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Research report

Facial emotion recognition and its correlation with executive functions in bipolar I patients and healthy controls

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ABSTRACT

Introduction: The ability to recognize facial emotions is altered in patients with Bipolar Disorder (BD) during mood episodes and even in euthymia, while cognitive functioning is similarly impaired. This recognition is considered a fundamental skill for successful social interaction. However, it is unclear whether the ability to recognize facial emotions is correlated with the cognitive deficits observed in BD.
Objective: The objective of this study was to evaluate Facial Emotion Recognition (FER) and its correlation with executive function (EF) in BD I patients during mania, depression and euthymia compared to healthy controls.
Material and methods: A total of 110 patients with BD I, 18–40 years old were included (41 in manic episode; 31 in depressive episode and 38 euthymic). Patients were assessed for FER and EF (Wisconsin card sorting test – WCST), along with 96 healthy volunteers (18–40 years old) recruited from the University of São Paulo.
Results: The results showed that BD I patients had lower FER performance compared to controls on fear subtests, happiness, the surprise test, and FER total scores. Moreover, BD I manic patients showed poorer performance for EF compared to controls. Six out of the seven variables of the WCST correlated with FER in both healthy controls and BD euthymic subjects but not in BD patients during mood episodes.
Conclusion: Cognitive deficits and difficulties recognizing facial emotions are present in all mood episodes in BD I patients, even during remission. Although FER is not considered a cognitive domain, these results suggest that, along with EF, it has a complementary function. Hence, further studies should investigate this issue in larger samples and verify whether these similarities also occur at a neurobiological level.

1. Introduction

Bipolar Disorder (BD) is a chronic and recurrent illness that has a severe impact on social and vocational functioning in about two-thirds of those affected (Huxley and Baldessarini, 2007; Wingo et al., 2010). Growing evidence has revealed that patients with BD may have lower performance in several cognitive domains, especially attention, memory and Executive Function (EF), and that these deficits persist even during clinical remission or euthymia (Malhi et al., 2007; Torres et al., 2007; Arts et al., 2008; Kurtz and Gerraty, 2009; Balanza-Martínez et al., 2010).

The EFs are top down processes that reflect neural efficacy in the prefrontal cortical regions (Fuster, 2001) and have been defined as the set of higher cognitive functions, considered essential for the control of information processing and coordination of behavior, being responsible for important activities such as resolution of problems, transformation of thought into decisions and planned actions (Luria, 1981; Lezak, 1995; Malloy-Diniz et al., 2010).

Despite the robust body of work on neuropsychological aspects of BD, research on social cognition remains scant and inconclusive. Social cognition is a multidimensional psychological domain involving a complex set of processes that enable adaptive social interaction, such as the representation of internal somatic states, knowledge about the self, perception of others, and interpersonal motivations (Amodio, 2006). Recent investigations in euthymic BD patients have reported dysfunctions in central processes within this construct: facial emotion recognition (Martino et al., 2008., 2011; Bozikas et al., 2007), theory of mind (Martino et al., 2011; Bora et al., 2005; Olley et al., 2005; Lahera et al., 2008; Montag et al., 2010; Wolf et al., 2010), and affective decision-making (Adida et al., 2011), as well as spared social-cognitive abilities (Rubinsztein et al., 2000; Clark et al., 2002; Harmer et al., 2002; Lembke and Ketter, 2002; Keightley et al., 2003; Venn et al., 2004; Martino et al., 2010).

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Emotion processing, a central aspect of social cognition, encompasses the ability to identify and discriminate ‘basic emotions’, which are thought to be innate and have universally recognizable facial expressions (Ekman and Friesen, 1976). Evidence for BD deficits in FER ranges from reports of no alterations and even improved recognition for disgust (Harmer et al. 2002), isolated fear recognition impairment (Lembke and Ketter, 2002; Venn et al., 2004), and a selective effect of mood state on surprise recognition (Rocca et al., 2009). However, in a recent meta-analysis, Kohler et al. (2011) concluded that FER impairments in BD represent a moderate and stable deficit that appears to be moderated by a limited number of demographic and clinical factors such as self-reported depression, age at time of testing, and years of education.

Although dysfunctions in both EF and FER have previously been reported, there is scant data linking these deficits. Recent evidence indicates that BD patients are unable to engage the prefrontal cortex when processing emotional stimuli (Lagopoulos and Malhi, 2011). Along these lines, Gopin et al. (2011) demonstrated impairment in BD I patients' ability to discriminate and respond accurately to positive and negative emotional stimuli in an executive task requiring the inhibition of a proponent response. Brand et al. (2012) found similar results in a group of unaffected bipolar siblings, where a response bias to negative emotional cues was observed. Similarly, Bora et al. (2005) reported that the ability to conceptualize another's mental/emotional state was positively correlated with measures of flexibility in a euthymic BD sample.

Indeed, the literature reports deficits of FER and EF in BD while some studies have correlated some measures of social cognition with EF functioning. However, it is unclear whether the impairment observed represents a generalized performance deficit, a problem processing emotional stimuli, or a specific deficit in FER (Bryson et al., 1997; Mandal et al., 1998; Marwick and Hall, 2008, Kohler et al., 2009). Given this data, the objective of the present study was to evaluate FER and its correlation with EF in bipolar I patients during mania, depression and euthymia compared to healthy controls.

2. Material and methods

2.1. Subjects

One hundred and ten individuals (18–40 years old) with BD I were included. Diagnoses were determined by trained psychiatrists based on the Structured Clinical Interview (SCID-I) (First et al., 1996) for DSM-IV TR (DSM-IV 2000). Euthymic patients ($n=38$) were stable without medication adjustment for at least 2 months. Manic ($n=41$) and depressive ($n=31$) subjects were medication free at the time of the neuropsychological evaluation. These symptomatic patients were participants in the LICAVAL clinical trial (Campos et al., 2010) and evaluated immediately after the wash-out period (at least 4 weeks for antidepressants, mood stabilizers or antipsychotics, or 8 weeks for depot medications), prior to commencing use of medications in the trial. Subjects with neurological disorders, previous head trauma, currently abusing any substance or submitted to electroconvulsive therapy in the preceding 6 months, were excluded. The Young Mania Rating Scale (YMRS) (Young et al.,1978), and the Hamilton Depression Rating Scale (HDRS-21) (Hamilton, 1960) were used to evaluate symptoms.

2.2. Control group

Ninety-six healthy volunteers (18–40 years old) were recruited, consisting of students or staff of the Faculty of Medicine, University of São Paulo. All control subjects had no current or past history of psychiatric disorders according to the evaluation conducted by trained psychiatrists using The Mini International Neuropsychiatric Interview (MINI) (Sheehan et al. 1998). Similarly, all subjects had no family history (first-degree relatives) of mood or psychotic disorders and had not been in recent use of psychotropic medication or indulged in substance abuse over the last 3 months.

2.3. Cognitive assessment

Neurocognitive and FER tests were carried out under standardized conditions and scored by two trained neuropsychologists. EF was assessed using the Wisconsin Card Sorting Test [(WCST)-Conceptual level responses (WCST-CONC), Perseverative Responses (WCST-PR), Failure to Maintain Set (WCST-FMS), Corrected Categories (WCST-CC), Errors (WCST-E), Non-Perseverative Errors (WCST-NP), and Perseverative Errors (WCST-P)] (Lezak, 1995). FER was tested using a range of photographs from the Ekman and Friesen series of Pictures of Facial Affect (Ekman and Friesen, 1976). The Emotion Hexagon Test is a test of FER utilizing pictures of emotional faces derived from Ekman and Friesen's Pictures of Facial Affect. Ekman and Friesen's original pictures were modified using computer manipulation techniques to generate stimuli of varying levels of difficulty. Each emotional face was blended with a picture depicting another emotion, which it was most likely to be confused with. For each emotion, three levels of intensity were generated: 90%, 70% and 50%. Each face was presented for 5 s, following which, participants were asked to decide which of the six emotions (happiness, sadness, surprise, disgust, anger and fear) best described the face. Participants completed a practice block followed by 5 test blocks of 30 trials each. Faces were presented in random order. Data from the practice block and stimuli at the 50% intensity level were not analyzed.

2.4. Ethics

The research ethics committee of the ***Hospital das Clínicas of the University of São Paulo*** approved the study (Process no. 2010/16934-4). Written informed consent was obtained from all study participants.

2.5. Statistical analysis

Subjects were classified into four groups (euthymia, mania, depression and controls). The Chi-square test was used for comparison of categorical data, and the ANOVA for continuous data.

Emotion Hexagon (HEX) scores (TOTAL, ANGER, DISGUST, FEAR, HAPPY, SAD AND SURPRISE) were compared among patients with euthymia, mania, or depression, and controls using the ANOVA test and subsequently by applying Turkey's multiple variables correction test. Pearson's correlation test was employed to investigate the impact of EF on FER scores. The PASW statistics version 18.0 software (SPSS Inc., Chicago, Illinois) was used for all analyses and a level of significance of <0.05 was adopted for all comparisons.

3. Results

A total of 110 patients with BD I (18–40 years old, 75 females) were included, of whom 41 were in manic episode; 31 depressive episode and 38 euthymic. Mean age of the sample was 29.3 ($\pm$5.3) years old; 26.9 ($\pm$5.2) years and 32.9 ($\pm$10.9) years, respectively. Average schooling was 12.2 years ($\pm$3.5) in mania, 12.6 years ($\pm$2.4) in depression, 12.6 years ($\pm$3.1) in euthymic state (Table 1).

Table 1
Sociodemographic characteristics of controls, euthymia, mania and depression groups.

	Gender (female/male)	Age	Education
Controls ($N=96$)	51/45		
Mean		24.3	13.9
Std. deviation		4.7	2.4
Euthymia ($N=38$)	25/13		
Mean		32.9	12.6
Std. deviation		10.9	3.1
Mania ($N=41$)	32/9		
Mean		29.3	12.2
Std. deviation		5.3	3.5
Depression ($N=31$)	18/13		
Mean		26.9	12.6
Std. deviation		5.2	2.4

Table 2
Comparison of EF and FER scores among mania, depression, euthymia and control groups.

Test	F	ANOVA Sig.	Tukey's post hoc test[a]
WCST-CONC	5.74	0.001	M < C
WCST-PR	4.04	0.008	M > C
WCST-FMS	0.77	0.511	–
WCST-CC	4.90	0.003	M < C
WCST-E	5.78	0.001	M > C
WCST-P	6.59	< 0.001	M > C, D,E
WCST-NP	3.48	0.017	M > C
HEX	6.59	< 0.001	M < C > E
HEX ANGER	1.48	0.222	–
HEX DISGUST	0.55	0.646	–
HEX FEAR	8.21	< 0.001	M < C > E
HEX HAPPY	2.83	0.039	C > M
HEX SAD	1.04	0.374	–
HEX SURP	5.42	0.001	C > M,D,E

Caption: WCST (Wisconsin Card Sorting Test)-Conceptual level responses (WCST-CONC), Perseverative Responses (WCST-PR), Failure to Maintain Set (WCST-FMS), Corrected Categories (WCST-CC), Errors (WCST-E), Non-Perseverative Errors (WCST-NP), Perseverative Errors (WCST-P); C=controls; M=mania; D=depression, E=euthymia.

[a] Significance level < 0.05.

3.1. BD I patients performed worse than healthy controls on FER and EF tests

Comparison of measures of FER among the groups showed that the group of manic patients underperformed the control group on HEX total ($p=0.0001$), HEX fear subtests ($p=0.0001$), HEX happiness ($p=0.039$) and HEX surprise ($p=0.001$). Moreover, the group of euthymic patients showed significantly lower performance on HEX total ($p=0.0001$) and HEX fear ($p=0.0001$) compared to controls. The depression group did not differ to the control group for facial emotion recognition scores.

Comparing EF between the groups, the manic group had the poorest performance on almost all measures of the WCST. The manic group had a higher number of WCST-PR ($p=0.008$), WCST-E ($p=0.001$), WCST-P ($p=0.001$) and WCST-NP ($p=0.017$) and fewer WCST-CC ($p=0.003$) and WCST-CONC ($p=0.001$) (Table 2).

3.2. EF correlated with FER in euthymic BD subjects and in healthy controls

A correlation between EF and facial emotion recognition was observed in healthy controls and BD subjects during euthymia. However, no correlation between FER and EF tests was observed in the mania or depression groups.

In the euthymic BD group, HEX total score positively correlated with WCST-CONC ($p=0.0004$, $r=0.54$) and WCST-CC ($p=0.004$, $r=0.45$) but negatively correlated with WCST-PR ($p=0.0001$, $r=-0.58$), WCST-E ($p=0.0005$, $r=-0.53$), WCST-P ($p<0.001$, $r=-0.62$) and WCST-NP ($p=0.03$, $r=-0.35$). HEX-ANGER and HEX-DISGUST negatively correlated with WCST-P ($p=0.0007$, $r=-0.52$) ($p=0.04$, $r=-0.32$), respectively. HEX-FEAR positively correlated with WCST-CONC ($p=0.004$, $r=0.44$) and WCST-CC ($p=0.004$, $r=0.44$) but negatively correlated with WCST-PR ($p=0.0005$, $r=-0.53$), WCST-E ($p=0.001$, $r=-0.50$), WCST-P ($p<0.001$, $r=-0.51$) and WCST-NP ($p=0.02$, $r=-0.37$). HEX-HAPPY followed the same pattern of correlation as HEX-FEAR, i.e. positively correlated with WCST-CONC ($p=0.001$, $r=0.49$) and WCST-CC ($p=0.006$, $r=0.43$) but negatively correlated with WCST-PR ($p=0.003$, $r=-0.46$), WCST-E ($p=0.0015$, $r=-0.49$), WCST-P ($p<0.001$, $r=-0.49$) and WCST-NP ($p=0.01$, $r=-0.40$). HEX-SAD positively correlated with WCST-CONC ($p=0.002$, $r=0.47$) and WCST-CC ($p=0.01$, $r=0.38$) but negatively correlated with WCST-PR ($p<0.001$, $r=-0.55$), WCST-E ($p=0.002$, $r=-0.47$) and WCST-P ($p<0.001$, $r=-0.56$). HEX-SURPRISE negatively correlated with WCST-PR ($p=0.04$, $r=-0.33$) and WCST-P ($p=0.01$, $r=-0.39$) (Table 3).

Pearson's correlation test revealed that, in the healthy control group (Table 4), HEX total score positively correlated with WCST-CONC ($p=0.01$, $r=0.26$) but negatively correlated with WCST-PR ($p=0.02$, $r=-0.22$), WCST-E ($p=0.01$, $r=-0.25$) and WCST-P ($p=0.005$, $r=-0.28$). For the HEX subtests, HEX-FEAR positively correlated with WCST-CONC ($p<0.001$, $r=0.38$) and WCST-CC ($p<0.001$, $r=0.33$) but negatively correlated with WCST-PR ($p<0.001$, $r=-0.36$), WCST-E ($p<0.001$, $r=-0.38$), WCST-P ($p<0.001$, $r=-0.39$) and WCST-NP ($p=0.005$, $r=-0.28$). HEX-SURPRISE positively correlated with WCST-CONC ($p=0.006$, $r=0.27$) and negatively correlated with WCST-E ($p=0.006$, $r=-0.27$) and WCST-NP ($p=0.007$, $r=-0.27$) (Table 4).

4. Discussion

Our findings are in agreement with the literature, showing that BD I patients in euthymia and maniac episodes performed worse than healthy controls on FER (Rocca et al., 2009; Schaefer et al., 2010). Comparison of measures of the FER among the groups showed that the group of manic patients underperformed the control group on fear subtests, happiness and surprise. The group of euthymic patients showed significantly lower performance on fear compared to controls. The depression group did not differ to the control group for facial emotion recognition scores. The data in the related literature are conflicting, where some studies found no differences between BD euthymic and control groups (Venn et al., 2004; Vaskinn et al., 2007). By contrast, Rocca et al. (2009), in a systematic review, concluded that euthymic BD patients present impaired recognition of disgust and fear, whereas maniac BD patients have difficulties recognizing fear and sad faces. Schaefer et al. (2010) found that participants with BD in a depressive episode appeared to require a more intensive facial expression before they could correctly identify emotions, yet when labeling emotions tended to be relatively accurate, particularly with disgust. However, previous studies have suggested a possible reduction in sensitivity for happy faces (Gray et al., 2006; Rich et al., 2008; Summers et al., 2006).

We report a correlation between FER and EF, suggesting that the more preserved the EF, the better the ability to recognize facial emotions globally and for their subtypes. On the other hand, this correlation was disrupted during mania and depression episodes.

To the best of our knowledge, no previous studies have compared FER and executive function in bipolar disorder and

Table 3
Correlation between facial emotion recognition scores and executive function in bipolar patients.

MOOD STATE		HEX TOTAL	HEX ANGER	HEX DISGUST	HEX FEAR	HEX HAPPY	HEX SAD	HEX SURP
EUTHYMIA	$n=38$							
WCST-CONC	Pearson's correlation	**54.33%**	42.72%	24.17%	**50.37%**	**49.09%**	**47.56%**	31.91%
	Sig. (2-tailed)	**0.0004**	0.0075	0.1438	**0.0013**	**0.0018**	**0.0025**	0.0509
WCST-PR	Pearson's correlation	**−58.26%**	−47.43%	−23.20%	**−53.98%**	**−46.57%**	**−55.63%**	**−33.20%**
	Sig. (2-tailed)	**0.0001**	0.0026	0.1610	**0.0005**	**0.0032**	**0.0003**	**0.0417**
WCST-FMS	Pearson's correlation	2.31%	8.76%	1.43%	−5.73%	−1.60%	−2.51%	8.30%
	Sig. (2-tailed)	0.8907	0.6012	0.9322	0.7327	0.9241	0.8813	0.6204
WCST-CC	Pearson's correlation	**45.01%**	32.89%	20.92%	**44.83%**	**43.52%**	**38.51%**	24.84%
	Sig. (2-tailed)	**0.0046**	0.0437	0.2075	**0.0048**	**0.0063**	**0.0170**	0.1327
WCST-E	Pearson's correlation	**−53.92%**	−42.80%	−20.84%	**−50.77%**	**−49.73%**	**−47.20%**	−31.62%
	Sig. (2-tailed)	**0.0005**	0.0073	0.2093	**0.0011**	**0.0015**	**0.0028**	0.0531
WCST-P	Pearson's correlation	**−62.60%**	**−52.33%**	**−32.86%**	**−51.82%**	**−49.99%**	**−56.02%**	**−39.71%**
	Sig. (2-tailed)	**0.0000**	**0.0007**	**0.0440**	**0.0009**	**0.0014**	**0.0003**	**0.0135**
WCST-NP	Pearson's correlation	**−35.07%**	−24.49%	−12.77%	−37.01%	−40.92%	−29.87%	−15.93%
	Sig. (2-tailed)	**0.0309**	0.1383	0.4449	0.0222	0.0107	0.0685	0.3393
MANIA	$n=41$							
WCST-CONC	Pearson's correlation	13.66%	27.70%	−5.98%	21.21%	−6.02%	14.10%	9.29%
	Sig. (2-tailed)	0.4006	0.0835	0.7138	0.1888	0.7119	0.3854	0.5684
WCST-PR	Pearson's correlation	−18.33%	−20.87%	−8.49%	−11.77%	−2.67%	−1.89%	−15.30%
	Sig. (2-tailed)	0.2639	0.2023	0.6073	0.4756	0.8718	0.9093	0.3525
WCST-FMS	Pearson's correlation	13.42%	2.52%	19.91%	8.39%	14.45%	−8.10%	10.90%
	Sig. (2-tailed)	0.4153	0.8792	0.2243	0.6118	0.3800	0.6241	0.5091
WCST-CC	Pearson's correlation	14.72%	29.64%	−1.96%	20.01%	−9.25%	19.13%	11.01%
	Sig. (2-tailed)	0.3711	0.0670	0.9056	0.2220	0.5755	0.2432	0.5047
WCST-E	Pearson's correlation	−13.66%	−27.70%	5.98%	−21.21%	6.02%	−14.10%	−9.29%
	Sig. (2-tailed)	0.4006	0.0835	0.7138	0.1888	0.7119	0.3854	0.5684
WCST-P	Pearson's correlation	−19.22%	−25.77%	−4.03%	−17.70%	−3.84%	−7.59%	−12.76%
	Sig. (2-tailed)	0.2411	0.1133	0.8076	0.2812	0.8166	0.6459	0.4387
WCST-NP	Pearson's correlation	−0.28%	−13.67%	12.06%	−10.40%	10.06%	−10.30%	−1.19%
	Sig. (2-tailed)	0.9865	0.4067	0.4647	0.5288	0.5422	0.5327	0.9428
DEPRESSION	$n=31$							
WCST-CONC	Pearson's correlation	−6.34%	−15.13%	−16.81%	−2.80%	4.73%	−22.01%	25.00%
	Sig. (2-tailed)	0.7439	0.4332	0.3834	0.8852	0.8075	0.2512	0.1908
WCST-PR	Pearson's correlation	−3.63%	−3.11%	6.71%	−6.97%	−27.13%	5.50%	0.34%
	Sig. (2-tailed)	0.8516	0.8726	0.7295	0.7193	0.1546	0.7769	0.9862
WCST-FMS	Pearson's correlation	−25.68%	−30.56%	6.88%	−22.66%	−32.35%	−5.47%	0.48%
	Sig. (2-tailed)	0.1787	0.1069	0.7230	0.2372	0.06	0.7781	0.9801
WCST-CC	Pearson's correlation	8.82%	2.70%	−13.40%	18.48%	35.71%	−16.08%	8.41%
	Sig. (2-tailed)	0.6492	0.8893	0.4883	0.3372	0.052	0.4046	0.6644
WCST-E	Pearson correlation	1.72%	18.40%	8.91%	2.28%	−22.34%	15.96%	−27.12%
	Sig. (2-tailed)	0.9295	0.3394	0.6457	0.9067	0.2439	0.4082	0.1547
WCST-P	Pearson's correlation	−3.51%	−0.37%	7.54%	−10.37%	−21.59%	4.06%	0.05%
	Sig. (2-tailed)	0.8564	0.9848	0.6975	0.5926	0.2606	0.8343	0.9981
WCST-NP	Pearson's correlation	4.24%	22.29%	3.25%	10.19%	−13.92%	14.66%	−30.43%
	Sig. (2-tailed)	0.8273	0.2451	0.8671	0.5987	0.4714	0.4479	0.1085

Caption: Hex=Emotion Hexagon Test; Wisconsin Card Sorting Test (WCST), Conceptual level responses (WCST-CONC), Perseverative Responses (WCST-PR), Failure to Maintain Set (WCST-FMS), Corrected Categories (WCST-CC), Errors (WCST-E), Non-Perseverative Errors (WCST-NP), Perseverative Errors (WCST-P); C=controls; M=mania; D=depression; E=euthymia. Significance level <0.05.

Table 4
Correlation between facial emotion recognition scores and executive function in healthy controls.

MOOD STATE		**HEX TOTAL**	**HEX ANGER**	**HEX DISGUST**	**HEX FEAR**	**HEX HAPPY**	**HEX SAD**	**HEX SURP**
Healthy Controls	$n=96$							
WCST-CONC	Pearson's correlation	**0.26**	0.15	−9.42%	**0.38**	18.25%	1.97%	**27.85%**
	Sig. (2-tailed)	**0.010**	0.128	0.364	**< 0.001**	0.076	0.849	**0.006**
WCST-PR	Pearson's correlation	**−22.43%**	−16.01%	5.63%	**−36.99%**	−1.58%	−4.56%	−10.32%
	Sig. (2-tailed)	**0.028**	0.121	0.587	**< 0.001**	0.879	0.660	0.319
WCST-FMS	Pearson's correlation	13.87%	13.86%	12.86%	1.21%	9.37%	5.47%	9.53%
	Sig. (2-tailed)	0.180	0.180	0.214	0.907	0.366	0.598	0.358
WCST-CC	Pearson's correlation	18.95%	11.33%	−15.72%	**33.93%**	7.22%	3.27%	20.22%
	Sig. (2-tailed)	0.065	0.274	0.128	**< 0.001**	0.486	0.753	0.05
WCST-E	Pearson's correlation	**−25.85%**	−15.14%	9.76%	**−38.62%**	−18.67%	−1.87%	**−27.94%**
	Sig. (2-tailed)	**0.011**	0.143	0.346	**< 0.001**	0.070	0.857	**0.006**
WCST-P	Pearson's correlation	**−28.49%**	−20.75%	5.02%	**−39.87%**	−9.20%	−9.78%	−18.22%
	Sig. (2-tailed)	**0.005**	0.05	0.628	**< 0.001**	0.375	0.345	0.077
WCST-NP	Pearson's correlation	−17.92%	−7.60%	9.92%	**−28.26%**	−20.01%	3.16%	**−27.37%**
	Sig. (2-tailed)	0.082	0.464	0.338	**0.005**	0.051	0.761	**0.007**

Caption: Hex=Emotion Hexagon Test; Wisconsin Card Sorting Test (WCST), Conceptual level responses (WCST-CONC), Perseverative Responses (WCST-PR), Failure to Maintain Set (WCST-FMS), Corrected Categories (WCST-CC), Errors (WCST-E), Non-Perseverative Errors (WCST-NP), Perseverative Errors (WCST-P); Significance level <0.05.

healthy controls with a sample of this size. However, some investigations have found impaired recognition of facial affect and correlated the deficit with executive function in schizophrenia. Kohler et al. (2000), studying 35 patients with schizophrenia and 45 healthy subjects, reported that better emotion recognition performance was correlated with better performance on the WCST and that patients with schizophrenia performed worse than control subjects on emotion. Bryson et al. (1997) investigated 63 patients diagnosed with schizophrenia or schizoaffective disorder and found a moderate relationship between emotion recognition and WCST. Sachs et al. (2004), in a study involving 40 patients with schizophrenia and 43 healthy volunteers, also reported that patients with schizophrenia performed worse than control subjects on all emotions and found that happy facial emotion recognition correlated with WCST score.

Some studies in BD have shown a correlation of EF with some aspects of emotion regulation. Gopin et al. (2011) demonstrated impairment in BD I patients' ability to discriminate and respond accurately to positive and negative emotional stimuli on an executive task requiring the inhibition of a proponent response. Brand et al. (2012) found similar results in a group of unaffected bipolar siblings, where a response bias to negative emotional cues was observed. Similarly, Bora et al. (2005) reported that the ability to conceptualize another's mental/emotional state was positively correlated with measures of flexibility in a euthymic BD sample.

In addition, a number of studies have correlated the cognitive and emotional processing changes found in BD patients. For example, the observed changes in the dorsolateral PFC and anterior cingulate of BD patients have been implicated in impaired cognitive control and self-monitoring, leading to intrusions of affective material (Kerr et al., 2005; Lawrence et al., 2004; Malhi et al., 2004a, 2004b; Murphy et al., 1999; Yurgelun-Todd et al., 2000). Additionally, impairment of the dorsolateral PFC has been implicated in impaired working memory and executive control, resulting in poor modulation of attention to emotionally salient stimuli (Kerr et al., 2005; Murphy et al., 1999). Thus, our results are

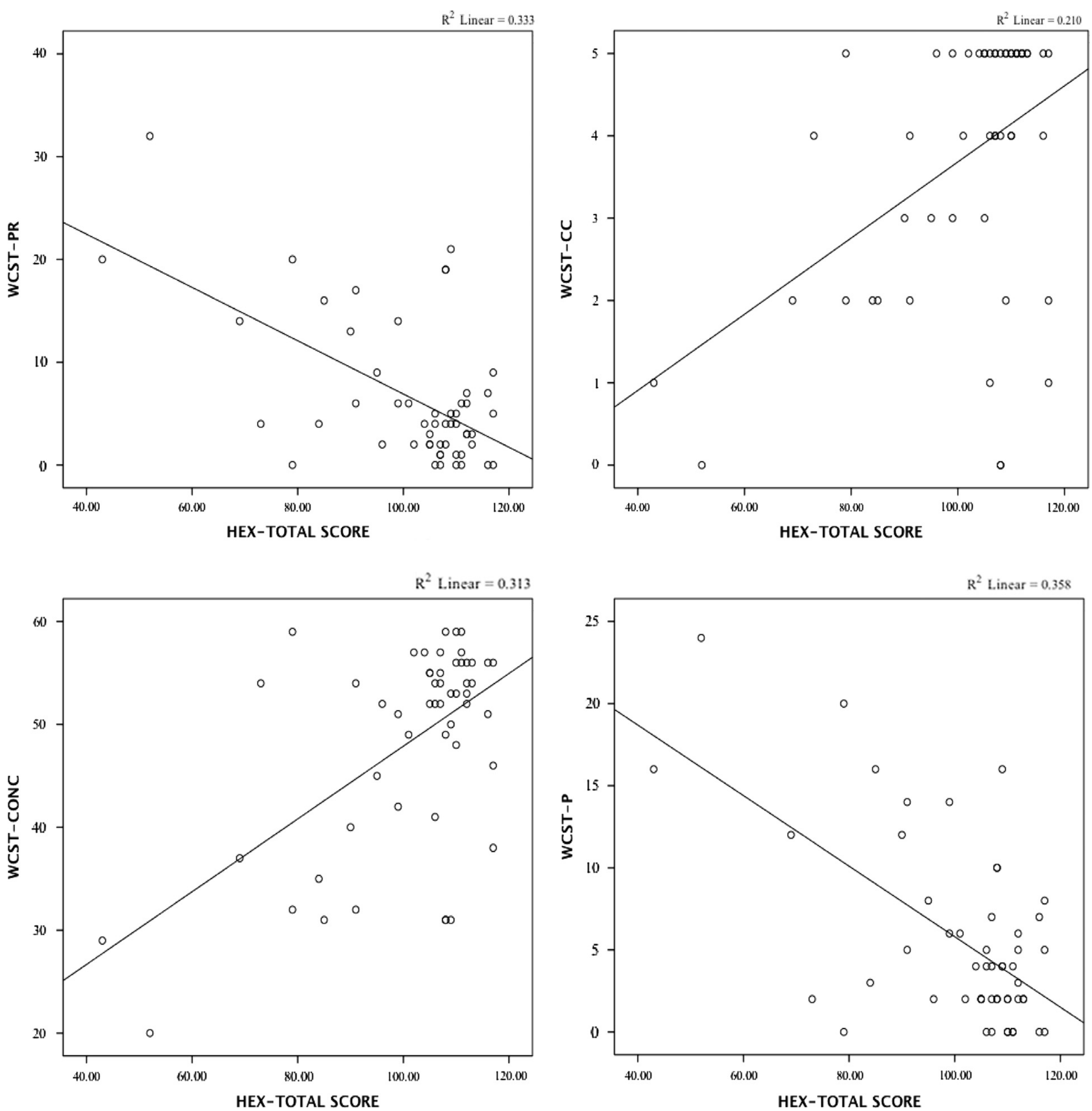

Fig. 1. Correlation between HEX-TOTAL score and WCST-CC, WCST-CONC, WCST-PR, and WCST-P.

in line with the literature which, in light of the reciprocal connections between cognitive and emotion neural systems, proposed neurobiological theories of BD that include functional and structural abnormalities in fronto-limbic circuits (Strakowski et al., 2004a, 2004b, 2005; Ochsner and Gross, 2005, Ochsner, 2007; Ochsner et al., 2004; Phillips et al., 2003, 2008).

Given that deficits in executive functioning are predictors of impaired occupational and skills in daily activities (Addington and Addington, 2000) as well as of poor social functioning and possibly poorer quality of life (Brissos et al., 2008), EF seems to be implicated in the regulation of social cognition. Recognizing briefly displayed emotional expressions requires attention to be focused on the relevant features as well as mental speed in order to process all relevant information in a timely manner. Therefore, Theory of Mind (ToM) tasks may require executive processes, such as cognitive flexibility, in order to generate a different perspective on the situation as well as inhibitory control in order to suppress one's own perspective. Because general cognitive deficits in mental speed, attention, memory, or EF are commonly found in BD I, an important question is the extent to which such deficits can explain impaired performance on social cognition tests, and the extent that these tests can specifically measure deficits in social cognition. It is unclear whether the impairment observed represents a generalized performance deficit, a problem in processing emotional stimuli, or a specific deficit in FER (Bryson et al., 1997; Mandal et al., 1998; Marwick and Hall, 2008; Kohler et al., 2009).

Limitations of this study include its small sample size and a control group comprising predominantly medical students. Another potential limitation of the present study was that the same patients were not compared in mood phases and euthymia. Future studies assessing the same patients during these phases should be conducted.

The strength of the present study is that it evaluated differences in FER scores among bipolar patients during manic episode, depressive episode or euthymia, and healthy controls, and correlated FER scores with EF scores. To the best of our knowledge, this is the first study to report the association between EF and FER scores in bipolar patients and healthy controls. Future studies should be directed towards the continued validation of social functioning and social cognitive measures and their adaptation for use in at-risk and early bipolar populations. However, to gain a comprehensive understanding of patient strengths and weaknesses, assessment of social cognition should always be combined with assessments of general cognition and psychiatric symptoms. Fig. 1.

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Conflict of interest

The authors do not have any conflict of interest to report.

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