et al., 2009; Ng et al., in press; Powers et al., 2013), both of which have been proposed as candidate endophenotypes of BD (Boland and Alloy, 2013; Ng et al., 2015).

The findings suggest that the use of therapeutic strategies targeting impulsivity may be warranted. Future studies should explore whether the use of psychotherapeutic approaches, such as cognitive behavioral therapy and contingency management, and pharmacologic treatments, such as non-stimulant medications, might reduce impulsivity in BD and potentially improve the course of BD and reduce the impact of comorbidities characterized by impulsivity, such as substance use disorder (Moeller et al., 2001). Given that deficits in executive functions may underlie impulsivity in BD (Christodoulou et al., 2006), cognitive remediation therapy may also be useful.

In summary, our findings indicate that impulsivity may be a mechanism conferring vulnerability to hypomania/mania onset and provides support for an integrated vulnerability-stress and stress generation model of BD. It may be helpful to consider how such a model, in combination with other existing biopsychosocial models, may help enrich our understanding of BD.

References

- Alloy LB, Abramson LY. The role of the Behavioral Approach System (BAS) in bipolar spectrum disorders. *Curr Dir Psychol Sci.* 2010; 19:189–194.10.1177/0963721410370292 [PubMed: 20606725]
- Alloy LB, Abramson LY, Urosevic S, Walshaw PD, Nusslock R, Neeren AM. The psychosocial context of bipolar disorder: Environmental, cognitive, and developmental risk factors. *Clin Psychol Rev.* 2005; 25:1043–1075.10.1016/j.cpr.2005.06.006 [PubMed: 16140445]
- Alloy LB, Abramson LY, Walshaw PD, Cogswell A, Grandin LD, Hughes ME, Iacoviello BM, Whitehouse WG, Urosevic S, Nusslock R, Hogan ME. Behavioral Approach System and Behavioral Inhibition System sensitivities and bipolar spectrum disorders: Prospective prediction of bipolar mood episodes. *Bipolar Disord.* 2008; 10:310–322.10.1111/j.1399-5618.2007.00547.x [PubMed: 18271911]

- Alloy LB, Abramson LY, Walshaw PD, Cogswell A, Smith JM, Neeren AM, Hughes ME, Iacoviello BM, Gerstein RK, Keyser J, Urosevic S, Nusslock R. Behavioral Approach System (BAS) sensitivity and bipolar spectrum disorders: A retrospective and concurrent behavioral high-risk design. *Motiv Emot.* 2006; 30:143–155.10.1007/s11031-006-9003-3
- Alloy LB, Abramson LY, Walshaw PD, Gerstein RK, Keyser JD, Whitehouse WG, Urosevic S, Nusslock R, Hogan ME, Harmon-Jones E. Behavioral Approach System (BAS)-relevant cognitive styles and bipolar spectrum disorders: Concurrent and prospective associations. *J Abnorm Psychol.* 2009a; 118:459–471.10.1037/a0016604 [PubMed: 19685944]
- Alloy LB, Bender RE, Wagner CA, Whitehouse WG, Abramson LY, Hogan ME, Sylvia LG, Harmon-Jones E. Bipolar spectrum substance use co-occurrence: Behavioral Approach System (BAS) sensitivity and impulsiveness as shared personality vulnerabilities. *J Pers Soc Psychol.* 2009b; 97:549–565.10.1037/a0016061 [PubMed: 19686007]
- Alloy LB, Bender RE, Whitehouse WG, Wagner CA, Liu RT, Grant DA, Jager-Hyman S, Molz A, Choi JY, Harmon-Jones E, Abramson LY. High Behavioral Approach System (BAS) sensitivity, reward responsiveness, and goal-striving predict first onset of bipolar spectrum disorders: A prospective behavioral high-risk design. *J Abnorm Psychol.* 2012a; 121:339–351.10.1037/a0025877 [PubMed: 22004113]
- Alloy LB, Nusslock R, Boland EM. The development and course of bipolar spectrum disorders: An integrated reward and circadian rhythm dysregulation model. *Annu Rev Clin Psychol.* 2015; 11:213–250.10.1146/annurev-clinpsy-032814-112902 [PubMed: 25581235]
- Alloy LB, Urošević S, Abramson LY, Jager-Hyman S, Nusslock R, Whitehouse WG, Hogan M. Progression along the bipolar spectrum: A longitudinal study of predictors of conversion from bipolar spectrum conditions to bipolar I and II disorders. *J Abnorm Psychol.* 2012b; 121:16–27.10.1037/a0023973 [PubMed: 21668080]
- Altman EG, Hedeker D, Peterson JL, Davis JM. A comparative evaluation of three self-rating scales for acute mania. *Biol Psychiatry.* 2001; 50:468–471.10.1016/S0006-3223(01)01065-4 [PubMed: 11566165]
- Altman EG, Hedeker D, Peterson JL, Davis JM. The Altman Self-Rating Mania Scale. *Biol Psychiatry.* 1997; 42:948–955.10.1016/S0006-3223(96)00548-3 [PubMed: 9359982]
- American Psychiatric Association. Diagnostic and statistical manual of mental disorders. 4. Author; Washington, DC: 2000. text rev
- Beck, AT.; Rush, AJ.; Shaw, BF.; Emery, G. Cognitive therapy of depression. Guilford Press; New York, NY: 1979.
- Boland EM, Alloy LB. Sleep disturbance and cognitive deficits in bipolar disorder: Toward an integrated examination of disorder maintenance and functional impairment. *Clin Psychol Rev.* 2013; 33:33–44.10.1016/j.cpr.2012.10.001 [PubMed: 23123569]
- Bumberry W, Oliver JM, McClure JN. Validation of the Beck Depression Inventory in a university population using psychiatric estimate as the criterion. *J Consult Clin Psychol.* 1978; 46:150–155.10.1037/0022-006X.46.1.150
- Carver CS, White TL. Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The BIS/BAS Scales. *J Pers Soc Psychol.* 1994; 67:319–333.10.1037/0022-3514.67.2.319
- Chapman LJ, Chapman JP, Numbers JS, Edell WS, Carpenter BN, Beckfield D. Impulsive nonconformity as a trait contributing to the prediction of psychotic-like and schizotypal symptoms. *J Nerv Ment Dis.* 1984; 172:681–691.10.1097/00005053-198411000-00007 [PubMed: 6491653]
- Christodoulou T, Lewis M, Ploubidis GB, Frangou S. The relationship of impulsivity to response inhibition and decision-making in remitted patients with bipolar disorder. *Eur Psychiatry.* 2006; 21:270–273.10.1016/j.eurpsy.2006.04.006 [PubMed: 16762532]
- Cyders MA, Smith GT, Spillane NS, Fischer S, Annus AM, Peterson C. Integration of impulsivity and positive mood to predict risky behavior: development and validation of a measure of positive urgency. *Psychol Assess.* 2007; 19:107–118.10.1037/1040-3590.19.1.107 [PubMed: 17371126]
- Dawe S, Gullo MJ, Loxton NJ. Reward drive and rash impulsiveness as dimensions of impulsivity: Implications for substance misuse. *Addict Behav.* 2004; 29:1389–1405.10.1016/j.addbeh.2004.06.004 [PubMed: 15345272]

- Dawson EL, Shear PK, Howe SR, Adler CM, DelBello MP, Fleck DE, Strakowski SM. Impulsivity predicts time to reach euthymia in adults with bipolar disorder. *Bipolar Disord.* 2014; 16:846–856.10.1111/bdi.12232 [PubMed: 25039396]
- Depue RA, Iacono WG. Neurobehavioral aspects of affective disorders. *Annu Rev Psychol.* 1989; 40:457–492.10.1146/annurev.ps.40.020189.002325 [PubMed: 2648983]
- Depue, RA.; Krauss, SP.; Spoont, MR. A two-dimensional threshold model of seasonal bipolar affective disorder. In: Magnusson, D., editor. *Psychopathology: An Interactional Perspective, Personality, Psychopathology, and Psychotherapy.* Academic Press; San Diego, CA, US: 1987. p. 95-123.
- Eckblad M, Chapman LJ. Development and validation of a scale for hypomanic personality. *J Abnorm Psychol.* 1986; 95:214–222.10.1037/0021-843X.95.3.214 [PubMed: 3745642]
- Edge MD, Johnson SL, Ng T, Carver CS. Iowa gambling task performance in euthymic bipolar I disorder: A meta-analysis and empirical study. *J Affect Disord.* 2013; 150:115–122.10.1016/j.jad.2012.11.027 [PubMed: 23219060]
- Endicott J, Spitzer RL. A diagnostic interview: The schedule for affective disorders and schizophrenia. *Arch Gen Psychiatry.* 1978; 35:837–844. doi:archpsyc.1978.01770310043002. [PubMed: 678037]
- Francis-Raniere EL, Alloy LB, Abramson LY. Depressive personality styles and bipolar spectrum disorders: Prospective tests of the event congruency hypothesis. *Bipolar Disord.* 2006; 8:382–399.10.1111/j.1399-5618.2006.00337.x [PubMed: 16879139]
- Giovannelli A, Hoerger M, Johnson SL, Gruber J. Impulsive responses to positive mood and reward are related to mania risk. *Cogn Emot.* 2013; 27:1091–1104.10.1080/02699931.2013.772048 [PubMed: 23472965]
- Hammen CL. Depression in college students: Beyond the Beck Depression Inventory. *J Consult Clin Psychol.* 1980; 48:126–128. [PubMed: 7365037]
- Harmon-Jones E, Abramson LY, Nusslock R, Sigelman JD, Urosevic S, Turonie LD, Alloy LB, Fearn M. Effect of bipolar disorder on left frontal cortical responses to goals differing in valence and task difficulty. *Biol Psychiatry.* 2008; 63:693–698.10.1016/j.biopsych.2007.08.004 [PubMed: 17919457]
- Harmon-Jones E, Allen JJ. Behavioral activation sensitivity and resting frontal EEG asymmetry: Covariation of putative indicators related to risk for mood disorders. *J Abnorm Psychol.* 1997; 106:159–163.10.1037/0021-843X.106.1.159 [PubMed: 9103728]
- Harvey AG, Talbot LS, Gershon A. Sleep disturbance in bipolar disorder across the lifespan. *Clin Psychol Sci Pract.* 2009; 16:256–277.10.1111/j.1468-2850.2009.01164.x
- Hayden EP, Bodkins M, Brenner C, Shekhar A, Nurnberger JI Jr, O'Donnell BF, Hetrick WP. A multimethod investigation of the Behavioral Activation System in bipolar disorder. *J Abnorm Psychol.* 2008; 117:164–170.10.1037/0021-843X.117.1.164 [PubMed: 18266494]
- Henna E, Hatch JP, Nicoletti M, Swann AC, Zunta-Soares G, Soares JC. Is impulsivity a common trait in bipolar and unipolar disorders? *Bipolar Disord.* 2013; 15:223–227.10.1111/bdi.12034 [PubMed: 23286455]
- Heponiemi T, Keltikangas-Järvinen L, Kettunen J, Puttonen S, Ravaja N. BIS BAS sensitivity and cardiac autonomic stress profiles. *Psychophysiology.* 2004; 41:37–45.10.1111/1469-8986.00118_41_1 [PubMed: 14692999]
- Jiménez E, Arias B, Castellví P, Goikolea JM, Rosa AR, Fañanás L, Vieta E, Benabarre A. Impulsivity and functional impairment in bipolar disorder. *J Affect Disord.* 2012; 136:491–497.10.1016/j.jad.2011.10.044 [PubMed: 22129768]
- Johnson SL. Life events in bipolar disorder: Towards more specific models. *Clin Psychol Rev.* 2005; 25:1008–1027.10.1016/j.cpr.2005.06.004 [PubMed: 16129530]
- Johnson SL, Carver CS, Gotlib IH. Elevated ambitions for fame among persons diagnosed with bipolar I disorder. *J Abnorm Psychol.* 2012a; 121:602–609.10.1037/a0026370 [PubMed: 22103804]
- Johnson SL, Carver CS, Mulé S, Joormann J. Impulsivity and risk for mania: Towards greater specificity. *Psychol Psychother Theory Res Pract.* 2013; 86:401–412.10.1111/j.2044-8341.2012.02078.x

- Johnson SL, Edge MD, Holmes MK, Carver CS. The Behavioral Activation System and mania. *Annu Rev Clin Psychol*. 2012b; 8:243–267.10.1146/annurev-clinpsy-032511-143148 [PubMed: 22077912]
- Kwapil TR, Miller MB, Zinser MC, Chapman LJ, Chapman J, Eckblad M. A longitudinal study of high scorers on the Hypomanic Personality Scale. *J Abnorm Psychol*. 2000; 109:222–226.10.1037/0021-843X.109.2.222 [PubMed: 10895560]
- Lam DH, Wright K, Smith N. Dysfunctional assumptions in bipolar disorder. *J Affect Disord*. 2004; 79:193–199.10.1016/S0165-0327(02)00462-7 [PubMed: 15023494]
- Lejuez CW, Read JP, Kahler CW, Richards JB, Ramsey SE, Stuart GL, Strong DR, Brown RA. Evaluation of a behavioral measure of risk taking: The Balloon Analogue Risk Task (BART). *J Exp Psychol Appl*. 2002; 8:75–84.10.1037/1076-898X.8.2.75 [PubMed: 12075692]
- Lipszyc J, Schachar R. Inhibitory control and psychopathology: A meta-analysis of studies using the stop signal task. *J Int Neuropsychol Soc JINS*. 2010; 16:1064–1076.10.1017/S1355617710000895 [PubMed: 20719043]
- Lombardo LE, Bearden CE, Barrett J, Brumbaugh MS, Pittman B, Frangou S, Glahn DC. Trait impulsivity as an endophenotype for bipolar I disorder. *Bipolar Disord*. 2012; 14:565–570.10.1111/j.1399-5618.2012.01035.x [PubMed: 22805501]
- Meyer B, Johnson SL, Winters R. Responsiveness to threat and incentive in bipolar disorder: Relations of the BIS/BAS Scales with symptoms. *J Psychopathol Behav Assess*. 2001; 23:133–143.10.1023/A:1010929402770 [PubMed: 21765592]
- Moeller FG, Barratt ES, Dougherty DM, Schmitz JM, Swann AC. Psychiatric aspects of impulsivity. *Am J Psychiatry*. 2001; 158:1783–1793.10.1176/appi.ajp.158.11.1783 [PubMed: 11691682]
- Molz AR, Black CL, Shapero BG, Bender RE, Alloy LB, Abramson LY. Aggression and impulsivity as predictors of stress generation in bipolar spectrum disorders. *J Affect Disord*. 2013; 146:272–280.10.1016/j.jad.2012.07.022 [PubMed: 22871530]
- Muhtadie L, Johnson SL, Carver CS, Gotlib IH, Ketter TA. A profile approach to impulsivity in bipolar disorder: The key role of strong emotions. *Acta Psychiatr Scand*. 2014; 129:100–108.10.1111/acps.12136 [PubMed: 23600731]
- Najt P, Perez J, Sanches M, Peluso MaM, Glahn D, Soares JC. Impulsivity and bipolar disorder. *Eur Neuropsychopharmacol*. 2007; 17:313–320.10.1016/j.euroneuro.2006.10.002 [PubMed: 17140772]
- Newman AL, Meyer TD. Impulsivity: Present during euthymia in bipolar disorder? - A systematic review. *Int J Bipolar Disord*. 2014; 2:2.10.1186/2194-7511-2-2 [PubMed: 25960939]
- Ng TH, Chung KF, Ho FYY, Yeung WF, Yung KP, Lam TH. Sleep-wake disturbance in interepisode bipolar disorder and high-risk individuals: A systematic review and meta-analysis. *Sleep Med Rev*. 2015; 20:46–58.10.1016/j.smrv.2014.06.006 [PubMed: 25060968]
- Ng TH, Chung KF, Lee CT, Yeung WF, Ho FYY. Eveningness and its associated impairments in remitted bipolar disorder. *Behav Sleep Med*. in press.
- Ng TH, Johnson SL. Rejection sensitivity is associated with quality of life, psychosocial outcome, and the course of depression in euthymic patients with bipolar I disorder. *Cogn Ther Res*. 2013; 37:1169–1178.10.1007/s10608-013-9552-1
- Nusslock R, Harmon-Jones E, Alloy LB, Urosevic S, Goldstein K, Abramson LY. Elevated left mid-frontal cortical activity prospectively predicts conversion to bipolar I disorder. *J Abnorm Psychol*. 2012; 121:592–601.10.1037/a0028973 [PubMed: 22775582]
- Patton JH, Stanford MS, Barratt ES. Factor structure of the Barratt impulsiveness scale. *J Clin Psychol*. 1995; 51:768–774.10.1002/1097-4679(199511)51:6<768::AID-JCLP2270510607>3.0.CO;2-1 [PubMed: 8778124]
- Peluso MAM, Hatch JP, Glahn DC, Monkul ES, Sanches M, Najt P, Bowden CL, Barratt ES, Soares JC. Trait impulsivity in patients with mood disorders. *J Affect Disord*. 2007; 100:227–231.10.1016/j.jad.2006.09.037 [PubMed: 17097740]
- Powers RL, Russo M, Mahon K, Brand J, Braga RJ, Malhotra AK, Burdick KE. Impulsivity in bipolar disorder: Relationships with neurocognitive dysfunction and substance use history. *Bipolar Disord*. 2013; 15:876–884.10.1111/bdi.12124 [PubMed: 24028391]

- Saddichha S, Schuetz C. Is impulsivity in remitted bipolar disorder a stable trait? A meta-analytic review. *Compr Psychiatry*. 2014; 55:1479–1484.10.1016/j.comppsy.2014.05.010 [PubMed: 25035161]
- Savitz J, van der Merwe L, Ramesar R. Hypomanic, cyclothymic and hostile personality traits in bipolar spectrum illness: A family-based study. *J Psychiatr Res*. 2008; 42:920–929.10.1016/j.jpsychires.2007.10.011 [PubMed: 18082182]
- Sharma L, Markon KE, Clark LA. Toward a theory of distinct types of “impulsive” behaviors: A meta-analysis of self-report and behavioral measures. *Psychol Bull*. 2014; 140:374–408.10.1037/a0034418 [PubMed: 24099400]
- Stanford MS, Greve KW, Boudreaux JK, Mathias CW, Brumbelow JL. Impulsiveness and risk-taking behavior: Comparison of high-school and college students using the Barratt Impulsiveness Scale. *Personal Individ Differ*. 1996; 21:1073–1075.10.1016/S0191-8869(96)00151-1
- Stanford MS, Mathias CW, Dougherty DM, Lake SL, Anderson NE, Patton JH. Fifty years of the Barratt Impulsiveness Scale: An update and review. *Personal Individ Differ*. 2009; 47:385–395.10.1016/j.paid.2009.04.008
- Stange JP, Adams AM, O’Garro-Moore JK, Weiss RB, Ong ML, Walshaw PD, Abramson LY, Alloy LB. Extreme cognitions in bipolar spectrum disorders: Associations with personality disorder characteristics and risk for episode recurrence. *Behav Ther*. 2015; 46:242–56.10.1016/j.beth.2014.09.003 [PubMed: 25645172]
- Stange JP, Molz AR, Black CL, Shapero BG, Bacelli JM, Abramson LY, Alloy LB. Positive overgeneralization and Behavioral Approach System (BAS) sensitivity interact to predict prospective increases in hypomanic symptoms: A behavioral high-risk design. *Behav Res Ther*. 2012; 50:231–239.10.1016/j.brat.2012.01.003 [PubMed: 22342167]
- Strakowski SM, Fleck DE, DelBello MP, Adler CM, Shear PK, Kotwal R, Arndt S. Impulsivity across the course of bipolar disorder. *Bipolar Disord*. 2010; 12:285–297.10.1111/j.1399-5618.2010.00806.x [PubMed: 20565435]
- Strakowski SM, Fleck DE, DelBello MP, Adler CM, Shear PK, McElroy SL, Keck PE, Moss Q, Cerullo MA, Kotwal R, Arndt S. Characterizing impulsivity in mania. *Bipolar Disord*. 2009; 11:41–51.10.1111/j.1399-5618.2008.00658.x [PubMed: 19133965]
- Sutton SK, Johnson SL. Hypomanic tendencies predict lower startle magnitudes during pleasant pictures. *Psychophysiology*. 2002; 39:S80.
- Swann AC, Anderson JC, Dougherty DM, Moeller FG. Measurement of inter-episode impulsivity in bipolar disorder. *Psychiatry Res*. 2001; 101:195–197.10.1016/S0165-1781(00)00249-3 [PubMed: 11286822]
- Swann AC, Dougherty DM, Pazzaglia PJ, Pham M, Steinberg JL, Moeller FG. Increased impulsivity associated with severity of suicide attempt history in patients with bipolar disorder. *Am J Psychiatry*. 2005; 162:1680–1687.10.1176/appi.ajp.162.9.1680 [PubMed: 16135628]
- Swann AC, Lijffijt M, Lane SD, Steinberg JL, Moeller FG. Increased trait-like impulsivity and course of illness in bipolar disorder. *Bipolar Disord*. 2009; 11:280–288.10.1111/j.1399-5618.2009.00678.x [PubMed: 19419385]
- Swann AC, Steinberg JL, Lijffijt M, Moeller FG. Impulsivity: Differential relationship to depression and mania in bipolar disorder. *J Affect Disord*. 2008; 106:241–248.10.1016/j.jad.2007.07.011 [PubMed: 17822778]
- Torrubia R, Avila C, Moltó J, Caseras X. The Sensitivity to Punishment and Sensitivity to Reward Questionnaire (SPSRQ) as a measure of Gray’s anxiety and impulsivity dimensions. *Personal Individ Differ*. 2001; 31:837–862.10.1016/S0191-8869(00)00183-5
- Victor SE, Johnson SL, Gotlib IH. Quality of life and impulsivity in bipolar disorder. *Bipolar Disord*. 2011; 13:303–309.10.1111/j.1399-5618.2011.00919.x [PubMed: 21676133]
- Watkins HB, Meyer TD. Is there an empirical link between impulsivity and suicidality in bipolar disorders? A review of the current literature and the potential psychological implications of the relationship. *Bipolar Disord*. 2013; 15:542–558.10.1111/bdi.12090 [PubMed: 23822918]
- Weiss RB, Stange JP, Boland EM, Black SK, LaBelle DR, Abramson LY, Alloy LB. Kindling of life stress in bipolar disorder: Comparison of sensitization and autonomy models. *J Abnorm Psychol*. 2015; 124:4–16.10.1037/abn0000014 [PubMed: 25688428]

- Wessa M, Kollmann B, Linke J, Schönfelder S, Kanske P. Increased impulsivity as a vulnerability marker for bipolar disorder: Evidence from self-report and experimental measures in two high-risk populations. *J Affect Disord.* 2015; 178:18–24.10.1016/j.jad.2015.02.018 [PubMed: 25770479]
- Whiteside SP, Lynam DR. The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. *Personal Individ Differ.* 2001; 30:669–689.10.1016/S0191-8869(00)00064-7
- Willett JB, Singer JD. Investigating onset, cessation, relapse, and recovery: why you should, and how you can, use discrete-time survival analysis to examine event occurrence. *J Consult Clin Psychol.* 1993; 61:952–965.10.1037/0022-006X.61.6.952 [PubMed: 8113496]
- Wright L, Lipszyc J, Dupuis A, Thayapararajah SW, Schachar R. Response inhibition and psychopathology: A meta-analysis of go/no-go task performance. *J Abnorm Psychol.* 2014; 123:429–439.10.1037/a0036295 [PubMed: 24731074]

Highlights

- Bipolar disorders are associated with high impulsivity.
- Impulsivity predicts a shorter time to onset of hypomanic and manic episodes.
- Results are independent of the effects of seven covariates.

Fig. 1. Time to (hypo)manic episode as a function of high versus low Balloon Analog Risk Task (BART) score (plotted using a median split).

Fig. 2.
Time to (hypo)manic episode as a function of high versus low attentional impulsivity (plotted using a median split).

Table 1

Sample Characteristics by Risk Group

	High BAS (N = 163)	Moderate BAS (N = 114)
Age (y)	18.3 (1.4)	18.0 (1.6)
Female (%)	65.0	71.1
Race/Ethnicity (%)		
Caucasian	55.8	50.9
African American	19.6	30.7
Asian/Pacific Islander	11.7	11.4
Hispanic/Latino	1.8	1.8
Other	9.8	4.4
Declined to respond	1.2	0.9
Fam Hx (%)	38.7	42.1
Tx Seeking (%) *	12.9	5.3
Pharmacotherapy	2.5	0
Psychotherapy	4.3	4.4
Both	6.1	0.9
ADHD Hx (%)	7.5	4.4
Alcohol or Drug Use Hx (%)	15.5	8.0
BD Hx (%)	4.9	0.9
Hyp or Ma Episode (%)	9.8	5.3
Hyp Episode (%)	9.2	5.3
Ma Episode (%)	0.6	0
First Hyp or Ma Episode (%)	4.9	4.4
BAS-T **	46.0 (2.7)	38.1 (0.9)
SR **	8.3 (1.3)	5.2 (1.4)
BDI *	7.8 (7.0)	6.0 (6.6)
ASRM **	6.5 (3.9)	5.1 (3.7)
BART	35.7 (13.2)	35.1 (12.0)
BIS-11-T **	66.5 (10.4)	61.5 (9.4)
Attentional Impulsiveness **	18.7 (4.2)	16.8 (4.4)
Motor Impulsiveness **	26.2 (4.9)	23.8 (4.4)
Nonplanning Impulsiveness	21.6 (4.0)	20.9 (3.5)

Note. Standard deviations are in parentheses. Fam Hx = Family history of mood disorder; Tx Seeking = Treatment seeking (medication or psychotherapy); Hyp or Ma Episode = Prospective onset of at least one *DSM-IV-TR* or RDC hypomanic or manic episode over the follow-up period; Hyp Episode = Prospective onset of at least one *DSM-IV-TR* or RDC hypomanic episode over the follow-up period; Ma Episode = Prospective onset of at least one *DSM-IV-TR* or RDC manic episode over the follow-up period; ADHD Hx = History of *DSM-IV-TR* ADHD; Alcohol or Drug Use Hx = History of *DSM-IV-TR* or RDC alcohol or drug use disorders; BD Hx = History of *DSM-IV-TR* or RDC bipolar disorders; BAS-T = Total scores from the BIS/BAS Scales; SR = Sensitivity to Reward from the SPSRQ; BDI = Beck Depression Inventory; ASRM = Altman Self-Rating Mania Scale; BART = Balloon Analog Risk Task; BIS-11-T = Total scores from the Barratt Impulsiveness Scale Version 11. Group differences in categorical variables were examined using Chi square tests; and in continuous variables using *t* tests.

* $p < .05$.

^{**}
 $p < .01$.

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Table 2

Summary of Measures

Screening/Baseline	
Self-reported Impulsivity	BIS-11 = Barratt Impulsiveness Scale Version 11 (Patton et al., 1995)
Behavioral Impulsivity	BART = Balloon Analog Risk Task (Lejuez et al., 2002)
Reward Sensitivity	BIS/BAS = BIS/BAS Scales (Carver and White, 1994) SPSRQ = Sensitivity to Punishment/Sensitivity to Reward Questionnaire (Torrubia et al., 2001)
Depressive Symptoms	BDI = Beck Depression Inventory (Beck et al., 1979)
Hypomanic Symptoms	ASRM = Altman Self-Rating Mania Scale (Altman et al., 1997)
Psychiatric Diagnoses and Family History of Mood Disorders	exp-SADS-L = Schedule for Affective Disorders and Schizophrenia Lifetime diagnostic interview (Endicott and Spitzer, 1978)
Follow-up	
Hyp or Ma Episode and Tx Seeking	SADS-C = Expanded Schedule for Affective Disorders and Schizophrenia Change version (Endicott and Spitzer, 1978)

Note. Hyp or Ma Episode = Prospective onset of at least one *DSM-IV-TR* or RDC hypomanic or manic episode over the follow-up period; Tx Seeking = Treatment seeking for mood problems (no treatment, pharmacotherapy, psychotherapy, or both).

Table 3

Cox Regression Models Predicting Time to Prospective Hypomanic or Manic Episode Controlling for Baseline Depressive and Hypomanic/Manic Symptoms, Family History of Mood Disorder, Treatment-Seeking Status, and BAS Risk Group.

	β	SE	Wald	OR	95% CI	p
BART						
Step 1						
BDI	0.00	0.04	0.00	1.00	0.93–1.08	.99
ASRM	0.07	0.06	1.09	1.07	0.94–1.21	.30
Fam Hx	0.94	0.50	3.56	2.56	0.96–6.82	.06
Tx Seeking	0.49	0.21	5.60	1.64	1.09–2.46	.02
BAS Risk Group	0.64	0.60	1.13	1.89	0.59–6.09	.29
Step 2						
BART	0.04	0.02	4.88	1.04	1.00–1.07	.03
BIS-11						
Step 1						
BDI	0.04	0.03	2.53	1.04	0.99–1.10	.11
ASRM	0.11	0.05	4.12	1.12	1.00–1.24	.04
Fam Hx	0.99	0.45	4.86	2.69	1.12–6.48	.03
Tx Seeking	0.42	0.20	4.20	1.52	1.02–2.25	.04
BAS Risk Group	–0.37	0.50	0.56	0.69	0.26–1.83	.46
Step 2						
Attentional Impulsiveness	0.15	0.06	6.18	1.16	1.03–1.30	.01
Step 2						
Motor Impulsiveness	–0.01	0.05	0.04	0.99	0.91–1.09	.84
Step 2						
Nonplanning Impulsiveness	0.02	0.06	0.08	1.02	0.91–1.14	.78
Step 2						
BIS-11 Total	0.02	0.02	1.03	1.02	0.98–1.07	.31

Note. Odds ratios (OR) less than 1.0 indicate a negative association between the predictor and hypomanic/manic episode onset. CI = Confidence Interval; BDI = Beck Depression Inventory; ASRM = Altman Self-Rating Mania Scale; Fam Hx = Family history of mood disorder; Tx Seeking = Treatment seeking (medication or psychotherapy); BAS = Behavioral Approach System; BART = Balloon Analog Risk Task; BIS-11 = Barratt Impulsiveness Scale Version 11. BART was missing for 13 high BAS individuals and 11 moderate BAS individuals.

Statistics are shown for each step of the model as the predictors on that step are entered. Four separate survival analyses were conducted for the BIS-11.