Published in final edited form as:

J Affect Disord. 2016 March 15; 193: 145–150. doi:10.1016/j.jad.2015.12.016.

The temporal course and clinical correlates of subjective impulsivity in bipolar disorder as revealed through ecological momentary assessment

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Abstract

Background—Impulsivity is frequently linked with bipolar disorder and is associated with mania and negative outcomes. The temporal dynamics of subjective impulsivity are unclear, in particular whether impulsivity precedes or follows changes in positive or negative affect.

Methods—A total of 41 outpatients with bipolar disorder (I or II) were provided with mobile devices for 11 weeks and completed twice-daily surveys about affective states and subjective impulsivity. We examined the association between aggregate subjective impulsivity with baseline global cognitive function, suicide risk ratings, and medication adherence, as well as concurrent and lagged associations with momentary positive and negative affect ratings.

Results—A total of 2902 ratings were available across study subjects. Higher aggregate mean ratings of impulsivity were associated with worse baseline global cognitive function, prior suicide attempts, and self-reported problems with medication adherence, as well as more severe manic (but not depressive) symptoms. Time-lagged models indicated that greater negative affect, but not positive affect, predicted subsequent increases in subjective impulsivity, which, in turn, predicted diminished positive affect.

Limitations—Other measures of impulsivity with which to validate subjective ratings were unavailable and the sample was restricted to generally clinically stable outpatients.

Conclusions—Subjective impulsivity as measured by daily monitoring was associated with worse cognitive function and self-rated medication adherence, and higher suicide risk ratings. Impulsivity may be a maladaptive strategy to regulate negative affect in bipolar disorder.

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Conflicts of interest

Dr. Granholm reported consulting fees from Otsuka America Pharmaceutical, Inc. None of the authors has any conflicts of interest to report.

Role of authors

All of the authors contributed to the interpretation of results and composition of the manuscript. Additionally, CD and EG oversaw design of the study; BM developed the statistical analysis plan.

Keywords

Assessment; Mobile health; Emotion; Bipolar disorder; Technology; Time series analysis

1. Introduction

Impulsivity is a multi-dimensional construct that has long been associated with hypo/manic states and bipolar disorder. Variously defined, dimensions of impulsivity include both over pursuit of short-term rewards at the expense of long-term goals, a tendency toward decision making without sufficient planning, and the failure to resist an urge to act, even if the action may cause harm to oneself or others (Moeller et al., 2001; Robbins et al., 2012). Across various measurement approaches and conceptualizations, elevated impulsivity has been associated with increased risk of negative outcomes, including cognitive impairment (Powers et al., 2013), medication adherence problems (Belzeaux et al., 2015), higher rates of suicidal behavior (Swann et al., 2014), comorbid substance abuse (Dougherty et al., 2005), and affective instability (Henry et al., 2008).

Recent work has indicated that aberrant performance on laboratory and self-report measures of impulsivity extends beyond mania to bipolar depressive and euthymic states (Swann et al., 2008). Thus, impulsivity can be seen as both a stable trait that is elevated in bipolar disorder, as well as a dynamic state that may fluctuate over the course of the illness, at least to some extent, in concert with symptoms. Global retrospective self-report measures do not address the variability of impulsivity over time nor their contextual influences (Dick et al., 2010). Behavioral tasks provide objective indication of impulsivity, but may offer limited ecological validity. Prior studies in bipolar disorder examining the impact of mood state on measures of impulsivity have employed cross-sectional designs contrasting patients experiencing episodes at different polarities, which confounds person-level variation with potential mood state effects. Thus, it is unclear to what extent impulsivity varies within individuals with bipolar disorder over time, and whether within-person fluctuation in impulsivity is associated with affective variability or other clinical factors such as cognitive abilities.

Ecological momentary assessment (EMA) could help further our understanding of the temporal associations with impulsivity among persons living with bipolar disorder. EMA involves intensive frequent assessment of emotions, behaviors and social contexts over time in one’s naturalistic environment (Shiffman, 2008), which enables analysis of contemporaneous and time-lagged association between subjective impulsivity and other affective states. To our knowledge, there have been no EMA studies involving momentary subjective self-ratings of impulsivity in bipolar disorder. One study in borderline personality disorder employing EMA found greater momentary impulsivity than in depressive disorder (Tomko et al., 2014) and another found that urges for action were associated with bouts of later affective instability (Dixon-Gordon et al., 2014).

Although the tendency toward intense emotion appears associated with increased trait impulsivity in bipolar disorder (Muhtadie et al., 2014), it is unclear which emotions may engender impulsivity in bipolar disorder. Increases in positive affect may increase likelihood of reward seeking (Carver and Johnson, 2009). On the other hand, prior research has

suggested that increases in negative affect could reduce cognitive efficiency and increase the likelihood of impulsivity, as patients with bipolar disorder and comorbid anxiety have been found to be more prone to impulsive choices on behavioral tasks (Bellani et al., 2012). As such, time-lagged models in EMA provide a potential means of testing whether increases in negative or positive emotion predict subsequent increases in subjective impulsivity. Finally, EMA affords the opportunity to examine intra-subject variability in subjective phenomena, in addition to mean levels. Mood instability is associated with somewhat unique correlates when compared to mood symptoms (Broome et al., 2015), and it is unclear if intra-subject variability of impulsivity may be also be unique compared to average impulsivity.

In this study, we examined the associations of level and intra-individual variability in self-reported impulsivity, as measured with EMA, within 41 patients with Bipolar I and II who participated in a self-management psychoeducation delivered in part by smartphone (Depp et al., 2015). Participants provided twice-daily self-ratings of affect, subjective impulsivity, and social context over 11 consecutive weeks on a smartphone device. The current study examined the associations of aggregated mean level and intra-individual variability in impulsivity with several measures that were gathered at baseline, including global cognitive function, clinician rated manic and depressive symptoms, suicide risk, and medication adherence. We also examined the association of impulsivity with concurrently gathered positive and negative affect ratings. We hypothesized that (1) level and intra-subject variability of impulsivity would relate to more severe manic and depressive symptoms at baseline, worse global cognitive function, worse medication adherence and increased suicide risk, and (2) contemporaneous and lagged associations between impulsivity and affective ratings would indicate that increases in both positive and negative affective ratings would predict subsequent increases in subjective impulsivity.

2. Method

2.1. Study overview

The data reported here derive from a parent study, which was a randomized controlled trial that evaluated the impact of augmenting brief psychoeducation with an automated mobile device-delivered intervention compared to brief psychoeducation alone. The design, methods and outcomes from this clinical trial have been reported previously (Depp et al., 2015), as has the convergent validity of an overall mood-state EMA items in relation to clinician-rated manic and depressive symptom assessments (Depp et al., 2012). The present study focused on the momentary ratings of impulsivity and affective states in the active arm of the intervention, as only the participants in the active arm of the intervention completed smartphone-based assessments (n=41). None of the data on impulsivity nor on individual affect ratings have been previously reported.

2.2. Participants

Participants were outpatients diagnosed with either Bipolar Disorder I or II recruited from various sources including flyers and advertisements placed online and in community residential and drop-in settings, depression and bipolar disorder self-help support groups, and outpatient psychiatric clinics in the San Diego area. To be eligible, participants needed

to be: (1) aged 18 and older, (2) outpatients and currently prescribed medications for bipolar disorder, and (3) free of visual or manual dexterity disabilities that would preclude operation of a touch screen device. We excluded participants who: (1) met criteria for any substance use disorder in the prior 3 months, (2) were psychiatrically hospitalized in the prior month, or (3) scored in the severe range for either depressive symptoms (a score on the Montgomery Asberg Depression Rating Scale >32) or manic symptoms (a score on the Young Mania Rating Scale >20). We excluded patients in more severe affective states because the intervention involved limited clinician contact, and patients in more severe states would likely need more intensive interventions.

This study was approved by the University of California, San Diego (UCSD) Institutional Review Board. All participants provided written, informed consent. Participants were compensated for assessment visits, but not treatment sessions. The study was registered in Clinicaltrials.gov (NCT01670123).

2.3. Measures

2.3.1. Demographics and diagnosis (baseline)—All participants were assessed at baseline for basic sociodemographic information, diagnosis and treatment history, current participation in treatment, and medications. Diagnoses were made by a clinically supervised research associate using the bipolar version of the MINI International Neuropsychiatric Interview for DSM-IV (Sheehan et al., 1998). Final diagnosis was attained by combining information from the MINI, chart reviews from treating providers, and confirmed in consensus meetings with the principal investigator.

2.3.2. Global cognitive functioning (baseline)—Global cognitive functioning was assessed with the Repeatable Battery of the Assessment of Neuropsychological Status (RBANS) (Gold et al., 1999). The RBANS was administered by a trained research assistant and covers 12 subtests which are then used to calculate five index scores: Immediate Memory (list learning and story memory tasks; score range=40–152), Visuospatial/ Construction (figure copy and line orientation tasks; score range=50–136), Language (picture naming and semantic fluency; score range=40–137), Attention (digit span and coding; score range=40–154), and Delayed Memory (list recognition, story recall, and figure recall; score range=40–137) (Randolph, 1998). Index scores are adjusted for age and education. The index scores were then combined to create the RBANS Total Score (with higher scores corresponding to better performance), which was used in the current analyses.

2.3.3. Suicide risk rating (baseline)—Suicide risk was determined at baseline with the MINI Suicidality module, which includes 6 questions concerning past month ideation, plans and behaviors as well as lifetime history of suicide attempt to create a tri-level global risk categorization from none, low, moderate and high. Predictive validity of this measure has been reported to be high in predicting the likelihood of suicidal behavior post hospital discharge (Roaldset et al., 2012).

2.3.4. Mood symptoms (baseline)—Severity of depressive symptoms were assessed with the Montgomery Asberg Depression Rating Scale (MADRS) (Montgomery and

Asberg, 1979) and manic symptoms were assessed with the Young Mania Rating Scale (YMRS) (Young et al., 1978). The MADRS is a 10-item clinician-rated scale that is widely used in assessing the severity of bipolar depression. The total score was used in the analyses. The YMRS is an 11-item clinician-rated scale that is the most commonly used scale for quantifying the severity of mania, again with total score used in the analyses. The MADRS and YMRS are interviewer-administered, and raters were trained on reliability to a gold standard on these instruments by more senior raters prior to administration.

2.3.5. Medication adherence (baseline)—The Morisky Medication Adherence Scale (MMAS-4; Morisky et al., 1986) was used to assess medication adherence. The MMAS-4 includes 4dichotomous (yes or no) items. The items correspond to endorsement of (1) ever forgetting medications, (2) stopping medications when feeling better, (3) stopping medications if feeling worse, and (4) being careless about taking medication. The score ranges from 0 (no items endorsed) to 4 (all items endorsed), with a score of 0 corresponding to high adherence and scores of 3 or 4 corresponding to poor adherence.

2.3.6. Ecological momentary assessment protocol—Participants were provided with an internet-enabled Samsung Fascinate smartphone, which was programmed to send twice-daily requests to complete a web-enabled survey of current momentary mood and related experiences. These requests were automatically sent at random times within two 3–4 h blocks every morning and every evening for 11 weeks. At the outset of the study, participants could select the earliest and latest time they would like to be alerted, so as not to interfere with their typical sleep/wake cycle. Once prompted to respond, participants had 15 minutes to complete the survey, after which they received a reminder prompt if no response was provided. The survey “expired” and could not be completed after two hours. Partial responses were logged such that participants did not need to complete all of the questions for data to be captured. At the outset of the study, participants were told to fill out the assessments as soon as they were received for the subsequent 11 weeks. They were also told that investigators would be able to monitor their data remotely but that stopping responding would not result in the participant being dropped from the trial. Participants were contacted every two weeks to provide an informal “check in” about their experience with the device, address any problems in receiving surveys, and remind them of their next assessment visit.

2.3.7. Ecological momentary assessment items—In total, eight momentary questions were asked during each survey time point. Momentary impulsivity (“How impulsive do you feel right now?”) was presented on a visual analogue scale from 1=”not at all” to 7=”extremely.” In addition to impulsivity, the following affective ratings were also measured at each time point in the same question format (“How _____ do you feel right now?”): happy”, “energetic”, “angry or upset”, “anxious or nervous”, “sad or depressed,” “stressed,” and “relaxed.” These questions were presented in this same order on each of the surveys. Participants also provided responses to questions about their current engagement in daily life activities (e.g., working, doing laundry), location (e.g., at home) and social context (e.g., alone). For this study, our analyses focused on positive and negative affect in relation to momentary impulsivity.

2.4. Statistical analysis

We first conducted a factor analysis of the seven affect items obtained from EMA, and found that the seven affect items divided into negative affect (four items: stressed, sad or depressed, angry or upset, anxious or nervous) and positive affect (three items: happy, energetic, relaxed). These two groupings explained 70.6% of the total variance. A Negative Affect Total Score and a Positive Affect Total Score, therefore, were created by summing items. Next, we examined the normality of the distributions of variables (none violated normality assumption), and calculated mean levels of negative and positive affect and impulsivity per individual aggregated across all time-points. We then correlated these mean values with baseline variables (e.g. suicidality, cognitive function, depressive symptoms) and mean levels of affect ratings aggregated across the study period. To assess variability in impulsivity, we calculated individual level within-person standard deviation for the impulsivity variable and correlated these values with the same variables above.

Finally, we evaluated lagged effects, adapting methods using daily process approaches (Gunthert et al., 2007), using generalized linear mixed models (GLMM). We first created lagged variables, shifting values one survey epoch before and excluding all lags greater than 24 h. We then evaluated a model with lagged positive and negative affect predicting impulsiveness ratings, adjusting for lagged impulsive ratings. These models evaluate the effect of recent affect on current impulsivity, adjusting for recent impulsivity. We then evaluated additional models with the converse: impulsiveness ratings predicting current positive and negative affect, controlling for yesterday's affect. For each of these analyses, subjects and time were included as a random effect and analyses, an autoregressive covariance structure was used. The p-value was set to 0.05 for all analyses.

3. Results

3.1. Sample characteristics

The sample was on average middle-aged (Mean age=47 years, SD=12), Caucasian (78%), educated with at least some college (Mean years of education=15, SD=2) and residing independently. Most of the participants were diagnosed as having Bipolar I disorder (87%) and had experienced the onset of illness in younger adulthood. At the time of baseline interview, the sample was, on average, experiencing a mild level of severity of depression on the MADRS, subthreshold severity of manic symptoms on the YMRS, and mild to non-detectable cognitive impairment on the RBANS. The majority of participants were taking a mood-stabilizer, and less than half were taking an anti-psychotic or anti-depressant. On average, participants reported at least some trouble in medication adherence on the MMAS-4, and the majority of participants were gauged to be at least at mild risk of suicide on the MINI Suicide Module. As such, the sample was consistent with other treated outpatient samples of patients with bipolar disorder (Simon et al., 2004) (Table 1).

3.2. Adherence to smartphone ratings

The 41 participants submitted a total of 2902 survey epochs over a maximum of 77 days (m=50.1 days, sd=17.6, range 12–76). A total of Adherence (number of days of survey completed/total number possible=65.1%, sd=0.22) and days on study was not associated

with mean impulsivity ratings (r=0.108, p=0.508) indicating that there was not a linear change in impulsivity over the course of the clinical trial.

3.3. Association of aggregate mean and within subject variability of subjective impulsivity with demographic and clinical variables

Mean subjective impulsivity, measured via EMA, was not associated with age, education, race/ethnicity or gender. As hypothesized, higher mean levels of subjective impulsivity were positively associated with more severe baseline manic symptoms, elevated baseline suicide risk, and self-reported problems with medication non-adherence. Also as hypothesized, impulsivity was negatively associated with baseline global cognitive function. Intra-subject variability in impulsivity was associated with worse cognitive function, greater manic symptoms, and greater suicide risk. Of note, among the other affect ratings, only mean happiness was (negatively) associated with suicide risk, and none of the other mean affect ratings were associated with medication adherence or cognition function (data not shown). Only aggregate ratings of angry/upset was associated with baseline YMRS scores, and all of the affect ratings were associated significantly with baseline MADRS Scores (e.g., positive affect r=−0.574, p<0.001 and negative affect r=0.522, r<0.001) (Table 2).

3.4. Association of mean level and instability of subjective impulsivity with affect ratings

Mean subjective impulsivity was correlated with negative affect scores and means of each of the individual negative affect items (stressed; sad or depressed; angry or upset; anxious or nervous). In positive affect items, impulsivity was inversely correlated with Positive Affect Total Score as well as happy and relaxed. In contrast to hypotheses, within subject variability in impulsivity was not associated with mean values of any of the affect ratings (Table 3).

3.5. Time-lagged models of positive and negative affect and subjective impulsivity

To evaluate whether negative or positive affect were associated with subsequent increases in impulsivity, we evaluated mixed models with lagged affect predicting impulsivity (these models controlled for lagged impulsivity). We found that greater lagged negative affect (p=0.005), but not positive affect (p=0.527), was associated with increased impulsiveness ratings. Additional models investigating the converse, lagged impulsivity predicting affect, revealed greater impulsivity predicting diminished positive affect (p=0.018) but was a non-significant (although marginal) predictor subsequent negative affect (p=0.117) (Table 4).

4. Discussion

4.1. Key findings

This is the first study, to our knowledge, to employ an intensive longitudinal data collection paradigm to assess subjective impulsivity in bipolar disorder. Patients with more severe manic symptoms and greater risk of suicide at baseline had higher aggregate values of impulsivity during the study period. Additionally, greater aggregated self-rated impulsivity was associated with diminished global cognitive function and with greater endorsement of medication adherence problems, such as forgetting medications or discontinuing their use when feeling well. Of note, other person-averaged intensively-sampled affective states gathered simultaneously with subjective impulsivity (e.g., sadness, anger) were largely

unrelated to baseline factors (except for depressive symptom severity). Overall levels of endorsement of feeling impulsive strongly correlated with overall levels of negative affect, in particular feeling anger, stress, sadness and anxiety. In contrast to what we expected, there was an inverse association between impulsivity and positive mood. Lagged models revealed negative affect (but not positive affect) seemed to predict greater increases in impulsivity, whereas impulsivity predicted diminished positive (but not negative) affect. These findings suggest subjective impulsivity may be part of dysfunctional approach to regulating negative affect. Moreover, these preliminary findings indicate that the antecedents and consequences of impulsivity could be effectively assessed with EMA methods.

4.2. Limitations

There are several limitations that deserve note. We lacked validated self-report measures of impulsivity or behavioral tasks with which to validate self-ratings of impulsivity. Thus the measurement of subjective impulsivity in this study must be considered preliminary. It is unclear if subjective impulsivity assessed in the moment differs from other measurement approaches, although prior work in other populations has identified moderate associations between more broadly mapped and validated momentary measures of impulsivity with rating scales (Tomko et al., 2014). Moreover, subjective experienced impulsivity may be important to study in its own right, potential revealing differences in patient perceptions of the construct and scientific definitions. We lacked data on behaviors that could have been classified as impulsivity-driven, and did not have available data from passive collection strategies such as movement patterns, frequency and timing, context and form of social interactions engaged in through the device (Faurholt-Jepsen et al., 2014). We also note that this study was a part of a clinical trial of an intervention that combined brief psychoeducation with reminders to engage in coping behaviors. Although there were no linear changes in impulsivity over the course of the trial, the results may differ in an untreated, purely naturalistic sample. Additionally, patients were, on average, mildly to moderately depressed and were not in a manic state at the outset of the study and the sample consisted of treated outpatients. Therefore, these results may not apply to patients in more acute states, in particular manic episodes. The comparative strength and sequence of associations between impulsivity and negative affect (versus positive affect) observed in this study may reflect the restricted variance in positive affect in the sample caused by depressive symptoms.

4.3. Comparison to other findings

Not withstanding these limitations, our aggregate findings on self-rated impulsivity corroborate associations found previously that impulsivity is associated with morbidity in bipolar disorder (Swann et al., 2008). Similar to some prior work (Watkins and Meyer, 2013), we found associations between aggregate impulsivity and baseline risk ratings for suicide (based on a structured interview that concatenates current ideation with past behavior). Of note, in the broader literature, the association of trait impulsivity and suicidality is small (Anestis et al., 2014). It possible that the EMA approach to impulsivity measurement reported here might be more specific to difficulty inhibiting urges and behaviors related to the management of negative emotions, which could be more directly linked to suicidal thoughts and behaviors. The association between global cognitive function

and impulsivity has been identified previously in a study that measured impulsivity with a rating scale (Powers et al., 2013), and it is possible that cognitive impairment (e.g., executive functions) may reduce capacity to effectively manage emotions (Green et al., 2007). Future studies with more in-depth neuropsychological testing might enable understanding of which cognitive functions relate to impulsivity and its association with affective symptoms. We also found that self-rated impulsivity was associated with problems in managing medication, which may deserve future study. The association could be bi-directional, with diminished exposure to medication association with impulsivity *vis a vis* diminished illness control, or impulsivity may interfere with the day-to-day intention to adhere and management of medications. Finally, we did not find associations between average intra-individual variation in impulsivity and affect ratings, which may be due to the limitations to capturing such variability with a single item indicator.

As hypothesized, greater self-rated impulsivity was associated with greater negative affect, but in contrast to hypotheses, inversely associated with positive affect. While there was a positive association between impulsivity and manic symptoms (in this sample largely subthreshold for mania), our findings did not seem consistent with positive emotions leading to greater impulsiveness. Rather, our lagged models indicated greater negative affect predicted increases in subjective impulsiveness, which is consistent with the finding that anxious patients with bipolar disorder are more prone to impulsivity on behavioral tasks (Bellani et al., 2012). When considering the other lagged models, our findings are more consistent with a seemingly maladaptive affect regulation process (Cooper et al., 2000), involving a “spiral” in which increases in negative affect predict greater impulsivity, which then predicts diminished positive affect. Unfortunately, we are unable to determine concurrent patterns in behavior during this affective sequence, such as whether patients engaged in a behavior that reduced positive affect. Nonetheless, mobile interventions could target dynamic and dysfunctional emotion regulation processes in bipolar disorder might reduce impulsivity, and our study would suggest that mitigation of negative affect might be an appropriate starting point.

4.4. Conclusions

Subjective impulsivity in bipolar disorder, gathered via a smartphone, appears to be associated with a number of negative illness factors, including diminished cognitive function, medication non-adherence, and higher suicide risk ratings. These findings are consistent with the broader literature on this multi-dimensional construct. Intensive longitudinal data gathered in this sample indicating that subjective impulsiveness may follow negative emotions (rather than positive ones), and future work may benefit from EMA methods in unraveling impulsivity in bipolar disorder; particularly its potential role as a disabling affect regulation strategy.

Acknowledgments

Funding source

The study was funded in part by National Institute of Mental Health Grants MH 077225 and MH100417 (CD), MH107260 (RM), and MH103318 (LE). The sponsors had no role in study design and no role in data collection, data analysis, data interpretation, or writing of the manuscript.

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Table 1

Sample characteristics (n=41).

	Mean (SD) or %	Range
Age	46.9 (11.8)	18–72
Sex (% female)	53.7%	–
Ethnicity		–
White	78.0%	
African-American	9.8%	
Asian	2.4%	
Latino/Hispanic	4.9%	
More than one ethnicity	4.9%	
Education (Years)	14.9 (2.1)	9–20
Marital Status (% Married)	14.6%	–
Living Situation		–
Independent living, in community	90.2%	
Residential facility	4.9%	
Homeless	4.9%	
Bipolar I (vs II)	87.8%	–
Age of First Onset of Mood Symptoms	21.9 (10.4)	–
Medications Prescribed		–
Mood stabilizer	75.0%	
Antipsychotic	46.3%	
Anti-depressant	56.1%	
Baseline MINI Suicide Risk Score		–
None (n=13)	31.7%	
Low (n=19)	46.2%	
Moderate/High: (n=9)	22.0%	
Baseline RBANS Total Score	84.9 (13.9)	60–110
Baseline MADRS Total Score	11.9 (9.0)	0–32
Baseline YMRS Total Score	7.2 (5.3)	0–19
Baseline MARS MAQ Score	1.3 (1.30)	0–4

Table 2

Associations between mean levels and instability of impulsivity with baseline clinical variables.

	Mean Subjective Impulsivity Rating Pearson *r* (*p*-value)	**Subjective Impulsivity Within-person Standard Deviation Pearson *r* (*p*-value)**
Age	−0.221 (0.171)	−0.207 (0.200)
Education	−0.145 (0.371)	−0.222 (0.169)
RBANS Total Baseline	**−0.453 (0.004)**	−0.307 (0.060)
MADRS Total Baseline	0.279 (0.081)	0.161 (0.319)
YMRS Total Baseline	**0.417 (0.007)**	**0.389 (0.013)**
MAQ Total	**0.436 (0.006)**	**0.317 (0.049)**
	Group Mean (SD) test statistic, *p*-value	**Group Mean (SD) Test statistic, *p*-value**
Gender	Women=2.4 (1.4)	Women=1.1 (0.7)
	Men=2.5 (1.3)	Men=1.0 (0.5)
	t(38)=0.1, *p*=0.921	*t*(38)=0.4, *p*=0.667
Ethnicity	White=2.4 (1.0)	White: 1.1 (0.6)
	Non-White=2.6 (1.7)	Non=White: 1.0 (0.7)
	t(38)=0.5, *p*=0.610	*t*(38)=0.2, *p*=0.850
MINI Suicide Risk	None=1.8 (0.7)	None: 0.7 (0.5)
	Low=2.6 (1.5)	Low: 1.1 (0.4)
	Medium/High=3.2 (1.3)	Medium/High: 1.4 (0.5)
	***F*(d*f*, 2,38)=3.7, *p*=0.034**	***F*(d*f*, 2,38)=0.022**

RBANS: Repeatable Assessment Battery for Neurocognitive Status; MADRS: Montgomery Asberg Depression Rating Scale; YMRS: Young Mania Rating Scale; MAQ: Morisky Adherence Questionnaire; MINI: MINI International Neuropsychiatric Interview.

Table 3

Association of aggregated subjective impulsivity with aggregated affect items with person-level mean values and variability.

	Mean Subjective Impulsivity Correlated with Mean Affect Ratings	Variability in Subjective Impulsivity Correlated with Mean Affect Ratings
POSITIVE AFFECT	**−0.468 (0.002)**	−0.001 (0.996)
Happy	**−0.462 (0.003)**	−0.039 (0.811)
Relaxed	**−0.496 (0.001)**	−0.047 (0.773)
Energetic	0.202 (0.211)	0.106 (0.517)
NEGATIVE AFFECT	**0.670 (0.001)**	0.220 (0.177)
Stressed	**0.585 (<0.001)**	0.176 (0.278)
Sad or Depressed	**0.613 (<0.001)**	0.132 (0.415)
Angry or upset	**0.732 (<0.001)**	0.215 (0.182)
Anxious or nervous	**0.584 (<0.001)**	0.164 (0.311)

Note: Variability indicated by within-person standard deviation; Pearson r correlation between mean impulsivity and wSD instability was 0.598, $p<0.001$.

Table 4

Lagged time-varying association between impulsivity and negative affect.

Variable	Coefficient	Std Error	*T*	*p*-value
T_{-1} Lagged Positive and Negative Affect Predicting Impulsivity[a]				
Negative Affect	0.114	0.041	2.8	**0.005**
Positive Affect	−0.022	0.035	0.6	0.527
T_{-1} Lagged Impulsivity Predicting Positive Affect[b]				
Impulsivity	−0.167	0.070	2.4	**0.018**
T_{-1} Lagged Impulsivity Predicting Negative Affect[c]				
Impulsivity	0.170	0.118	1.6	0.117

GLMM Models with an autoregressive covariance structure (AR1) and random effects for subject and time.

[a] Controlling for Lagged Impulsivity (coefficient=0.5, s.e.=0.03, t=15.8, p-value<0.001).

[b] Controlling for Lagged Positive Affect (coefficient=1.4, s.e.=0.07, t=19.6, p-value<0.001).

[c] Controlling for Lagged Negative Affect (coefficient, 2.5, s.e.=0.109, t=22.9, p-value<0.001).