Letters

Processing Environmental Stimuli in Paranoid Schizophrenia: Recognizing Facial Emotions and Performing Executive Functions*

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Abstract

Objective To study the contribution of executive function to abnormal recognition of facial expressions of emotion in schizophrenia patients.

Methods Abnormal recognition of facial expressions of emotion was assayed according to Japanese and Caucasian facial expressions of emotion (JACFEE), Wisconsin card sorting test (WCST), positive and negative symptom scale, and Hamilton anxiety and depression scale, respectively, in 88 paranoid schizophrenia patients and 75 healthy volunteers.

Results Patients scored higher on the Positive and Negative Symptom Scale and the Hamilton Anxiety and Depression Scales, displayed lower JACFEE recognition accuracies and poorer WCST performances. The JACFEE recognition accuracy of contempt and disgust was negatively correlated with the negative symptom scale score while the recognition accuracy of fear was positively with the positive symptom scale score and the recognition accuracy of surprise was negatively with the general psychopathology score in patients. Moreover, the WCST could predict the JACFEE recognition accuracy of contempt, disgust, and sadness in patients, and the perseverative errors negatively predicted the recognition accuracy of sadness in healthy volunteers. The JACFEE recognition accuracy of sadness could predict the WCST categories in paranoid schizophrenia patients.

Conclusion Recognition accuracy of social-/moral emotions, such as contempt, disgust and sadness is related to the executive function in paranoid schizophrenia patients, especially when regarding sadness.

Key words: Executive function; Japanese and Caucasian facial expressions of emotion; Paranoid schizophrenia; Wisconsin card sorting test

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INTRODUCTION

Empirical, cross-cultural studies demonstrated that anger, contempt, disgust, fear, happiness, sadness, and surprise are the basic facial emotions[1-2]. As adaption to environmental stimuli, human facial expressions can be differentiated as responses to physical properties such as color, shape or configuration, and to social characteristics such as social or moral meanings[3-4]. The early perceptual processing constructs the detailed facial configuration on occipital and temporal lobes, and subsequent recognition generates the knowledge about the emotion signaled on the face which involves frontal cortex and amygdala[5]. Some scholars suggested that contempt and disgust are the moral emotions because they are responses to the violations of social norms or divinity[6-8], and sadness is a social emotion because it is typically embedded in structures of social relationship, intentionality, and language expressions[5,9-10].

Schizophrenia, characterized by mood and social interaction problems, has a markedly reduced ability to recognize facial expressions of emotion in general[11-14] or specific fear or sadness[15]. Other studies showed that different impairments are task-dependent[16-17] and others demonstrated that this deficit is positively correlated with poor outcomes in social functioning of patients[18-19]. Therefore, it is still not clear whether these deficits are due to the abnormal visual processing of facial stimuli or due to the disordered, generalized emotion recognition procedure[11,20].

In addition, executive function, as a high order cognitive construct, involves abstract reasoning, concept forming, decision making, and behavior planning[21-22], and is anatomically linked with the prefrontal cortex[23]. Schizophrenia displays some deficits of attention, working memory, and executive function[24] which are usually associated with its negative symptoms such as the flatten affect[25], and the recognition deficits of facial expressions of emotion[26-27]. Although the prefrontal functioning may be the common node of recognition impairments in facial expressions of emotion and executive dysfunction[5,28], few studies are available on the two phenomena in schizophrenia up to date[15,29].

With all these issues in mind, we hypothesized that schizophrenia would show recognition impairment in facial expressions of emotion, which is associated with the deficits of executive function. It was reported that schizophrenia is a heterogeneous disorder and its common subtype is paranoid[30]. Emotion recognition impairments in different subtypes of schizophrenia are quite diverse[31]. However, patients with paranoid schizophrenia are more accurate in recognizing expressions than those with non-paranoid schizophrenia[32]. Therefore, only paranoid schizophrenia was enrolled in this study.

Furthermore, recognition of facial expressions of emotion and executive function of the participants were assessed according to Japanese and Caucasian facial expressions of emotion (JACFEE)[33] and Wisconsin card sorting test (WCST)[34]. JACFEE is a widely used set of standardized facial expressions of emotion[2] while WCST is a widely used test of executive function[22,35] which is considered an endophenotypic marker for schizophrenia[36-37]. Moreover, depression[38-39] and anxiety[40] influence the recognition of facial expressions of emotion in schizophrenia patients. Hamilton anxiety and depression scale[41-42] was thus used in this study.

SUBJECTS AND METHODS

Subjects

Eighty-eight patients (two outpatients and 86 inpatients, 50 males and 38 females) at a mean age of 23.31±6.61 years (range 15-48 years) were diagnosed as paranoid schizophrenia according to the International Classification of Diseases-10 (ICD-10)[43]. Of these patients, 54 were at the first episode and 86 were at the acute or post-acute stage. The mean duration of illness was 20.38 months. All patients were free from affection or substance-related disorders and treated with antipsychotics. Some patients were treated with other drugs such as antidepressants and benzodiazepines according to their clinical condition (Table 1). 75 healthy volunteers (33 males and 42 females) at a mean age of 23.19±6.68 years (range 14-62) were enrolled from community. After a semi-structured interview, they were confirmed to be physically healthy, without neurologic or psychiatric disorders and alcohol/ substance abuse. Groups were matched in regard to age (t=0.12, P=0.91), sex (χ^2=2.66, P=0.10), and educational level (t=-1.83, P=0.07) (Table 1). All subjects were Han people and provided their informed consent. The study was approved by the local ethic committee.

Table 1. Demographic and Clinical Data about Paranoid Schizophrenia Patients (*n*=88) and Healthy Volunteers (*n*=75)

	Schizophrenia	Healthy Controls
Age (years; mean±SD)	23.31±6.61	23.19±6.68
Gender (male: female)	50: 38	33: 42
Education level (years; mean±SD)	13.57±3.32	14.36±1.87
Duration of illness (months; mean±SD)	20.38±24.85	-
Positive and Negative Symptom Scale scores (mean±SD)		
Positive symptom scale	15.78±4.34*	7.00±0.00
Negative symptom scale	13.64±4.07*	7.00±0.00
General psychopathology scale	32.99±7.78*	19.21±1.88
Hamilton Depression Scale	6.32±3.34*	3.61±2.09
Hamilton Anxiety Scale	5.02±3.65*	3.75±2.27
Medication (numbers of patient medicated)		
Antipsychotics	olanzapine(62); risperidone(12); quietapine(10); clozapine(8); paliperidone(7); penfuridol(7)	-
Antidepressants	fluoxetine(9); sertraline(3)	-
Benzodiazepines	alprazolam(23); clonazapam(4); lorazepam(2)	-

Note. *$P<0.05$ *vs* controls.

Methods

The clinical assessment, JACFEE, and WCST were conducted for all participants by trained professionals, while the said assessment and tests were conducted by randomization in a quiet room.

The positive and negative symptom scale[44], a peer-rated instrument used by experienced psychiatrists, is consisted of 30 items coded from 1 to 7 for each symptom, and has positive (7 items), negative (7 items), and general psychopathology scales (16 items) with an internal reliability of 0.73-0.83[44].

The Hamilton anxiety scale[41] with an internal reliability of 0.84 or higher[45] is a 14-item scoring clinical anxiety symptoms, which are rated on a five-point scale (0-4). Participants were considered to have no, mild and moderate (or severe) anxiety when their score was ≤5, 6-14, and ≥15, respectively.

The Hamilton depression scale (17-items)[42], a 5-point (0-4) or 3-point (0-2) scale with an internal reliability of 0.70 or higher[42,46], is used where quantification of the item is either difficult or impossible. Participants were considered to have no, mild, moderate or severe depression when their score was ≤7, 8-17, 18-24, or >24, respectively.

Matsumoto & Ekman's Japanese and Caucasian facial expressions of emotion (JACFEE) photo set[33] containing 56 slides is consisted of 8 photos (2 Caucasian males, 2 Caucasian females, 2 Japanese males, and Japanese females) for each of the 7 emotions (anger, contempt, disgust, fear, happiness, sadness and surprise). No poser appears more than once for each emotion. The 56 photos are displayed on a computer screen at a visual angle of 9°×7°, twice for each participant. The presentation order of the photos in the two viewing procedures is exactly identical. During the first procedure, participants are requested to choose a single term from a list of 7 emotion names (anger, contempt, disgust, fear, happiness, sadness, and surprise) which best describe the emotion portrayed in the photo. Two minutes after the first procedure, participants are required to view the 56 photos again, and judge the intensity of each emotion displayed, using a 9-point scale (0-8) labeled as (0), little (1), a moderate amount (4), and a lot (8).

WCST (Ririxin Inc., Changsha, China) which is consisted of 4 stimulus-cards and 128 response-cards depicts figures of different forms, colors, and numbers. The participants face a set of 4 stimulus-cards at the top of the screen, with the first response-card displayed at the left bottom. The participants were instructed to match the response-card to one of the stimulus-cards. The cards can be matched according to the sorting principles of color and form, or the number of depicted figures. The participants were never told

which sorting principle should be used but had to look for a correct sorting strategy according to the visual feedback provided by the program, namely right or wrong message which appeared on the screen after the participants matched the current response-card to one of the stimulus-cards, and then the 10 consecutive and correct matches of an initial sorting principle were finished. The principle would change without warning, and participants had to develop a new sorting strategy according to the subsequent feedbacks. Test was over when the participants successfully completed the 6 WCST categories or when the 128 response-cards were used. The following WCST scores were calculated, including the number of completed categories, total responses, correct responses, total errors, perseverative errors, and the percentage of conceptual level[34].

Statistical Analysis

The mean scores on the Hamilton anxiety and depression scale were compared between the two groups by independent *t* test. While those on the positive and negative symptom scale (3), WCST categories (6), JACFEE recognition accuracy (7) and intensities (7) were compared by two-way ANOVA between the two groups. Whenever a significant effect was found, differences were assessed by post-hoc Duncan's new multiple range test between the two groups. The scores of clinical symptoms were compared according to the Spearman correlation test, JACFEE and WCST scale between the two groups. The relation between executive functions and recognition of facial expressions of emotion was studied by stepwise multiple regression test. $P<0.05$ was considered significant.

RESULTS

Since the patients with schizophrenia at its first-episode or non-first-episode were scored similarly, they were considered as a whole group in the subsequent analyses. According to the positive and negative symptom scale, the scores on the 3 subscales were significantly higher in the schizophrenia patients than in healthy volunteers [group effect: F (1, 161)=358.50, $P<0.001$, mean square effect (MSE)=11504.28; scale effect: F (2, 322)=1178.23, $P<0.001$, MSE=12595.42; group × scale interaction effect: F (2, 322)=50.81, $P<0.001$, MSE=543.18]. The scores on the Hamilton anxiety and depression scale were also significantly higher in the schizophrenia patients than in healthy volunteers ($P<0.001$, Table 1). The JACFEE recognition accuracy was significantly different between the two groups [group effect, F (1, 160)=11.83, $P<0.001$, MSE=1.31; accuracy effect, F (6, 966)=111.24, $P<0.001$, MSE=6.19; group × accuracy interaction effect, F (6, 966)=0.85, $P=0.53$, MSE=0.05]. Post-hoc Duncan's test showed that patients scored significantly lower than healthy volunteers did on the recognition accuracies of contempt, disgust, fear, happiness, and sadness, but not on those of anger and surprise (Table 2). However, no significant difference was found in JACFEE recognition intensities between the two groups [group effect, F (1, 148)=0.05, $P=0.82$, MSE=0.28; intensity effect, F (6, 894)=198.46, $P<0.001$, MSE=159.36; group × intensity interaction effect, F (6, 894)=4.09, $P<0.001$, MSE=3.28].

Table 2. Scores of JACFEE Recognition Accuracy and Intensity, and WCST Performance in Schizophrenia Patients (*n*=88) and Healthy Volunteers (*n*=75)

	Schizophrenia	Healthy Controls
JACFEE Recognition Accuracy		
Anger	0.59±0.29	0.63±0.26
Contempt	0.72±0.29*	0.81±0.22
Disgust	0.51±0.31*	0.60±0.30
Fear	0.31±0.29*	0.45±0.31
Happiness	0.93±0.16*	0.97±0.08
Sadness	0.58±0.28*	0.70± 0.23
Surprise	0.84±0.20	0.87± 0.16
JACFEE Intensity Rate		
Anger	5.24±1.36	5.37±1.30
Contempt	3.57±1.20	3.27± .97
Disgust	5.32±1.32	5.31± 1.17
Fear	5.61±1.28	5.91± 1.13
Happiness	5.76±1.53	6.20± 1.42
Sadness	3.83±1.05	3.50± .97
Surprise	5.52±1.29	5.68±1.33
WCST		
Completed categories	4.92±1.10*	5.39±0.97
Total responses	120.57±13.04*	111.19±17.83
Correct responses	52.07±8.93*	55.75±7.91
Total errors	68.50±19.21*	55.44±22.93
Perseverative errors	50.95±19.83*	38.61±22.41
Conceptual level (%)	57.23±17.14*	65.18±19.26

Note. * $P<0.05$ *vs* controls.

WCST scores were significantly different between the two groups [group effect, F (1, 161)=15.34, *P*<0.001, MSE=3474.86; scale effect, F (5, 805)=793.06, *P*<0.001, MSE=205875.53; group × scale interaction effect, F (5, 805)=12.54, *P*<0.001, MSE=3255.11]. Post-hoc Duncan's test displayed that the performance on the 6 categories was significantly poorer in schizophrenia patients than in healthy volunteers(Table 2).

In patients, no significant correlation was found in clinical symptoms and JACFEE recognition intensities, Hamilton anxiety and depression scale score and JACFEE recognition accuracy. However, the recognition accuracy of disgust and contempt was negatively correlated with the negative symptom scale score, the recognition accuracy of fear was positively with the positive symptom scale score, and the recognition accuracy of surprise was negatively with the general psychopathology score (Table 3). No significant correlation was found between clinical symptoms and JACFEE recognition accuracy or intensity in healthy volunteers.

Table 3. Correlation (r) between JACFEE Recognition Accuracy and Clinical Characteristics in Schizophrenia Patients (*n*=88)

	Positive and Negative Syndrome Scale			Hamilton Scales	
	Positive symptom	Negative symptom	General psychopathology	Anxiety	Depression
Anger	0.03	-0.18	-0.07	-0.11	-0.06
Contempt	0.03	-0.27*	-0.02	0.04	0.02
Disgust	-0.06	-0.30*	-0.21	-0.01	-0.11
Fear	0.21*	0.15	0.10	-0.03	0.03
Happiness	-0.03	-0.07	-0.11	-0.04	-0.03
Sadness	-0.09	0.10	-0.06	0.04	0.08
Surprise	-0.18	-0.19	-0.27*	-0.13	-0.12

Note. *P <0.05.

The WCST categories could significantly predict the JACFEE recognition accuracy of contempt [β=0.23; F (1, 86)=4.72, adjusted R^2=0.04, *P*<0.05], disgust [β=0.26; *F* (1, 86)=6.36, adjusted R^2=0.06, *P*<0.05] and sadness [β=0.67, F (3, 84)=4.28, adjusted R^2=0.10, *P*<0.01] in patients. The perseverative errors significant-negatively predict the recognition accuracy of sadness in healthy volunteers [β=0.26, F (1, 73)=5.44, adjusted R^2=0.06, *P*<0.05] (Table 4). Moreover, we found that the recognition accuracy of sadness significantly predicted the WCST categories [β=0.23; F (7, 80)=2.39, adjusted R^2=0.10, *P*<0.05] in schizophrenia patients.

Table 4. WCST Categories Predicting JACFEE Recognition Accuracy in Schizophrenia Patients (*n*=88) and Healthy Volunteers (*n*=75)

	Schizophrenia		Healthy Controls	
	Adjusted R^2	β, predictors	Adjusted R^2	β, predictors
Anger	-		-	
Contempt	0.04*	0.23#	-	
Disgust	0.06*	0.26#	-	
Fear	-		-	
Happiness	-		-	
Sadness	0.10*	0.67#	0.06*	-0.26$
Surprise	-		-	

Note. *P<0.05, #completed categories, $perseverative errors.

DISCUSSION

Our patients scored higher on the Hamilton Anxiety and Depression Scales and on the Positive and Negative Symptom Scale, displayed lower JACFEE recognition accuracies and poorer WCST performances than healthy volunteers did, which is consistent with the findings in other studies[11,13,30,47-48]. The JACFEE recognition accuracy of contempt and disgust was negatively correlated with the negative symptom scale score, the JACFEE recognition accuracy of fear was positively with the positive symptom scale score, and the JACFEE recognition accuracy of surprise was negatively

correlated with the general psychopathology score in schizophrenia patients. Moreover, the WCST categories could predict the JACFEE recognition accuracy of contempt, disgust, and sadness in schizophrenia patients, and the perseverative errors could negatively predict the recognition accuracy of sadness in healthy volunteers. The JACFEE recognition accuracy of sadness could predict the WCST categories in schizophrenia patients.

It is easy for healthy people to recognize the facial expression of happiness[49-50], and the ability to recognize the facial expression of happiness remains intact in many patients with neurological diseases such as Huntington's disease[51] or with psychiatric disorders such as depression[39], euthymic bipolar disorder[52] or phobic disorder[53]. However, the sensitivity of schizophrenia patients is low in perceiving happy face[38], which may decrease the recognition accuracy of happiness in schizophrenia patients[13,54].

Sadness is an emotion about loss, which is connected with a focus on inner experience, and is often linked with empathy which denotes a sense of similarity between one's own feelings and those expressed by others[55-56]. Normally, empathy is positively associated with the recognition accuracy of sadness[57]. However, schizophrenia patients often show apathy to other people and environment[58-59], which may underlie the lower recognition accuracy of sadness in schizophrenia patients.

In order to be alert on a threat and to avoid harm in environment, people need to recognize the facial expressions of contempt and disgust[8]. Due to the loosened association, inappropriate affect, ambivalence and autism, schizophrenia patients may restrain themselves to their inner world and show no interests to other people, or to the outer world, and ignore the risks from the outer world due to conflict with other people or harming themselves[58,60]. In this case, they may display a lower recognition accuracy of contempt and disgust. Negative symptoms of schizophrenia would deposit the loss of motivation or drive, loss of awareness of appropriate social behavior, apathy, or flattening of mood, while their ability to recognize contempt and disgust often needs social interaction or practice reinforcement[61]. Therefore, the recognition accuracy of contempt and disgust was negatively correlated with the negative symptom scale score in this study.

It was reported that amygdala plays a pivotal role in processing fear recognition and expression[62-63], but its volume and function are reduced in schizophrenia patients[64], which explains well the lower recognition accuracy of fear in our patients. Unlike the negative symptoms, the positive symptoms such as hallucination or delusion lead to a high vigilance to environmental stimuli in schizophrenia patients, thus making them to focus more on the threatening information including the facial expression of fear[65-66]. Such a speculation may underline the correlation between positive symptom scale score and recognition accuracy of fear in our patients.

General psychopathology scale of schizophrenia includes the deficit of cognition and volition, which hinders patients to perceive surprise, while the latter often offers a motivation to look for new and interesting things nearby[54,67]. This association may help to present a negative correlation between recognition accuracy of surprise and the general psychopathology scale found in our patients.

The WCST categories denote a general executive function including the concepts of formulating, comparing, shifting, and decision making[21]. Recognition of facial expressions of emotion also depends on concepts of formulating and comparing the emotional types[68], which are similar to the executive function mobilization as those embodied in WCST test. The explanation may be behind the relation between WCST categories and JACFEE recognition accuracy of contempt, disgust and sadness in schizophrenia patients.

However, no reasonable explanation is available on why such an association between the 3 facial emotions instead of the 7 facial emotions, thus we should strive more to recognize these facial emotions. It was reported that schizophrenia patients display more deficits when they are dealing with more sophisticated emotions than when they are dealing with less sophisticated emotions[69-70]. Furthermore, because schizophrenia patients display impairments when they are recognizing complicated facial emotions[15,29], they may mobilize more cognitive strategies when they are recognizing complicated facial emotions, which may explain the association between WCST categories and JACFE recognition accuracy of contempt, disgust and sadness in schizophrenia patients. The adjusted R^2 in our study was small, suggesting that other variables may interfere with the relation between JACFEE and WCST. For instance, illness duration[71] or medication[72] can influence the performance of the recognition of facial emotions.

The perseverative errors were negatively

associated with the recognition accuracy of sadness in healthy volunteers. Since the number of perseverative errors is an inverse indicator for the ability to shift strategy based on feedback information, the less the errors are, the better the concept shifting is[73]. Recognizing sadness involves more cognitive functions, including rapid concept shifting[9-10], thus demanding a negative association between the recognition accuracy of sadness and the perseverative errors.

The present study has some limitations. First, it was a cross-section study and all subjects were paranoid schizophrenia patients at acute or postacute stage. It was reported the duration of illness is negatively correlated with the recognition of facial emotion[71] and the executive functioning[74-75] in schizophrenia patients. Second, most of our patients were treated with drugs. Although the antipsychotics used in their treatment were a second generation drug, how it exerts its effect on the cognition of schizophrenia[76-77] remains unknown. However, these limitations help explain the adjusted R^2 in relation with JACFEE and WCST. Third, a standardized instrument was not used in assessment of psychiatric disorders and whether our paranoid schizophrenia patients had a high clinical homogeneity remains unsettled.

In conclusion, the poor WCST categorizing ability hinders the recognition accuracy of facial expressions of emotion in paranoid schizophrenia patients. Whether the pronounced association regarding sadness can be replicated in other subtypes of schizophrenia or whether it has a special meaning in the paranoid schizophrenia, remains to be further studied.

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