The Relation Between Functional Anatomy of the Face and Threat Perception Evoked by Facial Expression of Anger in Schizophrenia

Nilay SEDES BASKAK¹, Melike EZERBOLAT ÖZATEŞ², Oğuzhan HERDİ², Eda SONEL², Asena ULUSAN², Bora BASKAK²

¹Yenimahalle State Hospital, Department of Psychiatry, Ankara, Turkey

²Ankara University, Faculty of Medicine, Department of Psychiatry, Ankara, Turkey

ABSTRACT

Introduction: It is well known that patients with schizophrenia are more sensitive to negative rather than positive feelings. In this study, we aimed to evaluate the degree of explicitly perceived threat against facial expressions of anger. We were also interested in the association between perceived threat, and both the objective intensity of facial expression of anger and the functional anatomy of the perceived faces.

Method: Forty-eight patients with schizophrenia and 51 healthy controls were enrolled. Participants were presented a total of 21 sequences of anger including six different face images, which were selected from The Cohn-Kanade AU-Coded Facial Expression Database with emotions gradually changing from neutral to peak expression of anger. We measured when [time to threat (TtT)] and to which degree [Total perception of threat (TPoT)] threat was perceived by participants. The relation between perceived threat with the involvement of functional

anatomic units among the face stimuli was also investigated.

Results: TPoT was higher in the index compared to the control group. TtT was comparable in two groups and was associated with the severity of hallucinations among the index group. Total emotion intensity was lower in the sequences that evoked more threat in the index group. Functional contribution of the eyes and the upper lip to expression of anger were associated with TPoT among the index group.

Conclusion: Schizophrenia subjects may be prone to perceive more threat in response to facial expression of anger. This proneness may be evident in response to less intense expression of anger, particularly via eyes and the upper lip.

Keywords: Schizophrenia, perception of threat, hallucinations

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INTRODUCTION

Perceived threat has an important role in development and maintenance of psychosis and may have influence on development of positive psychotic symptoms. Cognitive models which try to explain psychotic symptoms enounce that biases in perception, reasoning and attention may lead to threat attribution to non-threatening stimuli (1). It has been suggested that higher levels of perceived threat is associated with persecutory delusions (1), paranoia (2), aggressive behaviours (3) and social isolation (4) in schizophrenia. Perceiving the situation or an individual more threatening may also evoke anxiety and/or be associated with exacerbation of psychotic symptoms (3,5). Some authors underscored the importance of meta-cognitive impairments in perceiving excessive threat. Thus, schizophrenia patients with persecutory delusions may hold a belief that they are being threatened even in absence of evidence. Cognitive explanations of persecutory delusions stress the

importance of increased attention to threatening stimuli (6). For example, schizophrenia patients remember the threatening stimuli better than controls in vignette remembering tasks (7). Such kind of hyper vigilance may lead to avoidance. Schizophrenia patients tend to voice the colours rather than the syntax of the threatening words in emotional Stroop tasks (8). On the other hand, main focus of research has been evaluating implicit reactions in response to situations that evoke negative emotions and explicit subjective responses are far less studied. Nevertheless, whether the cognitive response is implicit or explicit may be important in evaluation process. For example, emotion recognition studies in schizophrenia revealed more severe impairments in explicit tasks rather than implicit tasks (9). There is no research mainly focused on subjective threat perception in schizophrenia.

A group of researchers have suggested that there may be an information processing impairment characterized by miscoding shape and contour information of anatomic units of the face in schizophrenia (10). Also known as the holistic face processing impairment (11), this disturbance may be specific to isolated units of face, and similar to patients with prosopagnosia, could handicap perception of face as a whole, attribution of familiarity, and recognition of identity information (12). Such kind of integrated perception impairment may also be associated with abnormal threat perception.

It attracts attention that schizophrenia patient have sensitivity/difficulty in recognizing negative affect and especially anger when compared with healthy controls. Difficulty to recognise anger is feature that discriminates schizophrenia from bipolar disorder (13). At least two studies (14,15) reported that schizophrenia patients referred anger to neutral faces (14,15). Similarly, it has been shown that anger expression had more evident effect on cognitive performance than neutral expressions in response inhibition tasks (16).

The main purpose of this study is to evaluate explicit and subjective threat perceived by subjects with schizophrenia in response to faces with anger expression in point of time and severity, and to observe whether perceived anger is associated with positive psychotic symptoms as well as contribution of functional anatomic units to facial expression of anger. Our hypothesis is that there is a difference between patients and controls with regard to time and severity of the perceived threat; as well as the intensity of facial expression that cause this perception; and that there is a positive correlation between threat perception and positive psychotic symptoms in patients with schizophrenia.

METHODS

This study is a cross-sectional and case-control study that aimed to compare schizophrenia patients and healthy controls in terms of threat perception to face photographs with anger expression. We also examined whether level of this perception is associated with number of functional anatomic units that gives the anger expression to the face. It was studied that whether emergence time and severity of threat perception is associated with psychotic symptoms among the patient group.

Sample

Patient group comprised subjects with remitted schizophrenia/schizophreniform disorder who consequently applied to Ankara University Faculty of Medicine Psychiatry Department Outpatients Unit between January-March 2016 (n=52). Control subjects were healthy individuals without a history of a psychiatric disorder and were matched with the index subjects in terms of age and gender (n=51). Every schizophrenia or schizophreniform disorder patient who applied to the unit were evaluated for inclusion and exclusion criteria within the study period. Patients who met criteria for schizophrenia or schizophreniform disorder according to the DSM IV-TR (17), who had at least 8 years of education, who were between 18-65 ages, who were not diagnosed as alcohol or drug dependency, who did not receive ECT at last for 6 months and who did not have history of cranial trauma caused unconsciousness were included to the study. Psychotic disorders due to general medical condition or alcohol and drug use, an additional diagnosis of mental retardation, limited mental capacity, pervasive developmental disorder, co-morbid mood disorders, physical impairments that handicap performing psychiatric scales and cognitive test (vision, hearing, motor loss etc.) were the exclusion criteria. Subjects in the control group were recruited from relatives of researchers and

hospital staff. Inclusion criteria for the control group were, the absence of a current psychiatric diagnosis, matching for age, sex and education with patient group, completing at least 8 years of education, being aged between 18-65, absence of alcohol or drug dependency as well as a history of cranial trauma leading to unconsciousness. Individuals with intellectual disability or with limited mental capacity, those who were illiterate, who have physical impairment that handicap performing psychiatric scales and cognitive tasks (vision, hearing, motor loss etc.) were excluded from the control group as well. Four patients among the index group could not orient to tasks and so data from these patients were excluded from the data. Further analyses were performed upon data from 48 patients and 51 controls.

Ethic Committee Approval

The data used in this study was collected in the frame of Research Planning and Administration Module as part of Evidence-Based Medicine Lecture that is in the 3rd term curriculum in Ankara University Faculty of Medicine. Study procedures were approved by the Ankara University Faculty of Medicine Ethics Board (decision: 01.06.2016 – 72189195-050.03.04). All participants signed the written informed consent. Since the index group comprised vulnerable participants, oral and written informed consent was obtained from a first degree relative of a participant among the index group as well.

Measures

First, socio-demographic data form that was composed by researchers was presented to all participants. Then, the Scale for the Assessment of Positive Symptoms (SAPS) developed by Andreassen et al. (1984) was presented to participants among the index group (18). The reliability and validity of SAPS in Turkish population had previously been proved (19). The scale is 6 point likert scale and assesses positive symptoms with 36 items assembled in four subscales. The scale has to be performed by a clinician. In this study the scale was performed by a psychiatrist. Clinical Global Impression scale was used to assess disease severity (20).

Threat Perception Assessment Task was created by the researchers. Affective face photos that were used to create this task were selected from Cohn-Kanade Dataset (21) developed by Kanade et al.(2000). Permission was taken from Pittsburgh University Face Analysis Research Laboratory to use this dataset for research purposes. The dataset consists of 2105 digital face photographs that belong to 182 adults. These photos comprise sequences including standardized emotions. Each sequence is composed of 12 photos that include faces with emotions gradually increasing from neutral to peak intensity of that emotion.

Functional anatomic unit refers to a muscle or a group of muscles that contribute to expression of an emotion by contracting or relaxing. These units are readily defined in the dataset for the photograph with the most crystallized affect. Information also exists for the degree to which these units participate in any given affect. Actually Cohn-Kanade Dataset was created for carving out human faces with emotional expressions to use in virtual reality programmes (22).

In this study, 21 of anger expression sequences were selected. This selection was operationalized by; (i) confronting both male and female participants equally to male and female photographs; (ii) stratification of the sequences in terms of emotion intensity as low, medium and high, and (iii) excluding photographs including Asian and black actors in the purpose of a more valid measurement. Each sequence was presented on a 55,8 cm screen that was placed 50 cm away from the participants. Sequences were presented following short scenarios that were formed

Table 1. Comparison of patients and controls in terms of sociodemographic characteristics

	PG (N=48)	CG (N=51)	
Gender (F/M)	19/29	27/24	$\chi^2=1.78$, $P=0.18$
Age (Mean $\pm$ SD)	38.0 $\pm$ 11.0	40.7 $\pm$ 11.9	$T=-1.16$, $P=0.25$
Education (Elementary/high school or higher)	10/38	7/44	$\chi^2=0.88$, $P=0.35$

F, female; M, male; SD, standart deviation; PG, patient group; CG, control group.

by researchers (e.g.: 'You are going to see a photograph of a cashier that you met while shopping'). The scenarios were prepared in the frame of (i) delineating possible life events in daily life, (ii) balancing possible probability of happening of that event between the two groups, (iii) balancing for purposive/incidental and indoor/outdoor events, (iv) reducing possibility of the scenario itself to lead to threat. Immediately after the scenario, the neutral photograph was presented followed by photographs with increasing intensity of anger. The participants were instructed to press a button whenever they found the person on the photograph threatening. There were two behavioural outcomes. First one was 'time to threat' (TtT). The order of the photograph during which the participant pressed the button was recorded as TtT. On the last photograph of the sequence with the peak expression of anger, the participants were expected to rate the perceived intensity of threat on an eight point likert scale. This rating was defined as 'total perception of threat' /TPoT) and was recorded as the second behavioural output. For each participant, mean of 21 TtT and sum of 21 TPoT were calculated and these values were used in further analyses.

Functional anatomic units involved in anger emotion are readily defined in the Cohn-Kanade dataset for the last photographs of each sequence. According to these definitions there are 17 functional units involved in facial expression of anger. Contribution of each functional unit to anger expression in a given photograph may be different and these intensity values are also quantified for each functional unit in the dataset. Using this information we calculated the following values for each sequence; (i) sum of individual functional units that contribute to anger expression; number of functional units (NFU), (ii) sum of intensity of all functional units that contribute to anger expression; total intensity of anger (Int_{Total}), and (iii) total load of anger (AL) which is calculated by multiplication of Int_{Total} and NFU values.

Statistical Analyses

The two groups were compared for socio-demographic data, TtT and TPoT scores. Independent Samples T-test was used for variables that showed normal distribution and Mann-Whitney U was used for variables that violated normal distribution. Spearman correlations were performed to examine relationship between TtT, TPoT scores and SAPS item total scores among the patient group. The 21 sequences were divided into two groups as (i) those during which the patient group scored higher than the control group and (ii) those during which the two groups were equal in terms of TPoT ratings. These two sequence groups were compared for NFU, Int_{Total} and AL with Mann Whitney U Tests. In addition to that, functional units that contribute to expression of anger were anatomically divided into three groups: eyes and eyebrows, mouth and lips, other parts of the face (chicks and forehead). Total emotional intensity of each group of functional units were also calculated (respectively as Int_{eye} , Int_{lip} and Int_{other}). These intensity values were compared between two sequence groups with Mann Whitney U test. Finally, we performed Spearman correlations between Int_{eye} , Int_{lip} and Int_{other} and TPoT scores of in the patient and control groups. Spearman correlation coefficients were also calculated between mean TPoT of each sequence and participated intensity of each functional unit to examine particular sensitivity to individual functional units. Analysis were checked with False Discovery Rate (FDR alpha = 0.05) (23) to control Type-1 error due to multiple testing. SPSS 21.0 (IBM, New York) was used for statistical analyses.

RESULTS

Comparison of patients and controls in terms of socio-demographic characteristics was presented in Table 1. There was no difference between two groups in terms of age, gender and education years.

a. Rising of upper lips due to contraction of musculus levator labii superior
b. Squinting due to relaxation of musculus levator palpebra superior and orbicularis oculi-pars palpebralis

Figure 1. Functional units that are significant associated with perceived anger in the patients group.

Table 2. Comparison of two groups in terms of TPoT and TtT score

	PG (N=48)	CG (N=51)	
TPoT (mean ± SD)	55.8±26.9	45.5±21.3	T=2.11, P=0.037
TtT (mean ± SD)	5.1±1.2	5.2±1.0	T=-0.77, P=0.45

SD, standard deviation; PG, patient group; CG, control group; *, statistically significant

Table 3. Comparison of two group in terms of intensity of anger expression

	Sequence ^{Sch>C} (N=9)	Sequence ^{Sch=C} (N=11)	
NFU [median, (min-max)]	5, (4-9)	5, (4-7)	Z=-0.04, P=0.97
Int _{Total} [median, (min-max)]	9, (4-19)	17 (7-23)	Z=-2.39, P=0.017*
Int _{lip} [median, (min-max)]	2, (1-10)	6.5, (2-10)	Z=-1.76, P=0.080
Int _{eye} [median, (min-max)]	2, (1-8)	5.5, (2-9)	Z=-2.07, P=0.038*
Int _{other} [median, (min-max)]	2, (0-6)	4, (0-9)	Z=-0.89, P=0.371
AL [median, (min-max)]	63, (16-114)	80, (49-138)	Z=-2.03, P=0.043*

NFU, Number of Functional Unit; Int, Intensity of units; AL, Anger load; *, statistically significant; Sequence^{Sch>C}, sequences perceived as more threatening by schizophrenia patients; Sequence^{Sch=C}, sequences perceived as equally threatening in the two groups.

Among the patient group, mean total SAPS and CGI scores were respectively 8.02 ± 10.87 and 3.35 ± 0.73 .

Patient group scored higher than the control group in terms of TPoT in the threat perception task, but TtT scores were comparable among the two groups (Table 2).

There was no association between parameters of threat perception and age, gender and level of education. Nevertheless, there was a negative correlation between TtT scores and SAPS—hallucination subscale score in patient group ($r=-0.33$, $p=0.021$). There were no further relations between symptoms and threat perception parameters.

TPoT scores acquired from all sequences were compared between groups. There was not a single sequence during which controls received higher TPoT scores than patients. However, there were nine sequences that patients received higher TPoT scores than controls. These nine sequences were defined as sequences that lead to more threat perception in patient than controls (Sequence^{Sch>C}) and the remaining 11 sequence were defined as sequences that lead to similar threat perception in the two groups (Sequence^{Sch=C}). When these two sequence groups were compared for NFU, Int_{Total}, AL, there was no difference for NFU. However Sequence^{Sch=C} received statistically higher scores than Sequence^{Sch>C} in terms of Int_{Total} and AL scores. There was no difference for Int_{lip} and Int_{other} between two sequence groups. Nevertheless, Sequence^{Sch=C} received statistically higher scores than Sequence^{Sch>C} in terms of Int_{eye} (Table 3).

Mean TPoT scores were positively correlated with contribution of two individual functional units (rising of the upper lip and moving down of the eyelid) in the patient group ($r=0.42$, $p<0.05$; $r=0.43$, $p<0.05$ respectively) (Figure 1). There were no significant correlations between contribution of individual functional units to anger and TPoT scores among the control group.

DISCUSSION

We analysed whether subjective threat perception in response to angry faces was different between subjects with schizophrenia and healthy control subjects. We were also interested in possible associations between perceived threat and objective intensity of anger and functional anatomy of the angry face. Similarity of the two groups in terms of socio-demographic features facilitated further interpretations. SAPS and CGI scores suggest that the index group comprised schizophrenia patients with low severity of positive symptoms and mild level of general disease severity.

Higher TPoT scores among the patient group and similar TtT scores among the two groups suggest that subjective perception of threat in response to angry faces is higher – but does not arise earlier – in schizophrenia. In two previous studies evaluating threat perception in schizophrenia, it was shown that subjects with schizophrenia may exhibit sharper perception of anger and attention can easily be distracted by threatening stimuli (7,8). Together these results may point out to sensitivity in schizophrenia to stimuli that evoke negative emotions. Another study that examined such sensitivity to negative emotional stimuli showed that schizophrenia patients reacted to these conditions earlier (24). Nevertheless we could not find any difference between groups for TtT. This inconsistency may be due to evaluation of implicit versus explicit responses. To our knowledge, although cognitive models that explain positive psychotic symptoms mention sensitivity to negative emotional stimuli (25), no previous research compared subjects with schizophrenia and healthy controls in terms of explicit subjective threat in response to anger. Higher levels of perceived threat detected in this study in schizophrenia subjects particularly with lower severity of positive psychotic symptoms may support cognitive models of psychosis.

We detected relationship between severity of hallucinations and with TtT –but not TPoT – scores. This result may be inferred as patients with

more severe hallucinations may perceive threat earlier and may be in line with Smith et al. (2013) who suggested possible relationship between hallucinations and sensory gating impairment (26). Such a perception disturbance may both be associated with earlier perception of threat and hallucinations.

It was so interesting that Sequences^{Sch>C} had lower scores than Sequence^{Sch=C} in terms of AL and Int_{Total} and this finding may suggest that schizophrenia patients compared to healthy controls may perceive less intense expressions of anger as threatening. Cognitive models of psychosis refer to a jumping to conclusion bias (27). It has been shown that patients need fewer evidence to decide in probability-related inference tasks (28,29). Increased attention to expression of negative emotions together with the jumping to conclusion bias may lead identifying less intense expressions of anger as threatening in the index group.

We detected positive correlations between TPoT scores and rising of upper lip and moving down of eyelid in the patient group. These correlations suggest that the sensitivity among the index group may arise from increased attention to functional units related with the lip and the eyes. Eyes and lips are main parts of the face to deliver social information. In previous eye tracking studies, it was observed that schizophrenia patients exhibit shorter fixation to eyes and the lips while scanning emotional faces (30,31). In that case, misperceiving of social clues expressed by the eyes and the lips may be associated with such sensitivity. This information may be of particular importance for education of health professionals in direct contact with psychotic patients.

Main limitation of this study is that cultural validity of the dataset comprising angry face photographs has not previously been tested in our country. Therefore, it is not possible to be exactly sure whether the participants perceived these emotional expressions as anger. On the other hand, our main objective was to evaluate threat perception rather than emotion identification and therefore this limitation less likely have led to an observational bias. Another limitation may be related to the scenarios presented before the face photographs. Although these scenarios were prepared cautiously in order not the scenario itself to lead to any kind of threat, we can not exactly be sure whether presenting these scenarios prior to the face photographs have led to a differential observational bias between the two groups. On the other hand, reducing the possibility of such a bias, these scenarios comprise of a single sentence which give contextual information and does not include adjectives to describe a third person (e.g.: 'You are going to see a photograph of a cashier that you met while shopping'). Another limitation is that the patient group consists of participants recruited from a university hospital with low severity of positive symptoms and the results therefore may not be generalised to all psychotic subjects.

Ethics Committee Approval: Approved by the Undergraduate Student Research Committee Ethics Review Board of Ankara University Faculty of Medicine (date, 06.01.2016; decision no, 72189195-050.03.04).

Informed Consent: Oral and written consent was obtained from the first-degree relatives of the participants.

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