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Differential involvement of trait impulsivity, fluid intelligence, and executive function in creativity among euthymic patients with bipolar disorder

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Abstract

Background: While anecdotal evidence suggests a link between bipolar disorder and heightened creativity, empirical studies are scarce, and the underlying cognitive mechanisms remain unclear. This study aimed to explore the association between trait impulsivity, executive function, fluid intelligence, and creativity among euthymic patients with bipolar disorder.

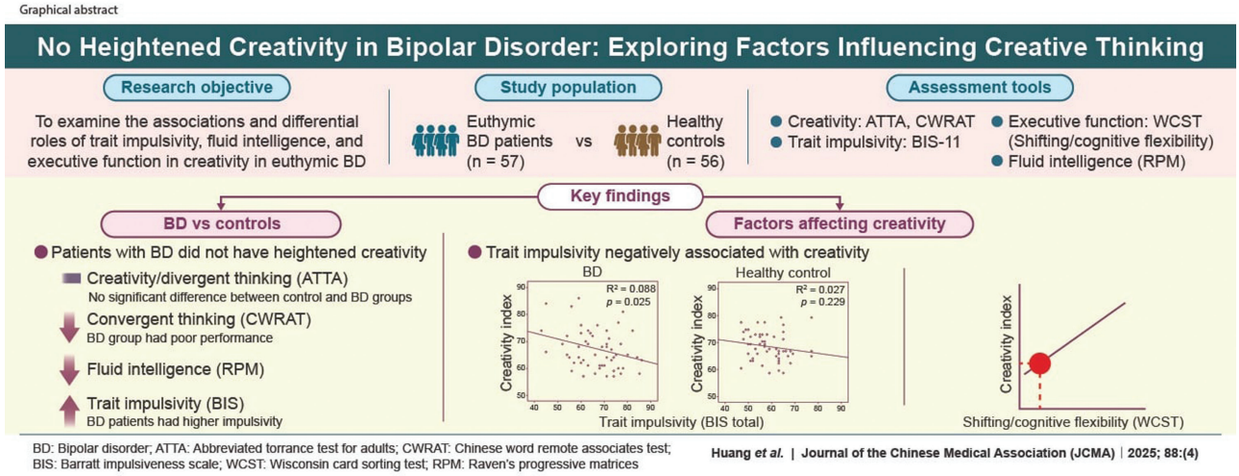
Methods: Euthymic outpatients with bipolar disorder and age- and sex-matched healthy controls were enrolled in this cross-sectional study. Creativity was assessed using the Abbreviated Torrance Test for Adults and the Chinese Word Remote Associates Test, which examined divergent thinking and convergent thinking, respectively. Trait impulsivity was measured using the Barratt Impulsiveness Scale, while cognitive flexibility was evaluated using the Wisconsin Card Sorting Test. Fluid intelligence was assessed using Raven's Progressive Matrices. General linear models were used to assess the associations between these cognitive measures.

Results: Fifty-seven euthymic patients with bipolar disorder and 56 controls were recruited. Euthymic patients with bipolar disorder exhibited comparable overall creativity to controls but underperformed in convergent thinking. General linear models confirmed a negative association between trait impulsivity and creativity, primarily observed in patients with bipolar disorder. Cognitive flexibility positively correlated with creativity among patients with bipolar disorder, independent of fluid intelligence.

Conclusion: Our study showed that euthymic patients with bipolar disorder do not have heightened creativity. The findings underscore the importance of considering trait impulsivity and cognitive factors in understanding creativity in bipolar disorder.

Keywords: Bipolar disorder; Cognitive flexibility; Convergent thinking; Divergent thinking; Trait impulsivity

Graphical abstract



1. INTRODUCTION

Bipolar disorder (BD) is a chronic and recurrent affective disorder characterized by manic and depressed episodes. Despite the inherent challenges posed by mood swings, patients with BD have reported certain advantages, notably increased creativity.[1–3] Measuring creativity is challenging, lacking a universal definition. Common conceptions of creativity highlight novelty and originality, with assessments typically focusing on divergent thinking (the capacity to generate highly variable or original

solutions to a given problem) and creative problem-solving/convergent thinking (ie, problems that can be resolved insightfully or analytically, often involving a reorganization of the problem's framework). Recent studies have also emphasized the significance of affective temperament or personality in the creativity of BD individuals.[4] Creativity in BD has predominantly been examined as a trait, with studies often documenting higher rates of BD in creatively eminent individuals through retrospective diagnoses or biographical research. However, limitations in retrospective studies, relying on biographical information rather than diagnostic interviews and lacking standardized diagnostic criteria, may overestimate BD incidence in creative populations and compromise reliability. Studies examining general clinical populations not specifically chosen for creativity may provide a clearer understanding of the association between BD and enhanced creativity.[1] Another approach involves exploring shared underlying cognitions between BD and creativity, such as impulsiveness and executive function.

Impulsiveness, a feature of BD, evident during mood episodes and as a trait characteristic in BD, may contribute to the association with creativity. Behavioral tasks of impulsivity indicated that cognitive inhibition prevents irrelevant information connections, enabling more effective cognitive allocation toward creative problem-solving.[5–7] However, it should be noted that impulsivity is a multifaceted construct with state impulsivity and trait impulsivity. State impulsivity, measured by behavioral tasks, is a transient and situational manifestation influenced by triggers like emotions or environmental cues. On the other hand, trait impulsivity, measured through self-report questionnaires, represents a stable predisposition toward impulsive behavior across diverse situations and it is not necessarily aligned with an individual's state impulsivity.[8] Commonly used psychological assessment tools to examine trait impulsivity include the Barratt Impulsiveness Scale (BIS-11) and the UPPS-P Impulsive Behavior Scale.[9,10] The BIS provides a broad measure of overall impulsivity, while the UPPS-P is grounded in the five-factor model, distinguishing different pathways and types of impulsive behavior. While the connections between creativity and state impulsivity have been demonstrated, the association between creativity and trait impulsivity in BD warrants further investigations.

Achieving creative performance involves deviating from conventional routes, contemplating and recombining diverse and unrelated concepts, and showing flexibility of perspective. This implies that the core facets of executive function (EF)—updating, shifting, and inhibition—may also play a crucial role in creativity. Updating is the ability to monitor and revise the content of working memory by replacing old information with new, relevant information; shifting, a form of cognitive flexibility, represents the ability to switch attention between different tasks or mental sets, adapting to changing demands or priorities. Evidence indicates a positive correlation between creativity and inhibition as well as updating abilities, but the association with shifting/cognitive flexibility remains uncertain.[11,12] The relationship between EF and creativity is consistently correlated with intelligence, particularly fluid intelligence, which plays a key role in creative thinking.[13,14] In addition, divergent thinking and fluid intelligence both require shifting/cognitive flexibility—a higher-order function often disrupted in BD.[15] Fluid intelligence involves the deliberate use of various mental processes to address novel challenges, including concept development, inference-making, relationship identification, classification, and hypothesis generation.[16] Despite this, the link between fluid intelligence and creativity remains debated, with no clear consensus.[11] Understanding how fluid intelligence, shifting/cognitive flexibility and creativity interact may provide insight into cognitive and creative potential in patients with BD.

Creativity is not only valuable for solving problems and driving innovation in the workplace but is also a fundamental aspect of personal development. A deeper comprehension of trait impulsivity, EF, and their correlation with creativity could provide valuable insights into the prognosis of BD, and could inform the development of treatment approaches that target both aspects. Additionally, studying patients with BD in the euthymic state minimizes the impact of mood episodes (mania/hypomania or depression) on cognitive processes, fluid intelligence, and impulsivity, allowing researchers to more accurately assess baseline cognitive and impulsive traits in BD and their relationship to creativity without the confounding effects of mood fluctuations. The aim of this study was to investigate the differential involvement of trait impulsivity, fluid intelligence, and EF in creativity among euthymic patients with BD.

2. METHODS

2.1. Patient selection

Consecutive outpatients, aged 20 to 50 years, diagnosed with BD based on the Mini-International Neuropsychiatric Interview (MINI)[17] and the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5),[18] were enrolled from the psychiatric outpatient department of the related hospital. All participants were in a stable mood state, indicated by scores below 7 on both the Montgomery-Asberg Depression Rating Scale (MADRS) and the Young Mania Rating Scale (YMRS).[19,20] Exclusion criteria comprised major physical illnesses (eg, head trauma resulting in prolonged loss of consciousness or cognitive impairment), as well as a diagnosis of schizophrenia or other psychotic disorders according to the DSM-5. Patients were undergoing treatment with diverse antipsychotic, antidepressant, and mood-stabilizers. A cohort of healthy participants without any DSM-5 diagnoses, matched for age and sex, was recruited through posters within the clinic and community. These participants underwent thorough clinical evaluations by a psychiatrist to confirm the absence of psychiatric illness. The institutional review board of the related hospital approved the study, which adhered to the Declaration of Helsinki principles. Written informed consent was obtained from all participants before study inclusion.

2.2. Clinical assessment

Demographic characteristics, including age, sex, education, duration of illness, and use of psychotropic medications specifically for BD, were collected from all participants. The severity of depression and manic symptoms of patients with BD was evaluated using the MADRS and the YMRS, respectively.

2.2.1. Creativity

Two tests of creativity were used: the Chinese version of the Abbreviated Torrance Test for Adults (ATTA)[21,22] to assess divergent thinking and the Chinese Word Remote Associates Test

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(CWRAT)[23] to assess creative problem-solving and convergent thinking.

The ATTA involves participants responding to one verbal and two figural tests. The test encourages individuals to generate original responses to verbal or visual stimuli, assessing their imagination problem-solving ability. The evaluation includes four norm-referenced measures: (1) fluency, assessing the ability to generate a large number of relevant ideas; (2) originality, evaluating the generation of uncommon or entirely new ideas; (3) elaboration, measuring the ability to embellish ideas with details; and (4) flexibility, gauging the capacity to process information or objects in diverse ways for the same stimulus. The study utilizes the creativity index, scored based on the sum of four norm-referenced measures and fifteen criterion-referenced indicators. Using the standard ATTA assessment procedure (Supplementary Table 1, http://links.lww.com/JCMA/A317),[22] five verbal and ten nonverbal criterion-referenced indicators were identified. The verbal indicators were derived from the verbal test, while the nonverbal indicators came from the two figural tests. Each of the fifteen indicators received a score: 0 if absent, 1 if present once, and 2 if present more than once. According to Chen,[22] the test-retest reliability of various creativity indicators of the Chinese version of ATTA ranges from 0.34 to 0.68; the inter-rater reliability ranges from 0.31 to 0.97, indicating that this test has good stability. In terms of validity, the correlations with the "Problem Solving Creativity Test" are 0.37 and 0.46, both reaching the reliability level of 0.05.[22]

The CWRAT is an adaptation of Mednick's Remote Association Test (1962).[24] Cronbach's α was 0.81, and criterion-related validity showed a positive correlation with insight problem-solving (r = 0.51), while discriminant validity testing using the New Creativity Test revealed no correlation with divergent thinking (r = –0.06 to 0.08).[23] In each CWRAT session, participants encounter 30 questions, each comprising three seemingly unrelated stimulus words. The challenge is to generate a fourth word that connects to all three initial words. The test prompts individuals to identify unexpected connections between the provided words. Scores are then calculated based on the number of correct responses, with a higher score indicating better remote associative ability.

2.2.2. Trait impulsivity

When assessing trait impulsivity, we chose the BIS-11 over the UPPS-P Impulsive Behavior Scale because the BIS-11 is shorter than the UPPS-P (59 items), with fewer items to complete. This can reduce respondent burden and improve completion rate. The BIS-11 was used to gather self-reported assessments of trait impulsivity through 30 queries, graded on a four-point Likert scale from 1 (rarely/never) to 4 (almost always/always). The BIS-11 assesses impulsive behavior across three second-order factors: attentional (lack of focus on tasks), motor (acting without thinking), and non-planning (present orientation rather than future). These second-order factors are derived from six first-order factors: attention and cognitive instability (attentional), motor and perseverance (motor), and self-control and cognitive complexity (non-planning).[9] Most studies reporting BIS-11 scores have focused on the three second-order factors.[25] Using second-order factors could reduce the complexity of the analysis by grouping the first-order factors into larger categories, and may maintain statistical robustness under multiple comparison corrections. Higher scores indicate increased trait impulsivity. The BIS-11 has acceptable internal consistency as indicated by Cronbach's alphas ranging from 0.79 to 0.83.[9] Patient with BD were classified as highly impulsive or within normal limit with a cutoff score of 71 on BIS-11 in the statistical analysis.[25]

2.2.3. Executive function

EF was evaluated utilizing a computerized Wisconsin Card Sorting Test (WCST), a commonly used tool in neurobiological and neurocognitive investigations. Specifically, the WCST is a neuropsychological test of set-shifting, a capability to show cognitive flexibility in response to changes in reinforcement stimuli. According to the manual,[26] the following indices were assessed: (1) percent errors: total errors divided by the number of trials conducted; (2) percent perseverative responses: dividing the total number of perseverative responses by the number of trials administered; (3) percent perseverative errors: the ratio of perseverative errors relative to overall test performance; (4) conceptual level response: representing the proportion of consecutive correct responses occurring in runs ≥3, indicative of insight into correct sorting principles; and (5) number of categories completed.

2.2.4. Fluid intelligence

The Raven's Progressive Matrices (RPM) is a nonverbal test commonly used to assess abstract reasoning and fluid intelligence. Comprising 60 multiple choice questions arranged by increasing difficulty, the RPM presents subjects with a 3 × 3 matrix. Each cell, except the last one, contains various geometric figures. Participants were asked to analyze the patterns in other rows and columns, deducing rules that govern these features. Using these rules, the participants were asked to determine the correct answer for the blank cell from a set of eight options. For each question, the correct response is given a score of 1, and any of the 5 to 7 incorrect responses is given a score of 0. The maximum total score for the test is 60. The RPM test has high test-retest reliability, with a correlation coefficient of 0.89.[27]

2.3. Statistical analyses

Independent sample t test and the chi-squared test were used to compare continuous and categorical data, respectively. To initially test the relationship between creativity, cognitive function, and trait impulsivity, Spearman bivariate analyses were used to examine the correlations between age, education, BIS-11 total scores, creativity index, RPM, CWRAT, and performance in WCST. General linear models (GLMs) were applied to assess creativity across groups (BD patients with normal or high trait impulsivity, and the controls), adjusting for age, sex, education, duration of illness, mood symptom severity, and psychotropic medication use. Then, linear regression models were used to examine the association between creativity, EF, and fluid intelligence, controlling for age, sex, education, duration of illness, mood symptom severity, psychotropic medication use, and disease group (patients with BD and the controls). Subanalyses stratified by disease group were also performed. The Benjamini-Hochberg false discovery method managed multiple comparisons. A p value of <0.05 was considered significant. Statistical analyses were conducted using SPSS 11.5 (SPSS Inc., Chicago, IL).

3. RESULTS

A total of 57 euthymic patients with BD (27 were bipolar I disorder and thirty are bipolar II disorder) and 56 healthy individuals were recruited in this study. Patients with BD significantly underperformed in convergent thinking and fluid intelligence compared to healthy controls (assessed using the CWRAT and RPM, respectively; Table 1). They also exhibited higher trait impulsivity, as assessed by the BIS-11, and showed greater impulsiveness across all second-order factors: attentional, motor, and non-planning, compared to healthy subjects (Table 1). No

Table 1

Demographic data and clinical characteristics of patients with bipolar disorder and healthy controls

n (%) or mean ± SD	BD (n = 57)	Controls (n = 56)	*p*
Age, y	35.2 (8.5)	33.9 (7.6)	0.400
Female	30 (53.6)	34 (60.7)	0.449
Education, y	14.9 (2.0)	16.4 (1.6)	<0.001
Duration of illness, y	10.8 (6.3)	0	
MADRS total score	3.50 (1.85)	0	
YMRS total score	4.33 (2.08)	0	
Performance of creative thinking			
ATTA (creativity index)	67.28 (7.33)	67.93 (5.90)	0.606
Fluency	15.00 (1.94)	15.30 (1.71)	0.379
Originality	13.91 (2.43)	13.30 (2.19)	0.165
Elaboration	16.75 (1.48)	16.63 (1.59)	0.655
Flexibility	15.18 (2.25)	15.55 (2.34)	0.382
CWRAT	13.89 (5.22)	18.11 (5.44)	<0.001
Raven's Progressive Matrices	34.68 (7.63)	39.98 (6.22)	<0.001
BIS			
Total score	66.58 (9.92)	58.95 (7.48)	<0.001
Second-order factor			
Attentional	17.46 (3.54)	14.75 (2.52)	<0.001
Motor	22.79 (4.69)	21.15 (3.09)	0.032
Non-planning	26.52 (4.45)	23.04 (3.53)	<0.001
WCST			
Percent errors	21.85 (8.87)	22.96 (14.92)	0.645
Percent perseverative responses	11.12 (5.59)	13.67 (15.05)	0.255
Percent perseverative errors	10.42 (4.55)	12.06 (11.80)	0.354
Percent conceptual level responses	73.02 (11.78)	72.49 (19.53)	0.868
Number of categories completed	5.69 (0.88)	5.45 (1.28)	0.290
Medications			
Antipsychotics	31 (55.4)	0	
Antidepressants	26 (46.4)	0	
Mood stabilizers	39 (69.6)	0	

ATTA = Abbreviated Torrance Test for Adults; BD = bipolar disorder; BIS = Barratt Impulsiveness Scale; CWRAT = Chinese Word Remote Associates Test; MADRS = Montgomery-Asberg Depression Rating Scale; WCST = Wisconsin Card Sorting Test; YMRS = Young Mania Rating Scale.

Table 2

Correlation of measures in trait impulsivity, fluid intelligence, executive function and performance of creative thinking from general linear models, with the adjustment of age, sex, level of education, duration of illness, mood symptom severity, psychotropic medication use, and disease group

	Creativity index			CWRAT		
	***B* (95% CI)**	***t***	***p***	***B* (95% CI)**	***t***	***p***
BIS total	**–0.224 (–0.362 to –0.087)**	**–3.231**	**0.002**	–0.002 (–0.104 to 0.100)	–0.041	0.968
Attentional	–0.325 (–0.745 to 0.096)	–1.531	0.129	–0.003 (–0.303 to 0.296)	–0.023	0.982
Motor	**–0.453 (–0.767 to –0.139)**	**–2.862**	**0.005**	0.113 (–0.117 to 0.343)	0.972	0.333
Non-planning	**–0.452 (–0.759 to –0.145)**	**–2.923**	**0.004**	–0.097 (–0.319 to 0.125)	**–**0.867	0.388
Raven's progressive matrices	0.125 (–0.083 to 0.334)	1.191	0.237	**0.158 (0.013-0.303)**	**2.161**	**0.033**
WCST						
Percent errors	–0.130 (–0.240 to –0.020)	–2.351	0.021	–0.054 (–0.135 to 0.026)	–1.342	0.183
Percent perseverative responses	–0.107 (–0.223 to 0.010)	–1.819	0.072	–0.060 (–0.144 to 0.024)	–1.418	0.159
Percent perseverative errors	–0.160 (–0.308 to –0.013)	–2.155	0.034	–0.083 (–0.190 to 0.024)	–1.538	0.127
Percent conceptual level responses	0.086 (0.003-0.169)	2.055	0.043	0.041 (–0.019 to 0.101)	1.352	0.180
Number of categories completed	1.003 (–0.156 to 2.163)	1.718	0.089	0.280 (–0.564 to 1.123)	0.659	0.512

BIS = Barratt Impulsiveness Scale; CWRAT = Chinese Word Remote Associates Test; WCST = Wisconsin Card Sorting Test.

statistical differences were found in WCST, creativity index and subscores of ATTA between BD patients and healthy subjects.

Bivariate correlation analyses showed that age negatively correlated with both divergent and convergent thinking tasks, and educational level positively correlated with creativity (Supplementary Table 2, http://links.lww.com/JCMA/A317). Divergent thinking (creativity index) was negatively associated with trait impulsivity (BIS-11), and convergent thinking (CWRAT) was positively associated with fluid intelligence (RPM). Divergent thinking, convergent thinking, and fluid intelligence were all positively linked to shifting/cognitive flexibility (WCST). Linear regression analyses with adjustment of

Table 3

Correlation of Barratt impulsiveness scale and performance of creative thinking among patients with bipolar disorder and healthy controls from general linear models, with the adjustment of age, sex, level of education, duration of illness, mood symptom severity, and psychotropic medication use

	Bipolar disorder				Healthy controls			
	Creativity index		CWRAT		Creativity index		CWRAT	
	B (SE)	*p*	B (SE)	*p*	B (SE)	*p*	B (SE)	*p*
BIS total	**–0.255 (0.098)**	**0.012**	–0.001 (0.065)	0.986	–0.145 (0.105)	0.174	0.023 (0.089)	0.795
Attentional	–0.187 (0.312)	0.551	0.059 (0.192)	0.760	–0.475 (0.308)	0.129	–0.020 (0.262)	0.940
Motor	**–0.474 (0.210)**	**0.029**	0.032 (0.139)	0.821	–0.384 (0.265)	0.154	0.352 (0.219)	0.113
Non-planning	**–0.623 (0.221)**	**0.007**	–0.034 (0.142)	0.809	–0.130 (0.227)	0.568	–0.136 (0.188)	0.473
Raven's progressive matrices	0.121 (0.157)	0.446	0.093 (0.098)	0.349	0.110 (0.142)	0.444	**0.246 (0.114)**	**0.035**
WCST								
Percent errors	**–0.278 (0.119)**	**0.024**	–0.128 (0.077)	0.102	–0.094 (0.059)	0.120	–0.047 (0.052)	0.370
Percent perseverative responses	**–0.422 (0.188)**	**0.030**	–0.068 (0.124)	0.586	–0.081 (0.056)	0.154	–0.075 (0.047)	0.120
Percent perseverative errors	**–0.597 (0.225)**	**0.011**	–0.117 (0.151)	0.441	–0.116 (0.071)	0.109	–0.097 (0.061)	0.115
Percent conceptual level responses	0.168 (0.090)	0.068	0.099 (0.056)	0.086	0.065 (0.045)	0.151	0.032 (0.039)	0.417
Number of categories completed	2.186 (1.188)	0.072	0.642 (0.764)	0.405	0.642 (0.650)	0.328	0.293 (0.558)	0.602

CWRAT = Chinese Word Remote Associates Test.

covariates revealed a negative association between the BIS-11 total score and creativity index, and this association was only found among patients with BD (Tables 2 and 3, Fig. 1). The second-order factors: motor and non-planning in the BIS-11 were also significantly negatively correlated with the creativity index; the correlations were only observed in BD (Tables 2 and 3). Regarding the correlation between EF and creativity, percent errors, percent perseverative responses, and percent perseverative errors in WCST negatively linked to creativity index among patients with BD (Table 3). These correlations were only found among patients with BD and were still significant even additionally adjusting for RPM (Table 3). Although no significant associations were found between fluid intelligence and divergent thinking among patients with BD or the controls, sub-analyses showed that fluid intelligence was significantly positively associated with originality in the ATTA among the healthy subjects ($t = 2.938$, $p = 0.005$).

The GLM, adjusted for covariates, revealed that patients with high trait impulsivity exhibited worse divergent thinking compared to those with normal levels of BIS-11 total score and the healthy subjects (Fig. 2). Additionally, patients with BD, regardless of their level of trait impulsivity, had lower capacity for convergent thinking than healthy controls (Fig. 2).

4. DISCUSSION

The current study found that euthymic patients with BD had higher trait impulsivity and underperformed in convergent thinking and fluid intelligence as compared to healthy controls. Trait impulsivity was negatively associated with divergent thinking, while shifting/cognitive flexibility positively correlated with divergent thinking. These associations were only found among patients with BD, even after adjusting for fluid intelligence. Given the multifaceted nature of impulsivity, we further explored the contribution of the three BIS-11 subscales to divergent thinking (creativity index). Our findings demonstrated significant correlations between non-planning impulsiveness and divergent thinking in BD, highlighting that the connections between divergent thinking and trait impulsivity partly stemmed from a specific relationship with the subscale covering disorganization, and a tendency to prioritize present gratification over careful planning.

We observed a significant negative correlation between trait impulsivity and divergent thinking in euthymic patients with BD, a relationship that was not present in healthy controls. This difference may be attributable to neurobiological distinctions between BD patients and healthy individuals. Specifically, previous research has linked divergent thinking in euthymic BD patients, other than healthy controls, to the right middle frontal cortex,[28] a region where decreased activation and connectivity have been associated with trait impulsivity.[29] Furthermore, greater variability in traits such as impulsivity and creativity in BD patients, compared to controls, may enhance the detection of significant associations within the BD group. Creativity encompasses a process with divergent thinking followed by convergent thinking. While the convergent thinking phase typically aims for a single correct solution, the divergent thinking phase is perceived as more creative as it encourages the generation of multiple, often unconventional ideas in response to a complex problem.[30] Literature has provided evidence that impulsivity negatively correlates with divergent thinking, specifically with fluency and flexibility of creativity.[31] However, not all studies find support for such relation. For instance, a study by TA Greenwood, conducted with a sample of 111 euthymic patients with BD, found no significant association between trait impulsivity and divergent thinking.[32] And there also exists a view that 'creative people are usually characterized by increased impulsivity'.[33] These above-mentioned inconsistent results may stem from variations in the types of tasks assessing impulsivity and creativity. Another potential explanation for the varying relationship between creativity and impulsivity could lie in differential engagement of inhibition. Evidence suggests that individuals with high levels of creativity tend to display slower responses in tasks requiring inhibition of distracting information, while exhibiting quicker responses in tasks devoid of such interference.[34] Moreover, differing levels of cognitive inhibition may correspond to distinct phases of the creative process. Reduced cognitive inhibition appears advantageous in the initial stages, facilitating the assimilation of a broad spectrum of information for the generation of novel ideas. Conversely, heightened cognitive inhibition becomes advantageous in later stages, enabling a deliberate, analytical approach to information processing conducive to producing innovative responses.[35] This perspective suggests that creativity may be linked to the flexible modulation of inhibitory control rather than a dichotomous classification as either low or high inhibition capacity.[36]

Our results indicated that shifting/cognitive flexibility can aid divergent thinking in euthymic BD patients, shedding light on

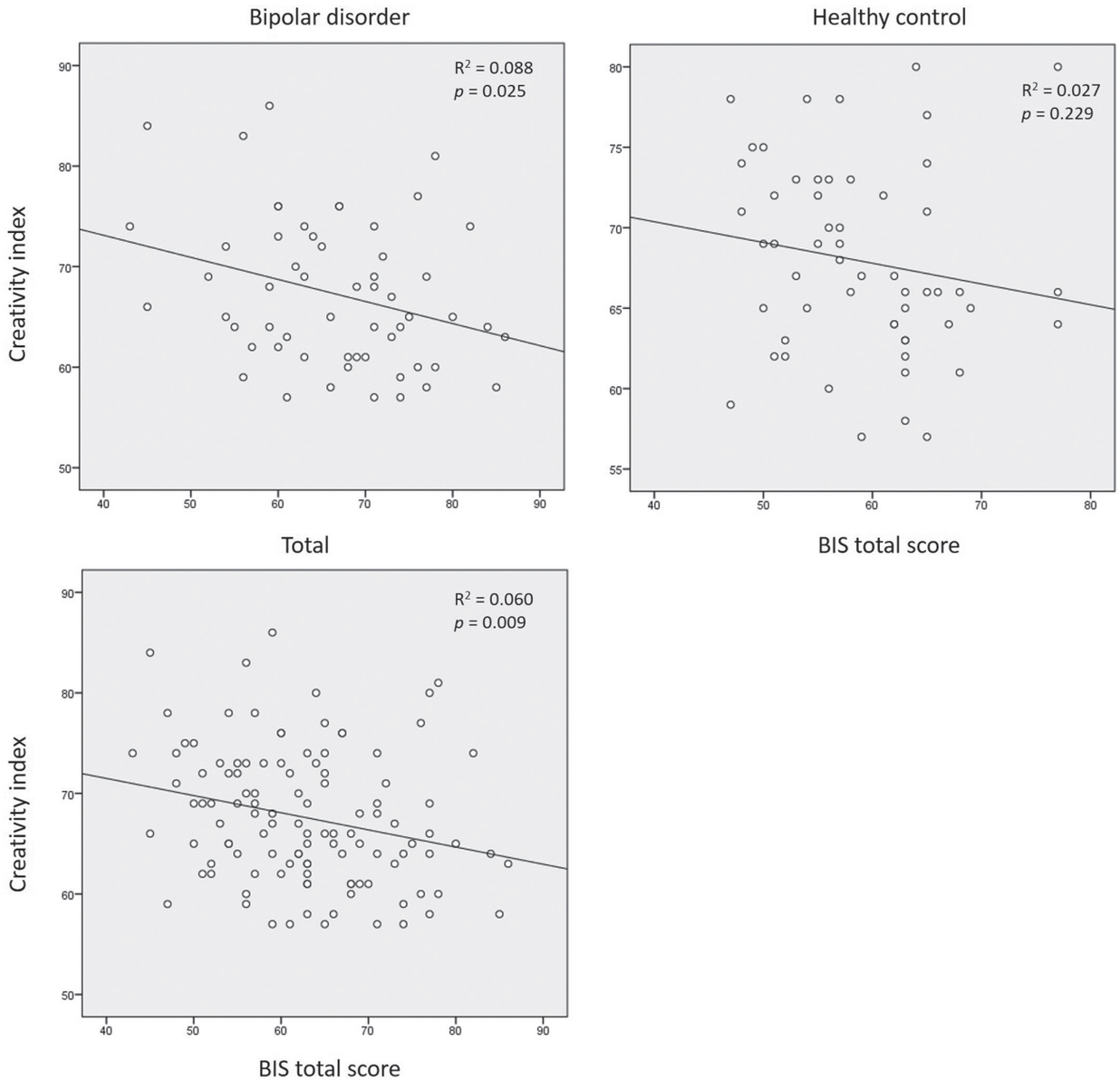

Fig. 1 BIS-11 total score was negatively associated with creativity index, and such significant correlation was only found among euthymic patients with BD. BD = bipolar disorder; BIS = Barratt Impulsiveness Scale.

the higher-order cognitive processes underlying individual variations in creativity.[37] This top-down cognitive process plays a significant role in the selection and assessment of ideas, facilitating enhanced efficiency in memory retrieval and implementation.[11] Additionally, it helps mediate task-switching abilities,[38] allowing individuals to override dominant responses and shift toward more creative, innovative ideas, ultimately enhancing divergent thinking.[39] Several studies have related divergent thinking to cognitive flexibility in adults,[40] and Soeiro-de-Souza et al[12] found that creativity may be influenced by EF measures only during manic episodes from a mixed cohort of BD patients experiencing a manic, mixed, or depressive episodes. A research involving 209 school-aged children revealed that cognitive flexibility, rather than intelligence, was a significant predictor of creativity.[41] Although the biological mechanisms of creativity remain largely unexplored, functional imaging studies indicate a potential involvement of the prefrontal cortex.[42] In addition, a close relationship between EF and creativity has been supported by a functional magnetic resonance imaging research: Goel and Vartanian[43] discovered that in healthy adults, engaging in creative problem-solving tasks triggered heightened activity in the prefrontal cortex compared to merely confirming solutions. They also suggested that the right ventrolateral prefrontal cortex plays a crucial role in the neural process of set-shifting.

Among the four subscales of ATTA, originality was positively associated with fluid intelligence as assessed by RPM among healthy controls. Our findings corroborate the significance of fluid intelligence in improving the ability to manage inference and recognize intricate ideational strategies.[44,45]

This study had several limitations. First, the study is limited due to its cross-sectional design, which only enables associations rather than deducing causal relationships between variables.

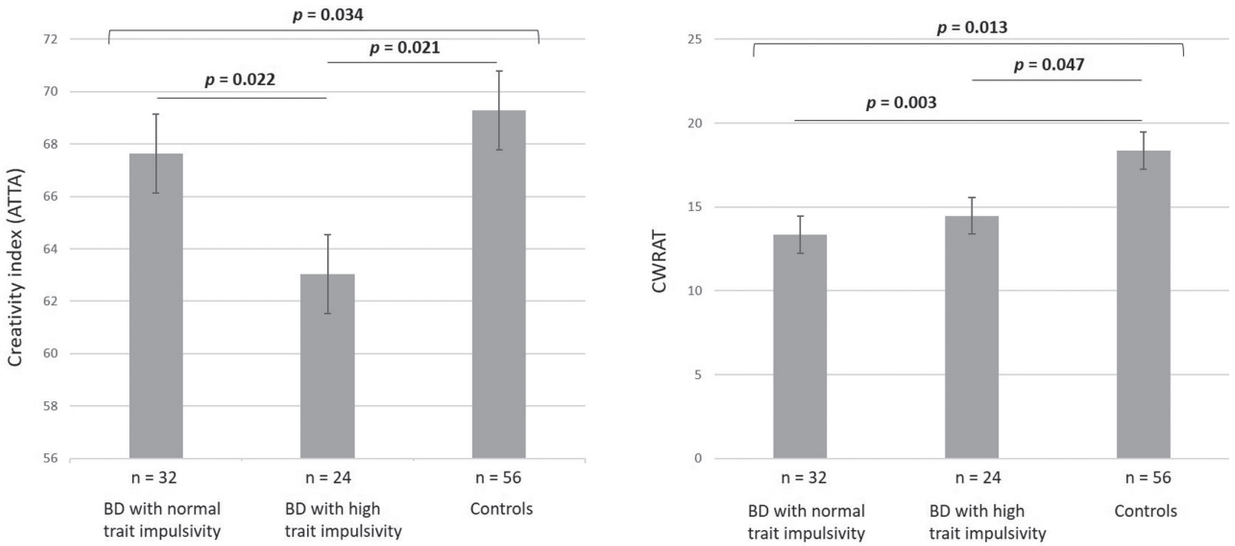

Fig. 2 Comparison of creativity index and Chinese word remote associates test among bipolar patients of average or high levels of trait impulsivity, adjusting for age, sex, education, illness duration, psychotropic medication use, and mood symptoms. ATTA = Abbreviated Torrance Test for Adults; BD = bipolar disorder.

Second, only euthymic patients with BD were recruited, so the influence of different mood states on creativity could not be assessed. Positive affect, a main characteristic of mania, can enhance verbal fluency and problem-solving abilities.[46,47] It should be noted that while hypomania is tied to creativity, full-blown mania may impede it.[48] Third, patients included in this study were undergoing treatment with psychotropic medications during assessment, which could have impacted the findings. However, the influence of psychotropic medications on neurocognitive function lacks consensus.[49] Ethically, patients were allowed to continue their medications, and psychotropic medications were adjusted for in the analyses. Another potential confounding factor, premorbid intellectual function, was not controlled for in this study. To address this limitation, educational level, which strongly correlates with premorbid IQ, was accounted for in the analysis.[50] Finally, history of alcohol or substance use disorder, and the number of previous mood episodes were not identified in this study, which may confound our results and should be address in future studies.

Strength of the current study includes an examination of a clinical population not selected for creativity, which may better address the level of creativity and associated cognitive factors in BD. Both divergent thinking and convergent thinking are used alternatively throughout the creative process,[51] and were assessed in this study. Our findings strengthen the hypothesis of a link between trait impulsivity, EF, and creativity in BD. Recognizing the variability in these characteristics among individuals with BD enables personalized care plans. Enhancing cognitive flexibility through targeted interventions may help improve creative thinking in BD patients, which could contribute to their overall functioning and quality of life. Tailoring treatment approaches to individual cognitive profiles in BD can promote personalized care, particularly in addressing both impulsivity and executive dysfunction, potentially optimizing outcomes in clinical and occupational settings.

Taken together, our findings highlight the negative impact of trait impulsivity on divergent thinking, alongside the positive role of shifting/cognitive flexibility in supporting creative processes. These associations were particularly pronounced in euthymic BD patients, suggesting unique cognitive profiles in this population. Future research should further investigate the biological and neurocognitive mechanisms underlying these relationships, with the aim of developing targeted interventions that enhance cognitive and creative capabilities, ultimately enhancing quality of life and clinical outcomes for individuals with BD.

APPENDIX A. SUPPLEMENTARY DATA

Supplementary data related to this article can be found at http://links.lww.com/JCMA/A317.

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