

Neuropsychological performance facilitates emotion recognition in bipolar disorder

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Abstract

The aim of the study. In bipolar disorder (BD), evidence for both cognitive impairment and deficit in emotion recognition has been found. Several investigations indicate that cognition and face processing can be interrelated. In this study, we assessed the correlations between cognitive functioning and emotion recognition (face expression) in patients with BD during an acute manic and depressive episode as well as in remission using a large battery of neurocognitive tests.

Material and methods Twenty-four manic subjects, 21 with bipolar depression, and 22 euthymics, age-, sex-, and education-matched were included. Cognitive functions were assessed by the Wisconsin Card Sorting Test (WCST), Trail Making Test (TMT), Stroop Color-Word Interference Test (SCWT), California Verbal Learning Test (CVLT), Benton Visual Memory Test (BVRT), Rey-Osterreich Complex Figure Test (ROFT), d2 test and Verbal Fluency Test (VFT). For emotion recognition, the Penn Emotion Recognition Test and Penn Emotion Discrimination Test were employed.

Results. In mania, performances on selected measures of the WCST, TMT, SCWT, CVLT, ROFT, d2 test, and VFT, achieved 19 positive correlations with better recognition of happiness. In depression, conducting these tests obtained 20 correlations with finer recognition of sadness. In remission, such performances acquired 18 correlations with greater identification of sadness (10 replicated those obtained in depression).

Conclusions. Better neuropsychological performance can facilitate emotion recognition. In manic patients, this concerns mostly happiness, while in depression and remission, mainly sadness. We hypothesize that the identification of sadness could be considered a biological marker of mood disorders.

bipolar disorders; neuropsychological test; emotion recognition; facial expression

INTRODUCTION

Recent meta-analyses point to both cognitive impairment [1] as well as the deficit in emotion-

al face processing [2] in bipolar disorder (BD). These disturbances occur during manic and depressive episodes and can persist into a euthymic state. The kind of deficiency in emotional face processing can be different in manic and depressed patients as well as in remitted ones. The studies performed during mania showed worse recognition of negative facial emotions, such as fear, anger, and sadness, compared with control subjects [3-6]. In depression, the patients

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generally recognize fewer emotions, and such recognition is slower [7-9]. Emotional face processing can be reflected in neuroimaging changes [10].

Several investigations indicate that cognition and face processing can be interrelated, i.e. that better cognitive performance can facilitate better face recognition and vice versa. According to the analysis of Van Rheenen and Rossell [11] such neurocognitive measures as processing speed, working memory, attention, learning, and executive functioning were related to the quality of emotion processing in patients with BD. In another study, investigating the relationship between facial emotion recognition in BD, type I patients, and executive functions assessed by the Wisconsin Card Sorting Test (WCST), it was found that six of the seven variables of the WCST correlated with facial recognition in both healthy controls and BD euthymic subjects but not in BD patients during mood episodes[12].

We were interested in whether a correlation between cognitive performance and emotion recognition can be detected by using a large battery of neurocognitive tests. We presumed that the ultimately perceived emotion should be that recognized with the best neurocognitive ability. Furthermore, we suggested that the best-recognized emotion during euthymia can make a biological marker of the disorder.

Therefore, the study aims to assess the cognitive functioning and the ability of emotion recognition based on the facial expression in patients with bipolar mood disorders (BD) during various phases of the illness (mania, depression, euthymia). The interrelation between these two domains was evaluated with special regard to the specific best-recognized emotions in mania, depression, and euthymia.

METHODS

Patients

The study included 67 patients with bipolar disorder. There were 24 subjects (17 female and 7 male), studied during a manic episode, 21 subjects (13 female and 8 male) studied during a depressive episode, and 22 subjects (15 female and 7 male) studied during euthymia. The groups

were age-, sex – and education-matched. The patients were hospitalized in the inpatient clinic of the Department of Adult Psychiatry, Poznan University of Medical Sciences, on account of an acute manic or depressive episode of BD. A consensus diagnosis of bipolar disorder was made for each patient by at least two psychiatrists according to DSM-IV criteria (SCID)[13]. Exclusion criteria covered any other psychiatric co-morbidity or serious medical condition.

The criterion for inclusion in the study for manic patients was an intensity of mania, as assessed by the Young Mania Rating Scale – YMRS [14] of ≥ 20 points, and for depressive patients was an intensity of depression, as assessed by the 17-item Hamilton Depression Rating Scale – HDRS [15] of ≥ 18 points. In the studied group, the mean intensity of mania was 24 ± 4 and depression 24 ± 3 points. The criterion for euthymia for bipolar patients studied was ≤ 8 points on the YMRS and/or ≤ 7 points on the HDRS. In the studied euthymic group, the mean intensity of symptoms was YMRS 2 ± 2 and HDRS 2 ± 2 .

The study was approved by the Bioethics Committee of Poznan University of Medical Sciences, and all the participants gave their informed consent after the nature of the procedures had been fully explained to them.

The assessment of cognitive functions

For the assessment of cognitive functions, the Wisconsin Card Sorting Test, Trail Making Test, Stroop Color-Word Interference Test, California Verbal Learning Test, Benton Visual Memory Test, Rey-Osterreich Complex Figure Test, d2 test, and Verbal Fluency Test, were used.

Wisconsin Card Sorting Test

The Wisconsin Card Sorting Test (WCST) assesses executive functions, controlling cognitive processes, and the strategy for solving problems. It is also a tool for the assessment of working memory, abstract thinking, and “set-shifting” i.e. the ability to display flexibility in the face of changing schedules of reinforcement. The subject is asked to match the 64 cards, according to color, shape, and number of elements. He/she is not told how to match. However, the subject is informed whether a particular match is right

or wrong. After ten correct matches, the criterion is changed without informing the participant. The test is terminated when six categories are correctly arranged or all the cards are used. Percentages of errors, perseverative responses (The abbreviation in the tables as "P"), conceptual responses (The abbreviation in the tables as "CON"), and the number of completed categories (The abbreviation in the tables as "CC") is calculated. A computer version of the WCST [16] was used in this study.

Trail Making Test

The Polish version of the Trail Making Test (TMT) is an element of the Halstead-Reitan test battery [17]. Part A of the test consists of connecting, by a continuous line, the points between 1 and 25 as quickly as possible and measures the psychomotor speed and visual-motor coordination. Part B consists of connecting, by a continuous line as quickly as possible, the digits alternatively with consecutive letters i.e. 1 – A – 2 – B – 3 – C, etc. – and reflects the ability to shift strategy and assess executive function and visuospatial working memory. The results, separately for A and B, are presented as the duration of the performance (in seconds), and the number of errors (The abbreviation in the tables as "err").

Stroop Color-Word Interference Test

The Stroop Color-Word Interference Test (SCWT) was constructed by John Ridley Stroop [18]. The test assesses verbal working memory and attention. The first part of the test (part A), Reading Color Names in black (The abbreviation in the tables as "RNCb"), measures verbal abilities and attention. The subject is asked to read as quickly as possible words (color names) printed with black ink on the white card. The second part (part B): Naming the Color of Word – different (The abbreviation in the tables as "NCWd") – measures verbal working memory and executive functions. The subject is asked to name the color of each printed word. The color of the printed word is different from the color described by the word. The results of the test include the time of performance of each part and the number of perseverative errors in part B (The abbreviation in the tables is "NCWe").

California Verbal Learning Test

The California Verbal Learning Test (CVLT) originated in 1987 [19]. It measures episodic verbal learning and memory, including coding and recall. The Polish version was published in 2010 [20]. In the test, the experimenter reads a list of 16 nouns aloud drawn from four semantic categories (tools, fruits, clothing, spices, and herbs), at one-second intervals, in a fixed order, over five learning trials (list A) (The abbreviation in the tables as "A1-5"). After each trial, the subject is asked to recall as many words as they can in any order (i.e., free recall). An interference list (list B) is presented that shares two categories from List A (e.g., fruit and tools) and has two unshared categories (e.g., fish and kitchen utensils). However, neither list uses common words for a specific category (e.g., apples used rather than bananas). Free and cued recall of list A is tested immediately (short-delay) (The abbreviations in the tables as "FSD" and "CSD"), and again after 20 minutes (long-delay) (The abbreviations in the tables "FLD" and "CLD"). In cued recall, the experimenter prompts the subjects with the word category. The CVLT ends with a recognition task, where the experimenter presents the subject with a 44-word list, and the subject must indicate whether it is a target word or a distractor.

Benton Visual Memory Test (BVMT)

The Benton Visual Memory Test (BVMT) authored by Arthur Benton [21] measures visual perception and visual memory. Polish adaptation of the test exists since 1996 [22]. The test is composed of 3 sets, or forms, of 10 designs. The most popular is the 10 sec. presenting of each table. The examinee is given a booklet containing 10 blank pages on which he or she reproduces the designs. The results of the test include the number of correctly reproduced tables (The abbreviation in the tables as "corr") and the number of errors (The abbreviation in the tables as "err").

Rey-Osterreich Complex Figure Test (ROFT)

The Rey-Osterreich Complex Figure Test (ROFT) is a neuropsychological assessment in which examinees are asked to reproduce a complicat-

ed line drawing, first by copying it freehand (recognition) (The abbreviation in the tables as “copy”), and then, after 3 min. interval, drawing from memory (recall) (The abbreviation in the tables as “repr”). The test permits the evaluation of different functions, such as visuospatial abilities, memory, attention, planning, working memory, and executive functions [23].

D2 Test

The D2 test, authored by Rolf Brickenkamp, was published in 1962 [24], and the Polish version exists since 2003 [25]. The test is a neuropsychological measure of selective and sustained attention and visual scanning speed. It is a paper and pencil test that asks participants to cross out any letter “d” with two marks around above it or below it in any order. The surrounding distractors are usually similar to the target stimulus, for example, a “p” with two marks or a “d” with one or three marks. The results of the test include the number of corrected letters (The abbreviation in the tables as “NCL”), the number and the percentage of errors (The abbreviation in the tables as “NPE”), as well as the indexes of general perception and concentration (The abbreviation in the tables as “IPC”).

Verbal Fluency Test (VFT)

Verbal fluency tests are a kind of psychological tests in which participants have to produce as many words as possible from a category in a given time (usually 60 seconds). This category can be phonemic, including words beginning with a specified letter, or semantic, including objects such as animals or fruits. These tests enable to the assessment of such cognitive functions as semantic memory, working memory, and executive functions [26]. In the present study, in the letter fluency test, the examinees were asked to produce as many words as possible beginning with K, O, and S. In the category fluency, the examinees were asked to produce as many words as possible for a category of animals, vegetables and fruits. The performance measure was the total number of words for each criterion, the number of incorrect words, and the number of perseverations.

The assessment of emotion recognition

For the assessment of emotion recognition, the two tests from the University of Pennsylvania Computerized Neuropsychological Test Battery such as the Penn Emotion Recognition Test and the Penn Emotion Discrimination Test were employed [27].

Penn Emotion Recognition Test (The ER40)

The ER-40 is a computerized task that presents 40 color photographs of four male and four female faces displaying expressions of four basic emotions (happiness, sadness, anger, and fear) and no emotion (neutral). Photographs were created by asking experienced actors to portray evoked facial expressions of emotion. Intended emotions displayed in photographs are consistent with those reported by healthy raters viewing the photographs (Gur et al., 2002). Stimuli included in the ER-40 were balanced for the actor’s gender, age, and ethnicity.

Participants were asked to examine the faces and decide what emotion the person is showing or to select “No Emotion” if the person is not showing any emotion. Accuracy and median response time (RT, log-transformed) for each emotion category were recorded.

Penn Emotion Discrimination Test (The EDF-40)

The EDF-40 Test consists of 40 black and white photographs of faces presented in pairs. Each pair is a photographs of the same person expressing a similar or different intensity of happiness or sadness. Participants are asked to assess whether the emotions on both faces are the same or whether one of them, the expression of emotion is more intense. The number of correct and incorrect responses for happiness and sadness is measured.

STATISTICS

The study parameters were compared in the three groups: manic, depressed, and euthymic. When the data were consistent with a normal distribution, the analysis of variance (ANOVA)

with Tukey’s post-hoc test was applied. In other cases, we used the Kruskal-Wallis test, with Dunn’s post-hoc test. The r-Spearman test was used to determine the correlation between variables. The calculations were performed using the Statistica (StatSoft-Poland) version 10 statistical package. The level of statistical significance was determined at $p < 0.05$.

RESULTS

Impairment of cognitive functioning and emotion recognition in mania and depression

Cognitive functioning during both manic and depressive episodes was worse compared to euthymia, regarding executive functions, visual-spatial and verbal working memory, verbal learning, visual-spatial functions, and attention. Cognitive disturbances during mania and depression were similar, except for more interference errors during verbal learning made by manic subjects.

The ability of emotion recognition during a manic episode was impaired compared to euthymia, mainly for recognition of the neutral face, anxiety, and sadness. Also, during a depressive episode, the ability of emotion recognition was impaired, mainly for the recognition of anger. In manic patients, compared to depressive ones, the recognition of anxiety and neutral faces was worse. In all periods of the illness, worse cognitive functions and the worse ability of emotion recognition correlated positively with age and illness duration. In addition, worse cognitive functions, correlated negatively with the time of education.

The relationship between cognitive functioning and emotion recognition

To assess the relationship between cognitive functioning and emotion recognition, the correlations of the results of cognitive tests with variables of Penn batteries were calculated. The results of such counting in mania are shown in Table 1

Table 1. The correlations between the results of cognitive tests and variables of PENN batteries (ER-40 and EDF-40) in mania

	WCST			TMT		Stroop			CVLT			Rey copy	D2		Fluency test			
	P	CON	CC	A	B	RCNb	NCWd	NCWe	B	CSD	CLD		NCL	OPC	K	O	S	anim
ER40 ANG	-0.20	0.24	0.14	-0.08	-0.41	0.09	-0.41	-0.58*	0.21	0.19	0.24	0.57*	0.36	0.38	0.38	0.05	0.15	0.34
ER40 FEAR	-0.19	0.21	0.20	-0.33	-0.22	-0.03	0.11	-0.16	0.31	0.43*	0.42*	0.22	0.14	0.26	0.25	-0.03	0.20	0.38
ER40 HAP	0.18	0.04	0.06	-0.63*	-0.31	-0.44*	-0.08	-0.35	0.55*	0.52*	0.43*	0.43*	0.08	-0.02	0.48*	0.47*	0.56*	0.51*
ER40 NOE	-0.31	0.48*	0.45*	-0.14	-0.35	-0.36	-0.34	0.22	0.56*	-0.25	0.13	0.37	0.14	0.28	0.23	0.07	-0.04	0.01
ER40 SAD	-0.37	0.35	0.30	-0.33	-0.33	-0.38	-0.09	0.10	0.42*	0.33	0.35	0.32	0.45*	0.35	0.32	0.12	0.14	0.16
EDF HAP_CR	-0.42*	0.52*	0.48*	-0.19	-0.51*	-0.27	-0.43*	-0.43*	0.19	0.14	0.19	0.35	0.56*	0.57*	0.47*	-0.10	0.10	0.34
EDF SAD_CR	-0.35	0.18	0.16	-0.28	-0.59*	-0.42*	-0.14	-0.18	0.05	0.22	0.18	0.04	0.55	0.39	0.40	-0.02	0.11	0.39

Significant correlations were printed in bold and marked with an asterisk (*)

Abbreviations of emotions: ANG – anger; HAP – happiness; NOE – neutral; SAD – sadness;

The abbreviations for the cognitive tests and their components are described in the Methods section

As can be noticed in the table, ten correlations were obtained between various measures of neu-

rocognitive tests and the indexes of happiness recognition on the ER-40 test. Furthermore, nine

other correlations were achieved between these measures and happiness discrimination on the EDF-40 test. Scanty associations were observed with recognition of anger (2), fear (2), and neutral (3) faces.

The correlations between the results of cognitive tests and variables of Penn batteries in depression are shown in Table 1

Table 2. The correlations between the results of cognitive tests and variables of PENN batteries (ER-40 and EDF-40) in depression

	WCST		TMT			BVRT		CVLT					D2	Rey repr	Fluency test			
	CON	CC	A	B	err	corr	err	A1-5	FSD	FLD	CLD	diff	IPC		O	S	anim	fruit
ER40 ANG	-0.04	-0.05	-0.20	-0.22	-0.31	0.38	-0.24	-0.01	0.15	0.27	0.24	0.28	0.23	0.31	0.31	0.26	0.19	0.26
ER40 FEAR	0.03	0.04	-0.05	-0.14	-0.14	0.48*	-0.39	0.17	0.21	0.22	0.24	0.28	0.48*	0.43	0.20	0.29	0.09	0.30
ER40 HAP	0.01	0.03	-0.06	-0.08	-0.17	0.08	-0.29	0.32	0.33	0.30	0.29	0.45*	0.03	-0.14	0.27	0.12	0.25	0.07
ER40 NOE	0.33	0.13	0.26	0.32	0.07	0.06	0.17	-0.09	-0.44	-0.22	-0.27	-0.01	-0.01	-0.08	0.11	0.06	0.10	-0.10
ER40 SAD	0.59*	0.47*	-0.53*	-0.58*	-0.33	0.46*	-0.55*	0.50*	0.46*	0.63*	0.49*	0.50*	0.48*	0.30	0.52*	0.63*	0.49*	0.11
EDF HAP_CR	0.08	0.31	-0.23	-0.43	-0.47*	0.13	-0.01	0.01	0.09	0.09	0.05	0.08	0.38	0.37	0.39	0.37	0.34	0.54*
EDF SAD_CR	0.23	0.34	-0.43	-0.47*	-0.47*	0.19	-0.12	0.09	0.24	0.30	0.20	0.33	0.47*	0.57*	0.38	0.33	0.40	0.46*

Significant correlations were printed in bold and marked with an asterisk (*)

Abbreviations of emotions: ANG – anger; HAP – happiness; NOE – neutral; SAD – sadness;

The abbreviations for the cognitive tests and their components are described in the Methods section.

As can be seen, fifteen correlations were obtained between various measures of neurocognitive tests and the indexes of sadness recognition on the ER-40 test. In addition, five other correlations were achieved between these measures and sadness discrimination on the EDF-40 test.

Few associations were observed with recognition of fear (2) and happy (3) faces.

The correlations between the results of cognitive tests and variables of Penn batteries during euthymia are shown in Table 3.

Table 3. The correlations between the results of cognitive tests and variables of PENN batteries (ER-40 and EDF-40) in euthymia

	WCST	TMT			Stroop			BVRT		CVLT		Rey repr	D2		Fluency test			
	CC	A	B	err	RCNb	NCWd	NCWe	corr	err	A1-5	CSD		NCL	IPC	O	S	anim	veget
ER40 ANG	-0.09	-0.36	-0.28	0.17	-0.19	-0.06	0.04	0.20	-0.15	0.03	0.22	0.33	0.32	0.35	0.20	0.53*	0.05	0.21
ER40 FEAR	0.20	-0.41	-0.38	-0.26	-0.66*	-0.00	-0.23	0.30	-0.27	-0.05	0.40	0.15	0.38	0.37	0.04	0.32	0.45*	0.01
ER40 HAP	0.36	-0.03	-0.27	0.16	-0.08	-0.09	-0.09	0.20	-0.05	0.32	0.33	0.10	0.27	0.21	-0.25	0.07	0.25	0.12

ER40 NOE	-0.46*	-0.09	-0.27	-0.54*	-0.12	-0.29	-0.20	0.36	-0.39	0.26	0.19	0.26	0.18	0.14	0.60*	0.36	0.24	-0.08
ER40 SAD	-0.11	-0.53*	-0.51*	-0.11	-0.25	-0.54*	-0.47*	0.44*	-0.39	-0.60*	0.44*	0.38	0.47*	0.44*	-0.13	0.17	0.60*	0.48*
EDF HAP_ CR	0.14	-0.39	-0.21	0.19	0.02	-0.14	-0.06	0.46*	-0.22	0.23	-0.21	0.14	0.27	0.22	-0.25	-0.17	0.46*	-0.09
EDF SAD_ CR	-0.03	-0.53*	-0.39	0.05	-0.24	-0.23	-0.01	0.61*	-0.61*	0.46*	0.01	0.49*	0.50*	0.54*	0.12	-0.03	0.67	-0.10

Significant correlations were printed in bold and marked with an asterisk (*)

Abbreviations of emotions: ANG – anger; HAP – happiness; NOE – neutral; SAD – sadness;

The abbreviations for the cognitive tests and their components are described in the Methods section.

In euthymic patients, eleven correlations were obtained between various measures of neurocognitive tests and the indexes of sadness recognition on the ER-40 test. In addition, seven other correlations were achieved between these measures and sadness discrimination on the EDF-40 test. Out of these 18 correlations, ten replicated those obtained in depression. Few associations were observed with recognition of anger (1), fear (2), neutral (3), and happy (2) faces.

DISCUSSION

We showed an impairment of cognitive functioning and faces recognition during both manic and depressive episode compared to euthymia what confirms the results of meta-analyses [1,2]. However, the original finding of our study is demonstrating the association between cognition and identification of emotional faces using a large battery of neurocognitive tests. In mania, we showed multiple significant positive correlations between cognitive performance and superior recognition of happiness, while in depression and remission, with better identification of sadness.

It has been known that experiencing a manic state favors greater recognition of positive emotions. In our previous study, we found evidence of increased affective empathy (over empathizing) during a manic episode in bipolar patients [28]. Trevisani et al [29] investigated 52 undergraduates who completed the Hypomanic Personality Scale (HPS) and recognized the affect in pictures of faces. They found a significant interaction between HPS scores and happiness levels

such that individuals with higher scores on the HPS reported a higher level of happiness and were particularly adept at identifying subtle facial expressions of happiness. In our study of manic patients, identification of happiness was strongly correlated with neurocognitive performance as 19 neurocognitive measures related to recognition and discrimination of happiness on faces.

Using a similar paradigm like in mania, significant correlations between best cognition and identification of sadness were found in depressed and euthymic bipolar subjects. It is understandable that in depression there is a preponderance to better recognize such negative emotions as sadness. However, better identification of sadness during remission may have further implications. Biyik et al [30] studied facial emotion recognition in women during remission of major depressive disorder and found that they had a higher accuracy rate for recognition of sadness compared to those of controls. A phenomenon that occurs during remission of the illness being distinct from healthy control persons can be regarded as a biological marker of the illness. Therefore, the higher recognition rates for sadness, correlating with neurocognitive performance can be postulated as a biological marker of mood disorder since it is present both in unipolar (major depressive disorder) and bipolar mood disorder.

A recent study by Wenzel et al. [31] could partly support our hypothesis. The authors investigated the perception of happy and sad faces in twenty bipolar patients in a depressive state, 32 euthymic patients with manic or depressive pre-

dominant polarity, and 20 healthy controls. Patients with both depression and euthymia had higher scores of selective attention to sad faces.

The limitation of our study may be a low number of patients. Also, the power analysis was not performed, therefore the results can be treated as preliminary. However, the main conclusions of our study were drawn from the multiplicity of correlations between specific facial emotions and numerous outcomes of neurocognitive performance. Using such a large battery of neurocognitive tests and examining them during various stages of bipolar mood disorder can be regarded as a significant strength of our study.

To the best of our knowledge, studies on the association between neurocognition and the identification of emotional faces using such a large battery of neurocognitive tests have not been performed. Using such a paradigm, we found a higher recognition of sadness in bipolar patients both in depression and euthymia. Therefore, we can speculate that such recognition could serve as a tentative biological marker in bipolar disorder. However, further research on this issue is needed as well as possible replication of these results by other investigators.

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