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Cognitive Profile and Relationship with Quality of Life and Psychosocial Functioning in Mood Disorders

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Abstract

Background: Comparisons between healthy controls (HCs) and individuals with mood disorders have shown more cognitive dysfunction among the latter group, in particular in bipolar disorder (BD). This study aimed to characterize the pattern of cognitive function of BD and major depressive disorder (MDD) and compare them to HC using the (CogState Research Battery) CSRB™.

Method: Participants were tested, comprising the following domains: processing speed, attention, working memory, visual memory, executive functions, and verbal memory. Quality of life and functionality were also assessed. Multiple linear regression models were performed to examine the effect of demographic characteristics and functionality on cognitive outcomes separately for BD and MDD.

Results: Ninety individuals participated in the study, of which 32 had BD, 30 had MDD, and 28 were HC. Differences were found between both BD and MDD and HC for the composite cognitive score, with significant differences between BD and HC (Diff $= -5.5$, 95% CI $= [-9.5, -1.5]$, $p = 0.005$), and MDD and HC (Diff $= -4.6$, 95% CI $= [-8.6, -0.5]$, $p = 0.025$). There were overall significant differences in five cognitive domains: processing speed ($p = 0.001$ and $p = 0.004$), attention ($p = 0.002$), working memory ($p = 0.02$), visual memory ($p = 0.021$), and verbal memory ($p = 0.007$). BD also presented worse performance than both MDD and HC, and MDD presented better performance than BD but worse than HC in quality of life and functionality. Multiple linear regression models were significative for education ($p < 0.001$) and age ($p = 0.004$) for BD and education ($p < 0.001$) for MDD.

Conclusion: In general, cognition is more affected in BD than MDD, which could be associated with functional and quality of life impairment.

Keywords: Cognitive impairment; Cognitive functioning; Quality of life; Bipolar disorder; Depression

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Introduction

Bipolar disorder (BD) and major depressive disorder (MDD) are complex, chronic, and severe mental illnesses with a high global prevalence (American Psychiatric Association [APA], 2013). BD is a highly disabling illness due to its early onset, severity, and chronicity, with a lifetime prevalence of 0.6% for type I BD, 0.4% for type II BD, and 2.4% for BD spectrum (Merikangas et al., 2011) and is also in the top five leading causes of disability-adjusted life year (DALY) among mental and substance use disorders (Whiteford, Ferrari, Degenhardt, Feigin, & Vos, 2015). MDD is one of the most common mental disorders and has a lifetime and 12-month prevalence ranging, respectively, from 11.1% to 14.6% and 5.5% to 5.9% (Bromet et al., 2011). Moreover, it is the third cause of burden and is responsible for the highest DALY (Ferrari et al., 2013). Both BD and MDD are associated with high rates of impairment with direct impacts on functional outcomes, such as quality of life, execution of daily activities, and treatment response, even during periods of euthymia (Grande, Berk, Birmaher, & Vieta, 2016; Mcintyre et al., 2018; Russo, Mahon, & Burdick, 2015; Solé et al., 2012, 2017).

Cognitive dysfunction is part of the symptomatology of both MDD and BD even during euthymic periods. Among BD individuals, cognition is highly recognized as one of the core symptoms of the illness. In general, individuals with BD are more likely to present impairment in executive functions, attention, working memory, and psychomotor speed in both acute and euthymia. In this population, cognitive impairments are more prominent in attention, executive, and verbal memory even during remission (Bourne et al., 2013; Martínez-Arán et al., 2004) and might be influenced by some pharmacologic treatments, such as mood-stabilizing and antipsychotics (Porter, Robinson, Malhi, & Gallagher, 2015; Vieta, 2009). For MDD individuals, cognitive dysfunction is also recognized as a core symptom of the functional impairment associated with the illness, and those individuals are more likely to display worse cognitive performance in processing speed, attention, executive function, learning, and memory, either in acute episode or euthymic state (McIntyre et al., 2013; Ragguett et al., 2016). In general, studies outcomes did not demonstrate deficits in a specific domain for both BD and MDD; instead, they showed moderate deficits across a broad range of domains in both illnesses (Arts, Jabben, Krabbendam, & van Os, 2008; Porter et al., 2015).

Similarly, there is no consensus in a specific pattern of cognitive dysfunction of acute and euthymic states in either BD or MDD. Euthymic BD individuals are more likely to present moderate impairment in executive control, verbal learning and memory, visual memory, and attention (Bourne et al., 2013; Cullen et al., 2015), while depressed BD individuals were more likely to present moderate impairment in attention, executive function, psychomotor speed, memory, and verbal fluency (Basso, Lowery, Neel, Purdie, & Bornstein, 2002; Neu, Kiesslinger, Schlattmann, & Reischies, 2001). Manic BD individuals were more likely to display poorer outcomes in selective attention and speed of responding (Gruber, Rathgeber, Bräunig, & Gauggel, 2007). Among individuals with MDD, data were also inconclusive, either during depressive episodes or remission. Porter et al. (2015) showed in a review study that most of meta-analyses focused on cognition of MDD individuals during depressive episodes did not found significant differences in comparison with healthy controls (HCs), showing only a slight difference in attention, executive function, and memory. When MDD individuals in euthymic state were compared with the latter group, similar outcomes were found, indicating no significant difference between MDD individuals during a depressive episode or in euthymia; however, no evidence of impairment in specific cognitive domains was found (Lam, Kennedy, McIntyre, & Khullar, 2014). Due to the inconsistency regarding clinical and mood state, possible bias, as well as a wide range of psychological tests used in different studies, cognitive characteristics of both illnesses, their magnitude, and how they relate to clinical and functional outcomes are not well understood.

According to MacQueen and Memedovich (2017), relatively few studies have compared the cognitive profile of individuals with MDD and BD, and a smaller number of studies have compared individuals from both mood disorder groups or both groups with HC. In general, studies have found better cognitive performance in HC when compared with either BD or MDD in domains such as processing speed and executive functions (Daniel et al., 2013; Gildengers et al., 2012). When comparisons were made only among patients with mood disorders, people with MDD showed better performance than BD across most cognitive domains (Canuto et al., 2010; Gildengers et al., 2012). Cognitive performance appears to be lower in established BD; however, results have been discrepant across studies, showing either differences or similarities between BD and MDD, which has provided little evidence for cognitive differences between both of them. There is a suggestion that people with BD have normal or even superior cognitive functioning before disease onset (Cannon et al., 2002; MacCabe et al., 2010) and that cognitive changes emerge as part of the trajectory of neuroprogression driven by the neurotoxicity of recurrence, especially of mania (López-Jaramillo et al., 2010).

In a recent review aiming to examine neurocognitive profile of mood disorders, Porter et al. (2015) identified only one study comparing directly BD and unipolar depression, which found no differences in the profile of deficits in both bipolar and unipolar depressive patients in comparison with HCs at baseline. Xu and colleagues (2012) found slight differences between BD and unipolar depression in processing speed, visual memory, and executive functions, which might be a status marker for either type I or II BD and a trait marker for unipolar depression. Additionally, a recent meta-analysis and a systematic review

including those and other studies found that there was insufficient evidence to differentiate cognition profiles across BD and MDD during periods of clinical remission (Samamé, Szmulewicz, Valerio, Martino, & Strejilevich, 2017; Szmulewicz et al., 2017). Szmulewicz and colleagues (2017) reported no quantitative cognitive difference between BD and MDD individuals, while Samamé and colleagues (2017) reported slight differences (but not significant) between both diagnostic groups during euthymia periods.

Even though there were discrepant findings concerning the extent and magnitude of cognitive deficits in both BD and MDD, an association between cognitive deficits and mood disorders is supported by the literature (Godard, Grondin, Baruch, & Lafleur, 2011). Individuals with BD or MDD were globally more impaired, characterized by occupational, relational, and social impairment, and had worse cognitive performance, whereas individuals with BD presented with greater functional impairment and worse cognitive performance than MDD. There were also important associations between psychosocial functioning and cognition for both BD and MDD (Godard et al., 2011; Wingo, Harvey, & Baldessarini, 2009). Cotrena, Branco, Kochhann, Shansis, and Fonseca (2016) found significant associations among quality of life and functionality, severity symptoms, and cognition in different clusters of patients. However, Baune and colleagues (2010) found no association among those variables. Methodological factors are important; however, research samples tend to be derived from tertiary treatment centres, which select the most unwell individuals. People well controlled on therapy seldom present to research active centres, leading to a severity bias in the literature.

Given the aforementioned discrepant reports on the magnitude of cognitive deficits among mood disorders, either in remission or euthymic states, different cognitive patterns found among individuals with MDD and BD and lack of knowledge about the associations among clinical variables, quality of life, and functionality, a better comprehension of this topic is necessary, particularly in a clinical population. In addition, there is only a few no established gold-standard cognitive assessment tool to assess both mood disorders to screen and monitor cognitive dysfunction in both BD and MDD. Ott and colleagues (2016) discussed the lack of feasible methods to monitor cognitive dysfunction among MDD individuals, validating two traditional paper and pencil instruments to screen cognitive dysfunction among those individuals. Similarly, Jensen and colleagues (2015) validated and evaluated two different paper and pencil instruments to screen and monitor cognitive dysfunction among individuals with BD. Considering the lack of new instruments, in particular those computerized, we decided to use the battery of cognitive tests from CogState Research Battery (CSRB™), one of the most prevalent computerized cognitive batteries available nowadays (https://www.cogstate.com/clinical-trials/computerized-cognitive-assessment/featured-batteries/). The CSRB™ is comparable to traditional paper and pencil tests, with some advantages over them, such as the fact that the battery has a readily adaptable design, reliability across cultures and populations (available and used in over 41 different languages), and the possibility to administer it in a short period of time (Falleti, Maruff, Collie, & Darby, 2006; Gates et al., 2020). Moreover, the battery has been used extensively with neurological, psychiatric, and other medical conditions, in over 1200 clinical trials and longitudinal studies (see https://www.cogstate.com/publication/; Gates et al., 2020). Finally, it is important to highlight that CSRB™ has not been consistently used to assess and monitor both BD and MDD individuals within the same study, making the present study more relevant and innovative. Therefore, the primary aim of the study was to characterize the pattern of cognitive function of BD and MDD and compare them to HC using the CSRB™. A second aim was to assess the association among different domains of cognition with functionality, quality of life, and clinical variables.

Method

Participants

A convenience sample of individuals with mood disorders, who were outpatients at the Psychiatric Unit of the Clinics Hospital of Londrina State University (UEL), were included in the study. HC participants were staff at the university without a history of mood disorders and first-degree relatives diagnosed with them as well as DSM axis I and II disorders excluded. Mood disorders individuals and HC participants from both sexes, aged 18–65, and all ethnicities were accepted in this study. The recruitment of participants with mood disorders occurred during their regular visits to the outpatient clinic at the end of their appointments, and those who met the inclusion criteria were invited to participate in the study by the first author. Regards BD, both type-1 and type-2 BD individuals were included, whereas BD individuals in mixed states were not included in the study. As described above, our data collection occurred at the Psychiatric Unit of a university hospital and thus we have a convenience sample, where most of the patients were at maintenance phase and late stage of the illness. All participants who met the inclusion criteria were invited to participate in the study. Inclusion criteria for participants with mood disorders were euthymia at assessment, according to the clinical assessment, independently of the stage of the illness. The recruitment of HC was made at the university by word of mouth and email invitations. All volunteers who were available and met the criteria were included in the study. The exclusion criteria were: pregnancy; diagnosis of cognitive disorders, medical conditions which could induce either manic or

Table 1. CogState Research Battery (CSRB™) tests description

Domain	Task name	Outcome	
		Better performance	Measure
Processing speed	*Groton Maze Task Learning (GMCT)*	Higher score	Number of correct movements per second
	Detection Task (DET)	Lower score	Average reaction time for correct responses
Attention	*Identification Task (IDN)*	Lower score	Response accuracy
Working memory	*One-back Task (ONB)*	Higher score	Response accuracy
	Two-back Task (TWOB)	Higher score	Response accuracy
Visual memory	*One card learning Task (OCL)*	Higher score	Response accuracy
	Continuous Paired associate (CPAL)	Lower score	Response accuracy
	Groton Maze Learning Task: Delayed Recall (GMR)	Lower score	Total number of errors
Executive functions	*Groton Maze Learning Task (GML)*	Lower score	Total number of errors at the end of five trials
	Set-Shifting Task (SETS)	Lower score	Number of errors
Verbal memory	*International Shopping List: Immediate Recall (ISL)*	Higher score	Total number of words recalled after three trials
	International Shopping List: Delayed Recall (ISLR)	Higher score	Total number of words recalled

Note. Based on the CogState Research Battery TM (description published by Benoit et al. (2014) and CSRB™ Manual.

depressive states (e.g., central nervous system neoplasm, multiple sclerosis, epilepsy, acquired immunodeficiency syndrome, neurosyphilis, strokes, hypothyroidism or hyperthyroidism, etc.), and the use of medication/substances which induce either manic or depressive states (See APA, 2013). The study was conducted from February 2016 to January 2017 and was approved by the Ethics Committee from UEL (approval number CAAE 34935814.2.0000.5231). Written informed consent was obtained from all participants before the study.

Clinical Assessment

All participants underwent a Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-VI) to confirm diagnoses of mood disorders. Following socio-demographic data (age, gender, relationship status, educational background, working status) and clinical information (i.e., estimated illness duration and current psychiatric medication) were collected. During the same interview, the following instruments were also administered: 17-item Hamilton Depression Rating Scale ($HDRS_{17}$; Hamilton, 1960) to assess depression severity; Hamilton Anxiety Rating Scale (HAM-A; Hamilton, 1959) to assess symptoms of anxiety; Young Mania Rating Scale (Young, Biggs, Ziegler, & Meyer, 1978) to assess symptoms of mania; Sheehan Disability Scale (SDS; Sheehan, 1983) to assess functionality, Clinical Global Impression—Severity (CGI-S) to assess the severity of illness, and WHOQoL-bref (Abbreviated World Health Organization Quality of Life Questionnaire; WHOQOL Group, 1994) to assess quality of life. In the present study, both WHOQoL-bref and SDS global and domains scores were reported, but only global domains were included in the multiple logistic regression.

Cognitive Assessment

Cognitive functioning was assessed using the CSRB™ (CogState Company Ltd., 2009), a computer-administered cognitive test battery, which comprises a set of 12 game-like subtests to assess different cognitive domains. Subtests were presented in a fixed sequence on a green screen along with standardized instructions provided by trained researchers before the commencement of each task. The battery was administered by the first author to each subject on a laptop computer in a quiet room to minimize distraction. CSRB™ results were uploaded to a secure account on the CogState™ server, where data were calculated and normalization transformed (logarithmic transformation for reaction time, arcsine transformation for accuracy. Then, all subtests results were standardized by calculating a Z-score. A composite cognitive score was automatically calculated by the CSRB™ software (CogState Company Ltd., 2009) by averaging scores from all subtests, in which higher values represented better performance (Gates et al., 2020). All domains, their subtests, as well as measures and outcomes, were briefly described in Table 1 (for a full description of each test, see Benoit et al., 2015).

Data Analysis

All continuous variables were tested for violation of statistical assumptions. Comparisons among HC, BD, and MDD groups concerning sociodemographic, clinical, and cognitive characteristics were conducted by one-way ANOVA followed by Tukey post-hoc tests. Kruskal—Wallis test was used when assumptions for ANOVA test were violated. Chi-square test or Fisher exact test followed by z-test was conducted to examine proportion differences among categorical variables, such as relationship status, educational background level, working status, and current medication. Comparison between BD and MDD only was conducted by independent *t*-tests, when the assumptions were not violated, or Mann–Whitney test, when the assumptions were violated (i.e., number of days lost and underproductive days from SDS). Cohen's *d* effect size (ES) was also reported and interpreted as small (0.2–0.49), medium (0.5–0.79), or large (≥0.8) (Cohen, 2013). Multiple linear regression models were performed to examine the effect of patients' characteristics and demographics on composite cognitive score separately for BD and MDD. Previous to the final multipolar linear regression models, symptoms of depression, mania, and anxiety were analyzed, and non-significant outcomes were found. Thus, models included educational background, age, gender, functionality (global SDS), and quality of life (WHOQoL-bref). The first model included only educational background, while the second model included educational background, age, and gender. The third model included all significant variables from the second model, functionality, and quality of life. Finally, to perform an overarching model with all sample data, previous models were replicated including each disorder as a nominal variable in the model, and two-way interactions were tested between mood disorder groups and significant confounders, such as age, gender, quality of life, and functionality. Additionally, two-way interactions between mood disorder groups and medications used on composite cognitive score were evaluated in separated analyses. A Bonferroni correction method was used for multiple comparisons. Partial eta square size was calculated as a measure of ES in all multiple linear models and interpreted as small (≤0.02), medium (0.03–0.13), or large (≥0.26) (Cohen, Cohen, West, & Aiken, 2002). All analyses were completed using IBM® SPSS®, version 23 (IBM Corp., 2015). The statistical significance level used was 0.05, two-tailed.

Results

Accrual Rates

During the period of data collection, a total of 129 individuals were regularly outpatients at the Psychiatric Unit of the Clinics Hospital of UEL, of which 71 were diagnosed BD and 58 were diagnosed with MDD. Of those 129 outpatients, 62 both accepted to participate in the study and meet inclusion criteria (BD: $n = 32$; MDD: $n = 30$), whereas 67 either did not meet inclusion criteria (BD: $n = 12$; MDD: $n = 10$) or refused to be part of the study (BD: $n = 27$; MDD: $n = 18$). Among HC, 40 individuals were invited to be part of the study, of which 11 refused to proceed with data collection and one did not meet inclusion criteria due to diagnosis of cognitive disorders and one did not show to the data collection appointment. The overall accrual rate was 53.25%, while accrual rates among BD, MDD, and HC groups were, respectively, 51.72%, 45.07%, and 70.00%.

Sample Characteristics

A total of 90 participants were included in this study, of which 32 had BD, 30 had MDD, and 28 were HC. Table 2 summarizes the comparisons of HC with BD and MDD. MDD individuals were older than both BD and HC. There were more women in the BD group than both MDD and HC. There were more participants with secondary education level in MDD than HC, while there were more participants with university level in HC than MDD. No differences were found among groups for primary education level and either between BD and MDD or between BD and HC for both secondary and university levels. There were also no significant differences in terms of age, gender, and educational level. Regarding working status, fewer participants with BD had a current and formal job in comparison with both MDD and HC, and more participants with BD were unemployed during data collection, in comparison with both MDD and HC. There were differences between HC and both BD and MDD, but no difference between MDD and BD in the frequency of participants receiving welfare and disability benefits. An overall significant difference was found among groups for working status ($p = 0.003$).

Functionality, Quality of Life, and Clinical Data

Individuals with BD and MDD presented higher $HDRS_{17}$ scores than HC, with significant differences in pairwise comparisons for both BD and HC (Diff = 10.1, 95% CI = [6.0, 14.2], $p < 0.001$), and MDD and HC (Diff = 7.5, 95% CI = [3.3, 11.7], $p < 0.001$). For YMRS, BD presented higher scores than MDD and HC, with significant differences in pairwise

Table 2. Clinical and sociodemographic characteristics of the sample

Characteristics	HC (n = 28)	BD (n = 32)	MDD (n = 30)	Group comparison
Age†	39.1 (±13.6)	41.3 (±11.8)	45.9 (±10.9)	$F(2, 87) = 2.4$; $p = 0.95$§
Gender (female)‡	18 (64.3%)	26 (81.3%)	24 (80%)	$\chi^2(2) = 2.8$; $p = 0.246$¶
Relationship status‡				
Single	13 (46.45)[a]	5 (15.6%)[b]	7 (23.3%)[ab]	$\chi^2(4) = 9.5$; $p = 0.050$¶
Stable relationship	14 (50%)[a]	20 (62.5%)[a]	18 (60%)[a]	
Other	1 (3.6%)[a]	7 (21.9%)[b]	5 (16.7%)[ab]	
Educational background (level)‡				
Primary school	2 (7.1%)[a]	4 (12.5%)[a]	4 (13.3%)[a]	$\chi^2(4) = 8.9$; $p = 0.065$¶
Secondary school	5 (17.9%)[a]	11 (34.4%)[ab]	15 (50%)[b]	
University	21 (75%)[a]	17 (53.1%)[ab]	11 (36.7%)[b]	
Work status‡				
Working	24 (85.7%)[a]	11 (34.4%)[b]	20 (66.7%)[a]	$\chi^2(8) = 23.6$; $p = 0.003$¶
Unemployed	2 (7.1%)[a]	10 (31.3%)[b]	2 (6.7%)[a]	
Welfare and disability benefits	0 (0.0%)[a]	4 (12.5%)[ab]	4 (13.3%)[b]	
Retired	0 (0.0%)[a]	2 (6.3%)[a]	3 (10%)[a]	
Voluntary or unpaid job	2 (7.1%)[a]	5 (15.8%)[a]	1 (3.3%)[a]	
Estimated Illness duration†	—	21.4 (±13.2)	15.8 (±11.7)	$t(60) = 1.8$; $p = 0.083$#
BD type				
Type I	—	19 (59.3%)	—	
Type II	—	12 (40.6%)	—	
17-item Hamilton Depression Rating Scale ($HDRS_{17}$)†	1.9 (±2.1)[a]	12.1 (±8.5)[b]	9.4 (±7.3)[b]	$H(3) = 28.3$; $p < 0.001$^
Young Mania Rating Scale (YMRS)†	0.4 (1.5)[a]	4 (5.27)[b]	0.7 (1.5)[a]	$F(2, 87) = 10.7$; $p < 0.001$§
Hamilton Anxiety Rating Scale (HAM-A)†	3.7 (5.1)[a]	18.3 (14.9)[b]	11.7 (8.3)[c]	$F(2, 87) = 14.5$; $p < 0.001$§
Clinical Global Impression—Severity (CGI-S)†	—	4.06 (±1.24)	3.77 (±1.5)	$t(60) = 0.9$; $p = 0.4$#
Sheehan Disability Scale (SDS)				
School/ work activities†	0.5 (±1.2)[a]	5.5 (±3.4)[b]	5 (±3.8)[b]	$H(3) = 34.5$; $p < 0.001$^
Social life/Leisure activities†	0.7 (±1.7)[a]	5.7 (±3.4)[b]	5.6 (±3.6)[b]	$H(3) = 34.7$; $p < 0.001$^
Family life/home activities†	0.8 (±2.5)[a]	5.4 (±3.6)[b]	5.3 (±3.5)[b]	$H(3) = 28.3$; $p < 0.001$^
Days lost (last 30 days) †	—	9.4 (±12.8)	4.3 (±9.5)	$U = 351$; $p = 0.035$¥
Days underproductive (last 30 days) †	—	10.2 (±12.6)	7.7 (±11.8)	$U = 410$; $p = 0.286$¥
Cognitive composite score†	98.9 (±5.2)[a]	93.4 (±7.4)[b]	94.3 (±6.6)[b]	$F(2, 87) = 5.9$; $p = 0.004$§
WHOQoL-Brief				
Physical†	30.8 (±2.8)[a]	21.6 (±5.3)[b]	22.6 (±4.7)[b]	$F(2, 87) = 36.8$; $p < 0.001$§
Psychological†	24.8 (±2.5)[a]	17.2 (±4.5)[b]	17.9 (±4.8)[b]	$F(2, 87) = 29.8$; $p < 0.001$§
Personal†	12.4 (±1.7)[a]	9.3 (±2.2)[b]	8.7 (±2.6)[b]	$F(2, 87) = 23.5$; $p < 0.001$§
Environmental†	32.4 (±2.9)[a]	24.7 (±4.8)[b]	27 (5.4)[b]	$F(2, 87) = 22.5$; $p < 0.001$§
Current medication (yes)				
Atypical Antipsychotic‡	0 (0%)[a]	12 (37.5%)[b]	4 (13.3%)[ab]	$\chi^2(2) = 14.9$; $p = 0.001$¶
Antidepressant‡	4 (14.3%)[a $]	14 (43.8%)[b]	17 (56.7%)[b]	$\chi^2(2) = 11.4$; $p = 0.003$¶
Lithium‡	0 (0%)[a]	13 (40.6%)[b]	1 (3.3%)[a]	$\chi^2(2) = 23.9$; $p < 0.001$¶
Other Mood stabilizer‡	0 (0%)[a]	18 (56.3%)[b]	3 (10%)[a]	$\chi^2(2) = 30.9$; $p < 0.001$¶

Notes: Letter subscripts the outcomes depict group differences where the same letters for the same variable indicate that there are no differences between the means among the groups and different letters for the same variable indicate that there are differences between the means among the groups. Bold text indicates a subtest with statistically significant differences ($p \leq 0.05$).

†Mean (± Standard deviation);

‡Frequency (%);

§ANOVA followed by post-hoc test;

¶Chi-square test;

#Independent samples t test;

^Independent-samples Kruskal–Wallis test;

¥Mann–Whitney test.

$Antidepressants were not prescribed to those patients by a psychiatrist. They were taken for a short term by them own. To confirm mood disorders criteria, those participants were evaluated by SCID-IV, and none of HC met criteria for MDD or BD.

Abbreviations. HC = Healthy Controls, BD = Bipolar Disorder, MDD = Major Depressive Disorder, WHOQoL-Brief = Brief World Health Organization Quality-of-Life Scale.

comparisons for both BD and HC (Diff = 3.6, 95% CI = [1.5, 5.7], $p < 0.001$), and BD and MDD (Diff = 7.5, 95% CI = [1.3, 5.4], $p = 0.001$). BD presented higher HAM-A scores than MDD and HC, indicating that BD individuals presented higher levels of anxiety than either MDD or HC. Significant differences in all pairwise comparisons were found for anxiety scores.

For quality of life and functionality, similar outcomes were found. Individuals with BD and MDD had lower scores for quality of life with significant differences in comparison with HC (BD vs. HC: Diff = −27.5, 95% CI = [−35.1, −20.0.], $p < 0.001$; MDD vs. HC: Diff = −24.2, 95% CI = [−31.9, −16.5], $p < 0.001$). However, no significant difference was noted between BD and MDD (Diff = −3.3, 95% CI = [−10.7, 4.1], $p = 0.536$). Likewise, similar results were found for all quality of life domains. When only BD and MDD were compared, no differences between groups were found for all domains, indicating that both BD and MDD present similar overall quality of life outcomes and both groups differ from individuals without mood disorders. For functionality, participants with MDD presented lower scores than both BD and HC for all fields; however, there were significant differences between HC and either BD or MDD but not between BD and MDD. Outcomes for both functionality and quality of life indicate that individuals with mood disorders presented lower levels of quality of life in comparison with individuals without mood disorders. Regarding current psychiatric medications, there were overall differences among groups for all medications. Finally, for those variables with comparisons made only between BD and MDD, there were no differences for the following parameters: estimated illness duration since the first episode (years), CGI-S, and days lost or underproductivity, indicating similar patterns among individuals with BD and MDD.

Cognitive Outcomes

There were differences among groups for overall cognitive scores ($p = 0.001$). Post-hoc tests among groups showed significant differences between both BD and HC (Diff = −5.5, 95% CI = [−9.5, −1.5], $p = 0.005$) and MDD and HC (Diff = −4.6, 95% CI = [−8.6, −0.5], $p = 0.025$). No difference was noted between BD and MDD (Diff = −0.9, 95% CI = [−4.9, 3.0], $p = 0.844$). Table 3 shows how mood disorders groups (individuals with BD and MDD) and HC performed on the CSRB™ battery and its subtests. There were overall differences in five cognitive domains among groups: processing speed, evaluated by Groton Maze Task Learning (GMCT) ($p = 0.001$) and Detection Task (DET) ($p = 0.004$); attention, measured by Identification Task (IDN) ($p = 0.002$); working memory, measured by Two-Back Task (TWOB) ($p = 0.02$); visual memory, measured by One card learning Task—OCL ($p = 0.021$); and verbal memory, measured by International Shopping List: Immediate Recall (ISL) ($p = 0.007$). There were neither significant differences nor medium and large ESs in executive functions among all groups. Even without significant differences, medium ES were found for the following domains: processing speed, attention, working memory, visual memory, and verbal memory. All pairwise comparisons and ES outcomes could be found in Table 3.

Association Between Cognition and Functionality, Quality of Life, and Clinical Data

Linear regression models were conducted for both BD and MDD groups in comparison with HC to understand the relationship between cognitive score and some significant confounders (Table 4). In Model 1, when the composite cognitive score was examined with education level, both BD and MDD models were statistically significant (BD: $R^2 = 0.33$, $p < 0.001$; MDD: $R^2 = 0.24$, $p < 0.001$). According to Model 1 for BD individuals, a change in one level of education (e.g., from primary education to secondary education or from secondary education to university) increased the composite cognitive score by 2.6 (95% CI: 1.3, 4.0, $p < 0.001$) with a large ES ($\eta^2 = 0.3$). Likewise, for MDD, a change in one level of education increased cognitive score by 3.3 (95% CI: [2.1, 4.5], $p < 0.001$) with large ES ($\eta^2 = 0.3$). In Model 2, both models were significant (BD: $R^2 = 0.59$, $p < 0.001$; MDD: $R^2 = 0.52$, $p < 0.001$). In the BD model, significant effects were found for education ($p = 0.004$), in which a change in one level increased the cognitive score by 0.9 (95% CI: [2.1, 4.5]) with medium ES ($\eta^2 = 0.2$); age ($p < 0.001$) in which an increase in 1 year decreased the cognitive score by −0.2 (95% CI: [−0.3, −0.1]) with large ES ($\eta^2 = 0.8$); and gender ($p = 0.039$), in which women were more likely to present a worse cognitive score in comparison with men by 3.3 (95% CI: [−0.2, 6.3]), but with small ES ($\eta^2 = 0.0$). In a similar model for MDD, significant outcomes were found for educational level ($p < 0.001$) but not for gender ($p = 0.083$) and age ($p = 0.02$). A change in one educational level increased the cognitive score by 3.2 (95% CI: [2.0, 4.4]) with large ES ($\eta^2 = 0.7$) and an increase in 1 year of age minimized cognitive score by −0.1 (95% CI: −0.2, −0.0) with large ES ($\eta^2 = 0.9$).

In model 3, all nonstatistically significant effects from previous models were removed, and overall functionality and quality of life scores were included. Both BD and MDD models were significant (BD: $R^2 = 0.59$, $p < 0.001$; MDD: $R^2 = 0.56$, $p < 0.001$). In the BD model, a significant effect was found for age ($p = 0.004$), in which an increase in 1 year decreased cognitive score by −0.2 (95% CI: [−0.3, −0.1]) with large ES ($\eta^2 = 1.0$). No statistically significant effects were found for educational level ($p = 0.032$), functionality ($p = 0.033$), gender ($p = 0.444$), and quality of life ($p = 0.141$), but large ESs were identified for gender ($\eta^2 = 0.4$), functionality ($\eta^2 = 0.9$), and quality of life ($\eta^2 = 1.0$). In the MDD models, a significant effect was found for

Table 3. Cognitive characteristics according to domains and subtests of the sample

Domain	Subtest	HC ($n = 28$)	BD ($n = 32$)	MDD ($n = 30$)	Group comparisons	Post-hoc test comparisons p-values			Cohen's d (CI 95%) (Pairwise comparison)		
						HC versus BD	HC versus MDD	BD versus MDD	HC versus BD	HC versus MDD	BD versus MDD
Processing speed[†]	GMCT	0.6 (±0.9)	0.3 (±1.1)	−0.2 (±0.8)	$F(2, 87) = 7.6$; $p = 0.001$[‡]	0.001	0.010	1.000	0.3 (0.0, 0.7)	0.9 (0.6, 1.2)	0.5 (0.1, 0.8)
	DET	−0.5 (± 0.6)	0.4 (±1.2)	0.1 (±0.9)	$F(2, 87) = 6.0$; $p = 0.004$[‡]	0.003	0.082	0.758	−1.0 (−1.2, −0.5)	−0.8 (−1.0, −0.5)	0.3 (−0.1, 0.6)
Attention[†]	IDN	−0.5 (±0.6)	0.4 (±1.2)	0.1 (±1.0)	$F(2, 87) = 6.6$; $p = 0.002$[‡]	0.02	0.088	0.505	−1.0 (−1.2, −0.5)	−0.8 (−1.0, −0.5)	0.3 (−0.1, 0.6)
Working memory[†]	ONB	0.3 (±0.9)	−0.1 (±0.9)	−0.3 (±1.1)	$F(2, 87) = 2.5$; $p = 0.085$[‡]	0.093	0.341	1.000	0.4 (0.1, 0.8)	0.6 (0.3, 1.0)	0.2 (−0.1, 0.6)
	TWOB	0.4 (±0.7)	−0.3 (±1.2)	0.1 (±0.9)	$F(2, 87) = 4.1$; $p = 0.020$[‡]	0.017	0.226	0.928	0.7 (0.5, 1.1)	0.4 (0.1, 0.7)	−0.4 (−0.8, −0.1)
Visual memory[†]	OCL	0.4 (±1.1)	−0.1 (±1.0)	−0.3 (±0.8)	$F(2, 87) = 4.1$; $p = 0.021$[‡]	0.260	0.017	0.745	0.5 (0.1, 0.8)	0.1 (−0.3, 0.4)	−0.4 (−0.8, −0.2)
	CPAL	−0.3 (±0.9)	−0.3 (±1.2)	0.0 (±0.9)	$F(2, 87) = 2.2$; $p = 0.120$[‡]	0.126	1.000	0.663	0.0 (−0.3, 0.4)	−0.3 (−0.7, 0.0)	−0.3 (−0.7, 0,0)
	GMR	−0.1 (±0.9)	0.1 (±1.3)	0.0 (±0.8)	$F(2, 87) = 0.6$; $p = 0.573$[‡]	0.878	1.000	1.000	0.2 (−0.5, 0.3)	−0.1 (−0.5, 0.2)	−0.1 (−0.5, 0.2)
Executive function[†]	GML	−0.2 (±0.9)	0.2 (±1.2)	0.0 (±0.9)	$F(2, 87) = 0.9$; $p = 0.398$[‡]	0.529	1.000	1.000	−0.4 (−0.7, 0.0)	−0.2 (−0.6, 0.1)	0.2 (−0.2, 0.5)
	SETS	−0.2 (±0.8)	0.2 (±1.1)	0.1 (±1.1)	$F(2, 87) = 1.1$; $p = 0.356$[‡]	0.494	0.907	1.000	−0.4 (−0.7, 0.0)	0.3 (−0.5, 0.2)	0.1 (−0.3, 0.5)
Verbal memory[†]	ISL	0.5 (±0.9)	−0.3 (±1.1)	−0.2 (±1.0)	$F(2, 87) = 5.2$; $p = 0.007$[‡]	0.010	0.039	1.000	0.8 (0.5, 1.2)	0.7 (0.4, 1.1)	−0.1 (−0.5, 0.3)
	ISRL	0.3 (±1.0)	−0.2 (±0.9)	−0.1 (±1.1)	$F(2, 87) = 2.1$; $p = 0.130$[‡]	0.212	0.258	1.000	0.5 (0.2, 0.9)	0.4 (0.0, 0.8)	−0.1 (−0.4, 0.3)

[†]Mean (± Standard deviation);
[‡]ANOVA with;
[a]Bonferroni Post-hoc test.
Abbreviations. HC = Healthy Controls, BD = Bipolar Disorder, MDD = Major Depressive Disorder, GMCT = Groton Maze Task Learning, DET = Detection Task, IDN = Identification Task, ONB = One-back Task, TWOB = Two-back Task, OCL = One card learning Task, CPAL = Continuous Paired associate, GMR = Groton Maze Learning Task: Delayed Recall, GML = Groton Maze Learning Task, SETS = Set-Shifting Task, ISL = International Shopping List: Immediate Recall, ISLR = International Shopping List: Delayed Recall.

Table 4. Multiple linear regression model predicting cognition of BD and MDD patients

Groups[¶]	Models	*b*	Partial Eta Square	*p*-value
BD	Model 1			
	Educational level	2.6 (1.3, 4.0)	0.3	<0.001
	Model 2			
	Educational level	1.9 (0.7, 3.2)	0.2	0.004
	Age	−0.2 (−0.3, −0.1)	0.8	<0.001
	Gender	3.3 (0.2, 6.3)	0.0	0.039
	Model 3			
	Educational level	1.4 (0.1, 2.6)	0.1	0.032
	Age	−0.2 (−0.3, −0.1)	1.0	0.004
	Gender	1.2 (−1.9, 4.3)	0.4	0.444
	SDS[†]	−0.2 (−0.4, 0.0)	0.9	0.033
	WHOQoL[‡]	−0.1 (0.0, 0.2)	1.0	0.141
MDD	Model 1			
	Educational level	3.3 (2.1, 4.5)	0.4	<0.001
	Model 2			
	Educational level	3.2 (2.0, 4.4)	0.7	<0.001
	Age	−0.1 (−0.2, 0.0)	0.9	0.020
	Gender	2.5 (0.3, 5.3)	0.1	0.083
	Model 3			
	Educational level	2.4 (1.2, 3.6)	0.6	<0.001
	Age	−0.1 (−0.2, 0.0)	1.0	0.022
	SDS[†]	−0.2 (−0.3, 0.0)	0.7	0.019
	WHOQoL[‡]	0.0 (−0.1, 0.2)	0.6	0.576

[†]Sheehan Disability Scale (Composite of three domains);
[‡]WHOQoL (Brief World Health Organization Quality-of-Life Scale) total score.
[¶]Bold text indicates variables with statistically significant difference ($p \leq 0.05$).
BD = Model 1: $R^2 = 0.33$; $p = <0.001$; Model 2: $R^2 = 0.5$; $p < 0.001$; Model 3: $R^2 = 0.59$; $p < 0.001$.
MDD = Model 1: $R^2 = 0.44$; $p < 0.001$; Model 2: $R^2 = 0.52$; $p < 0.001$; Model 3: $R^2 = 0.56$; $p < 0.001$.

educational background ($p < 0.001$), which means that an increase in one level of education increased the cognitive score by 2.4 (95% CI: [1.2, 3.6]) with large ES ($\eta^2 = 0.6$). Large ES was found for age ($\eta^2 = 1.0$), functionality ($\eta^2 = 0.6$), and quality of life ($\eta^2 = 0.6$).

When the previous models were replicated including all data sample, rather than mood disorder groups only, no significant interactions between mood disorder groups and significant confounders on composite cognitive score were found, such as educational level ($p = 0.717$), gender ($p = 0.085$), age ($p = 0.290$), quality of life ($p = 0.167$), and functionality ($p = 0.290$) (see Supplementary Table 1). Similarly, when interactions between the current use of medications reported during data collection and mood disorders on composite cognitive score were assessed, no significant interactions were found for antidepressants ($p = 0.376$), atypical antipsychotics ($p = 0.137$), lithium ($p = 0.332$), and mood stabilizers ($p = 0.45$) (see Supplementary Table 2).

Discussion

The main findings of the present study were differences in the overall cognitive scores among BD, MDD, and HC groups. When domains were analyzed separately, significant differences were found for processing speed, attention, working, and visual and verbal memories between MDD and HC and between BD and HC, with large and medium Cohen's *d* ESs in pairwise comparisons. In general, there were more significant differences between HC and BD rather than between HC and MDD, and in the first comparison, significant differences were found for processing speed, attention, working memory, and verbal memory, whereas in the latter comparison, differences were found for processing speed, visual memory, and verbal memory. Although large and medium Cohen's *d* ESs were identified in pairwise comparisons between BD and MDD, no significant differences were found between both groups, showing the similarities between them, even with slight differences in terms of cognitive performance. Additionally, associations between overall cognitive outcomes and functionality were found for both BD and MDD, when ESs were taken into consideration.

The present results add to the growing evidence that there are differences in terms of cognitive performance between individuals with mood disorders and those without mood disorder diagnosis. Our study supports investigations on cognition concerning differences among MDD, BD, and HC, showing that differences were clear between HC and mood disorder groups rather than only between individuals with mood disorders, such as BD and MDD. It is essential to highlight that even without

significant differences between BD and MDD, qualitative analyses could be carried out. Associations between variables assessed within each group were more frequently found and larger in BD than MDD. Previous systematic reviews and meta-analyses, aiming to describe cognitive patterns of both BD and MDD, reported worse performance in similar domains when compared with HC, as found in the present study. While individuals with BD were more likely to present impairment in attention, processing speed, and memory (Cipriani, Danti, Carlesi, Cammisuli, & Di Fiorino, 2017), the most common impaired domains in MDD are executive function, attention, verbal, nonverbal, and delayed memories (Cambridge, Knight, Mills, & Baune, 2018). However, comparisons for different cognitive domains between BD and MDD were not statistically significant across studies for overall cognitive outcomes (Lam et al., 2014; Porter et al., 2015; Samamé et al., 2017; Szmulewicz et al., 2017; Szmulewicz, Samamé, Martino, & Strejilevich, 2015). In the same way, there were no significant differences between BD and MDD when overall cognitive scores were analyzed separately, and even when the comparisons were made for subtests in the present study. There was only one significant difference between MDD and BD, for visual memory measured by the OCL. For the other subtests, there were neither statistically significant differences nor large and medium ESs between both mood disorder groups; however, differences were frequently identified when both of them were compared with HC.

Additionally, our outcomes add some new evidence in the association between mood disorder diagnosis and cognitive outcomes and their effects on both functionality and quality of life (Perini et al., 2019). Both BD and MDD individuals from the present study showed lower scores in quality of life and functionality when compared with HC, and the latter variable was associated with the composite cognitive score. Similar outcomes and associations have been reported in the literature between clinical variables, functionality, and cognition for both BD and MDD (Cotrena, Branco, Kochhann, et al., 2016; Evans et al., 2013; Godard et al., 2011; Godard, Baruch, Grondin, & Lafleur, 2012; Toyoshima et al., 2019; Wingo et al., 2009). Cognition was also identified as a strong predictor for impairment as well as treatment responsiveness in both BD and MDD (Mcintyre et al., 2018; Sole et al., 2012). Associations between all variables assessed within each group were more frequently found and larger in BD than MDD. It is also important to highlight that later stage individuals with BD reported worse quality of life, functionality, and cognitive outcomes when compared with other groups such as HC or even individuals with MDD (Tatay-Manteiga et al., 2019). These findings might suggest a more significant impact of the illness on daily life and functioning among BD when compared with MDD individuals (Cambridge et al., 2018; Cipriani et al., 2017; Cotrena, Branco, Kochhann, et al., 2016; Cotrena, Branco, Shansis, & Fonseca, 2016; Mcintyre et al., 2018; Purcell, Phillips, & Gruber, 2013; Solé et al., 2017).

Cognitive differences between patients with mood disorders and HC are related to functionality and daily life activities such as either work or school tasks, social life/leisure, and family life/home responsibilities. In the present study, individuals with BD and MDD displayed worse performance for processing speed when compared with HC, as demonstrated in the literature. There were slightly improved outcomes for MDD over BD for processing speed, measured by GMCT and DET, attention, measured by identification task (IDN), working memory, measured by TWOB, and verbal memory, measured by international shopping list immediate recall (ISL), but without statistical difference. However, when pairwise comparisons with Cohen's *d* were taken into consideration, there were larger ESs in comparisons between BD and HC than MDD and HC. In other words, BD patients were more impaired and had a worse cognitive performance than MDD. A potential explanation for this could be related to the duration and severity of symptoms of the illness as well as the stage of the disease. In general, individuals with BD experience both longer periods and more severe mood symptoms in comparison to individuals with MDD, in particular those in later stages of BD.

According to Cambridge and colleagues (2018) and Martínez-Arán and colleagues (2000), processing speed could be associated with psychomotor functioning and could suffer from irreversible cognitive deficits in either BD or MDD. Similarly, worse performance in attention is one of the most common outcomes among individuals with BD, in particular during manic and depressed episodes, and could be associated with worse general functioning. There is some evidence associating worse performance in processing speed and attention with prefrontal and hippocampal volume (Martínez-Arán et al., 2000). Verbal, visual, and working memories are also associated with the same cognitive domains, and some studies have found weaker performances in patients with BD or MDD when compared with HC. Cambridge and colleagues (2018) reported in their meta-analysis a relationship between daily activities and processing speed, attention, visuospatial ability, and working memory among MDD individuals. Although the association described in that meta-analysis is explicitly related to MDD individuals, similar discussions and outcomes could be found among studies with BD individuals (Cipriani et al., 2017).

Furthermore, additional findings of cognition were related to functionality and clinical variables. In the present study, MDD and BD patients reported worse functionality, which might be related to worse cognitive performance. Associations were significant for both BD and MDD in all models created and were stronger in BD than in MDD, after controlling for age and education level, demonstrating the importance of those variables in cognitive performance. Functionality outcomes were also significant variables for both BD and MDD and were consistent with previous studies, demonstrating the association between psychosocial functioning and cognition in mood disorders (Godard et al., 2011; Wingo et al., 2009). Moreover, even with no significant association found between quality of life and cognition, when ES (measured by Partial Eta Square) was calculated,

large ESs were noted for both BD and MDD models. The results found in the present study are partially discrepant with previous studies comparing the association between cognition and both quality of life and clinical variables (Cambridge et al., 2018; Cotrena, Branco, Shansis, & Fonseca, 2016). Further studies to assess the association among those variables in both BD and MDD are necessary to comprehend different impacts of cognition in the development of functional and psychosocial impairment (Mcintyre et al., 2018).

It is important to highlight the presence of higher levels of anxiety among individuals with BD in comparison with individuals with MDD or HC. According to Levy and Manove (2012) and Simon and colleagues (2004), individuals with BD presented higher rates of anxiety disorder, with a younger onset age in comparison with individuals with other mood disorders or even HC. In general, the comorbidity between BD and general anxiety could be related to poor functional outcomes, cognitive performance, and quality of life (Kauer-Sant'Anna et al., 2007). Additionally, higher levels of anxiety could be related to poorer attention and decision-making in individuals with BD, even during euthymic periods (Miu, Heilman, & Houser, 2008), and the possible association between cognition and higher levels of anxiety could be worse among individuals with BD. In our study, we found similar outcomes, in which individuals with BD presented higher levels of anxiety and also lower cognitive outcomes for attention. Anxiety levels could be reflecting a natural reaction due to the instability caused by the disease and also affect the overall cognition and functionality (Boylan et al., 2004). However, further studies associating anxiety levels and cognitive performance among individuals with mood disorders, in particular those with BD, are necessary.

Despite discrepancies in the literature, this study has aligned with previous results around cognitive outcomes in mood disorders. A potential strength of this study was the use of the CSRB™, one of the most prevalent computerized cognitive batteries available nowadays and not used to compare individuals with BD and MDD yet. To our knowledge, and to date, this is one of the first studies that used the CSRB™ as a primary cognitive measure to evaluate both BD and MDD and to compare their cognitive characteristics. Previous studies have investigated either BD or MDD with the CSRB™ independently, with promising outcomes (Davis et al., 2017; Douglas et al., 2018; Schretlen et al., 2007). Additionally, it is important to highlight that the CSRB™ is easy to administer and analyze, comparable with traditional assessment tools, and used across different cultures in over 41 different languages. Another important strength is related to the fact that we recruited patients from a clinical setting, in our case an Outpatients University Hospital, on latter stages of the disease. Individuals in later stages of the disease present an increased severity of subclinical symptoms as well as lower functionality and cognitive outcomes (Rosa et al., 2012). However, the study is limited by its cross-sectional design, which makes it impossible to conclude causative associations between exposure and the outcome; small sample size from a convenience sample, which limits the generalizability of the results; sampling method, including some differences between both mood disorder groups and HC in terms of educational background and gender; and differences found between HC and both mood disorder groups about the current use of psychiatric medications, in particular psychotropics. Regarding differences in terms of educational background and gender, the interaction of both of them and mood disorders on composite cognitive score were not significant. However, previous studies suggested that gender is an important variable in the modulation of clinical course and severity of symptoms in BD and also associated with memory function (Carrus et al., 2010; Suwalska & Łojko, 2014). Even with no significant interaction between mood disorder and gender, it should be a focus of future studies in this field. About psychiatric medication, it is not possible to neglect their influence on functionality and cognition; however, it is hard to recruit unmedicated individuals to the study, due to the importance of the medication in their treatment. Therefore, we also tested our data for possible interactions between mood disorder diagnosis and current psychiatric medication during data collection on the composite cognitive score and did not find any significant interaction. Additionally, it is important to highlight that a few studies conducted with BD and MDD individuals have found interesting outcomes. In general, individuals with BD displayed almost intact cognition, and the latter demonstrated impairment in executive functions (Mak et al., 2018; Taylor Tavares et al., 2007). For that reason, further studies, including the effects of psychiatric medication on cognition, should be conducted with those patients.

Taken together, the present study showed important results in cognitive performance and patterns between BD and MDD, and their comparison to HC, which supports some findings of previous studies (Samamé et al., 2017; Szmulewicz et al., 2015). There were significant differences between HC and individuals with mood disorders in attention, processing speed, working, verbal, and visual memory, whereas there were no significant differences in executive function. Significant associations between functionality and clinical variables were also identified in BD or MDD groups. Cognitive impairment in BD and MDD could have clinical implications through the association of poor overall functionality and lower quality of life (Mcintyre et al., 2018; Solé et al., 2017). The results of this study suggest that such variables are an important pathway to understanding the effects of cognitive dysfunction on daily functioning among patients with BD and MDD as well as pathways for new strategies to prevent functional decline.

Supplementary material

Supplementary material is available at *Archives of Clinical Neuropsychology* online.

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