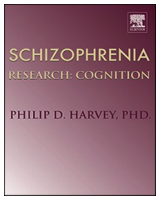
Schizophrenia Research: Cognition 36 (2024) 100301

Contents lists available at ScienceDirect

Schizophrenia Research: Cognition

journal homepage: www.elsevier.com/locate/scog



Research Paper

Face and emotion recognition in individuals diagnosed with schizophrenia, ultra-high risk for psychosis, unaffected siblings, and healthy controls in a sample from Turkey

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ARTICLE INFO

Keywords:
Schizophrenia
Ultra-high risk for psychosis
Sibling
Face recognition
Emotion recognition
Cognition

ABSTRACT

Face and emotion recognition are crucial components of social cognition. We aimed to compare them in patients diagnosed with schizophrenia (SCZ), ultra-high risk for psychosis (UHR), unaffected siblings of schizophrenia patients (SIB), and healthy controls (HC). Methods: One hundred sixty-six participants (45 SCZ, 14 UHR, 45 SIB, and 62 HC) were interviewed with the Structured Clinical Interview for DSM-5 (SCID-5). Positive and Negative syndrome scale (PANSS), PennCNB Facial Memory (CPF), and Emotion Recognition Task (ER40) were applied. Results: In CPF, SCZ performed significantly lower than SIB and HC. SIB was also significantly lower than HC for total correct responses. The sample size of the UHR group was small, and the statistical comparisons did not reach a significance, however, a trend towards decreased performance between the SCZ and SIB was found. In ER40, SCZ performed significantly lower than HC and SIB in all domains, except for the insignificant findings for angry ER between SIB and SCZ. SIB also performed significantly lower than HC for angry, negative, and total ER. UHR was similar to SCZ for happy and sad ER and performed significantly lower than HC for happy ER. The effect of SCZ diagnosis on the efficiency of CPF and ER40 was significant when corrected for age and education. For SCZ, PANSS also significantly affected the CPF and ER40. Conclusion: Our findings suggest varying levels of face and emotion recognition deficits in individuals with SCZ, UHR, and SIB. Face and emotion recognition deficits are promising schizophrenia endophenotypes related to social cognition.

1. Introduction

In addition to positive and negative symptoms, social cognition, defined as the mental processes underlying social interactions such as perceiving, interpreting, and reacting to others, is among the core features of schizophrenia, that appear in the prodromal period of the disorder and remain stable over the clinical course (Pinkham et al., 2005; Pinkham et al., 2007; Addington et al., 2008; Green et al., 2008). Improvement in social cognitive abilities is associated with an increase in overall functionality in SCZ (Halverson et al., 2019; Vaskinn and Horan, 2020) and individuals with ultra-high risk of psychosis (UHR) (Haining et al., 2020).

Patients with SCZ have deficits in face recognition (identifying whether two faces are the same or different) and emotion processing (emotion recognition, discrimination, and grading) (Addington and Addington, 1998; Addington et al., 2006) which are two social cognitive skills that are central to social interaction (Baudouin et al., 2002; Bediou et al., 2007; Ventura et al., 2013; Bortolon et al., 2015). Face recognition involves processing non-emotional information about facial features (such as gender, age, or identity), recognizing known faces, and distinguishing new faces (Green et al., 2015). Several studies have demonstrated that face recognition performance in SCZ is largely impaired. Still, some others did not show any deterioration (Addington and Addington, 1998; Hooker and Park, 2002; Hall and Matsumoto, 2004; Scholten et al., 2005; Van't Wout et al., 2007). The heterogeneity in the findings of the studies may stem from different designs including patient selection, tools used for assessment of face recognition, other cognitive dysfunctions such as memory impairments and cultural

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https://doi.org/10.1016/j.scog.2024.100301
Received 9 October 2023; Received in revised form 15 January 2024; Accepted 17 January 2024

differences. Patients with SCZ also demonstrated significant impairment in face memory tests (Sachs et al., 2004; Calkins et al., 2005; Silver et al., 2009). To ascertain the universality of this discovery and to investigate its manifestation across diverse cultures, it is essential to replicate these studies in various countries for cross-cultural generalizability. Face recognition and visual perception may vary across cultures (Blais et al., 2021) and the relation with psychopathology in different cultures needs to be assessed.

In addition to recognizing faces, patients with SCZ have considerable difficulties in recognizing, naming, and distinguishing emotions in the facial expressions of others, especially in the recognition of negative emotions such as sadness, fear, and anger (Gao et al., 2021). Some studies examining the relationship between clinical symptoms and emotion recognition from facial expression suggest that it may be associated with positive and negative symptoms (Addington and Addington, 1998; Tsoi et al., 2008; Kohler et al., 2010; Oliver, Haltigan et al., 2019). But, longitudinal studies have shown that these deficits can be seen both in patients with first-episode psychosis and those with a chronic course (Addington et al., 2006). First-episode psychosis patients had worse results in recognizing fear and sadness than those with mood disorders with psychotic features or controls (Edwards et al., 2001). In a similar vein, patients with SCZ in remission performed lower in naming emotions and predicting emotion intensity compared to patients with bipolar disorder (Addington and Addington, 1998). However, to the best of our knowledge, only one study explored the differences in emotion recognition among SCZ, UHR, familial risk, and healthy control groups (Tikka et al., 2020). To investigate the relationship between this difference and the stages of disease development and whether it is an endophenotype, higher number of studies are needed and it is necessary to compare these groups together.

It has been suggested that the impairment in recognizing emotion from facial expression might reflect an endophenotype that predisposes to SCZ. Facial emotion recognition skills are found to be impaired in unaffected relatives compared with the control group (Kee et al., 2004; Bediou et al., 2007; Leppanen et al., 2008; Erol et al., 2010), even though some studies reported no significant differences (Bolte and Poustka, 2003; Tikka et al., 2020). An earlier meta-analysis study that pooled studies using various tasks for face recognition reported decrease in emotional processing in familial risk groups (Lavoie et al., 2013). Furthermore, the neurodevelopmental model of SCZ suggests that some deficits may exist before the onset of the disease (Marenco and Weinberger, 2000). Accordingly, if the deficits in emotion recognition and face recognition represent susceptibility to SCZ, they might also be apparent in individuals at increased risk for psychosis. One meta-analysis study that focused on the social cognitive deficits in UHR underlined the limited number and heterogeneity of the studies on this topic and reported lower facial affect recognition compared to controls in UHR (Van Donkersgoed et al., 2015). In light of the contradictory findings of the current literature, further research is warranted.

In this study, we aimed to explore the impairments in face memory and emotion recognition at different levels of vulnerability to psychosis and in psychosis. Our primary objective was to explore impairments in face memory and emotion recognition in psychosis and at different levels of vulnerability to psychosis. Our secondary objective was to analyze the correlation of cognitive task scores with positive and negative symptom scores in the SCZ group. We hypothesized that emotion recognition and face memory scores would show a gradual decline from healthy controls to sibling, UHR, and SCZ groups, respectively. Secondly, we hypothesized that positive and negative SCZ symptom scores would be negatively correlated with emotion recognition and face memory scores.

2. Materials and methods

2.1. Participants

Individuals with SCZ (n = 45), Ultra-High Risk for Psychosis (UHR, n = 14) and unaffected siblings of schizophrenia patients (SIB, n = 45) were recruited from patients admitted to Marmara University and Istanbul University School of Medicine, Departments of Psychiatry. Healthy matched controls (HC, n = 62) were recruited through advertisements in the hospitals. Inclusion criteria for all groups were (1) willingness to participate in the study, (2) being between 18 and 65 years of age, (3) not being diagnosed with a neurological disease or having a head trauma history, (4) not having substance or alcohol use disorder, and (5) ability to do basic arithmetic tasks and literacy.

The Structured clinical interview for DSM-5 disorders (SCID-5) was conducted to diagnose schizophrenia. The SCZ group was confirmed to be in remission for at least six months. Comprehensive Assessment of At Risk Mental States (CAARMS) was utilized to establish the UHR group and consisted of individuals who met criteria for either brief limited intermittent psychotic symptoms (BLIPS) or attenuated psychosis or genetic risk plus functional deterioration (Yung et al., 2005; Yokuşoğlu et al., 2020). CAARMS interviews was carried out by a senior researcher (A.U.) A healthy matched group (HC) was assessed by Structured Clinical Interview for DSM-5 (SCID-5) to exclude any probable psychiatric diagnosis. For HC group, having any lifetime psychiatric disorder, or having a first-degree relative who have been diagnosed with schizophrenia were defined as the exclusion criteria.

Of the one hundred sixty-six participants, 123 were male and 43 were female. Mean age of the group was 32.51 ± 7.55 years. This study was in accordance with the Declaration of Helsinki and was approved by the Marmara University Medicine School Ethics Committee on Clinical Researches with protocol number 09.2016.461 and by the Koc University Ethics Committee on Biomedical Researches with the IRB number 2017.177.IRB2.062. All participants provided written informed consent.

2.2. Procedure

Sociodemographic information of all participants was obtained, and the medical records of the patients were examined. To confirm the patient group has only diagnosis for schizophrenia and the siblings and control groups have no psychiatric disorder diagnosis from Axis I, a Structured Clinical Interview for DSM-5 (SCID-5) was applied by the clinicians. In addition, the Positive and Negative Syndrome Scale was applied to the patient group to determine the severity of the schizophrenia symptoms. To confirm the UHR group and the control group, clinicians applied CAARMS and SCID-5, respectively. All participants took facial memory and emotion recognition tasks of the PennCNB through standardized equipment and in standard environmental conditions.

2.2.1. Measures

2.2.1.1. Semi-Structured Data Form. The participants' sociodemographic characteristics (age, gender, educational status, marital status, occupation, etc.) were recorded in the sociodemographic data form prepared by the researchers. In addition, for the SCZ group; age at first diagnosis, duration of disease, number of hospitalizations, and treatments used were obtained by the interview, examining files and medical records, and recorded in this form.

2.2.1.2. Structured Clinical Interview for DSM-5 (SCID-5). It is a semi-structured interview guide to establish primary DSM-5 diagnoses. The clinician applied SCID-5. An approved Turkish version of SCID-5 was used in the study (Elbir et al., 2019).

2.2.1.3. Positive and Negative Syndrome Scale (PANSS). It is a structured interview scale consisting of three parts to evaluate positive symptoms (PANSS-P, 7 items), negative symptoms (PANSS-N, 7 items), and general psychopathology (PANSS-G, 16 items) in schizophrenia (Kay et al., 1987). The Turkish validity and reliability study of the scale was performed by Kostakoğlu et al. (Kostakoğlu et al., 1999).

2.2.1.4. Cognitive Tasks from the Turkish version of PennCNB

2.2.1.4.1. Penn Facial Memory Test (CPF). This task is used for measuring face recognition memory. The first step is to show participants 20 faces so they can remember them later on. In the second step, 40 photos (20 new and 20 formerly seen faces) are presented to participants for them to determine whether they have seen the face previously. To answer the question, they have four options: "definitely no," "probably no," "probably yes," or "definitely yes" (Moore et al., 2015).

2.2.1.4.2. Penn Emotion Recognition Task (ER40). This task is used for measuring identification of emotions. Ekman's 40 facial series was shown to participants, and they were asked to select one answer from five options: happy, sad, anger, fear, and no emotions. There are eight different faces for each emotion in the task, half of the faces are male (Moore et al., 2015). For the ER40 task, three emotion subcategory scores are also created: positive (happy), negative (sad, anger, fear) and neutral. Test-retest validity of both tasks for Turkish was conducted by İzgi et al. (Izgi et al., 2022). Efficiency scores of tasks were calculated by dividing the number of correct response by the natural logarithm of the response time of correct answers. Only one participant's Penn Facial Memory Task score from the SCZ group was excluded from further analysis because of non-compliance for this task.

2.3. Statistical analysis

The Statistical Package for Social Sciences (SPSS; Version 28.0) was used in data analysis. We used nonparametric tests for demographic characteristics; age, education level and cognitive task variables, as data were not normally distributed (Kolmogorov-Smirnov test, $p < 0.005$ for all variables except CPF efficiency; $p = 0.2$). Chi-square test was used for comparison of gender distribution.

To investigate differences in CPF and ER40 scores between groups, a nonparametric Kruskal-Wallis test was used. Significance level for multiple comparisons for all pairwise groups to determine which groups significantly differed using Bonferroni correction was also reported. In addition, the relations between PANSS scores and efficiency scores of CPF and ER40 tasks were examined with Pearson's correlation test. To test if the findings related to SCZ are due to age and education difference, we conducted a multivariate linear regression analysis to predict CPF efficiency and ER40 efficiency scores, by including age, education and having a SCZ diagnosis in the model.

3. Results

3.1. Sociodemographic variables across groups

All demographic information of the groups can be found in Table 1. There was no difference in gender distribution among the groups (Table 1). UHR group was significantly younger than all other groups and other groups were not different for age. The mean year of education was significantly lower in SCZ group compared to SIB and HC groups ($p < 0.001$ for all group comparisons), however there was no significant difference for mean education between SCZ and UHR groups, in addition to UHR, SIB and controls ($p > 0.05$).

3.2. Facial memory and emotion recognition scores across groups

For all groups, CPF efficiency scores significantly correlated with ER40 efficiency scores (All sample: $n = 163$, PCC:0.63, $p < 0.001$; SCZ: $n = 44$, PCC:0,59, $p < 0.001$; UHR: $n = 12$, PCC:0,67, $p = 0.017$; SIB: $n = 45$, PCC:0,38, $p = 0.009$; HC: $n = 62$, PCC:0,35, $p = 0.006$). Groups were significantly different for all variables related to Facial Memory and Emotion Recognition (Table 2).

In CPF, SCZ group scored significantly lower in true positive (CPF-TP) and efficiency scores and higher in false-negative (CPF-FN) scores, compared to SIB and HC ($p < 0.005$), but showed no difference with UHR group (Table 2, Fig. 1a). No significant difference was observed between UHR and SIB and HC groups.

SCZ group scored significantly lower in total correct responses, efficiency, positive emotion recognition, neutral emotion recognition and all negative emotion subcategories compared to siblings and healthy controls ($p < 0.002$) (Table 2, Fig. 1). However, no difference was found for SCZ and UHR groups for neutral, positive (happy) and sad emotion recognition. Both UHR and SIB groups scored lower total correct responses compared to HC. UHR grouped differed in positive and sad emotion recognition, however SIB group differed in angry emotion recognition (Table 2, Fig. 1b).

3.3. Effect of age and education on face and emotion recognition scores

The multivariate linear regression analysis, including age, education and SCZ diagnosis, to detect if the difference related to SCZ is due to age and education difference in between the groups, revealed that the model explained 29.6 % of the variance for CPF efficiency and that the model was a significant predictor of the CPF efficiency ($(F = 3, 164) = 22.5$, $p < 0.001$). Both having a schizophrenia diagnosis and duration of education significantly predicted CPF efficiency scores (Table 3). For ER40 efficiency, the model explained 49.5 % of the variance and the model was a significant predictor of the ER40 efficiency ($(F = 3, 163) = 52.3$, $p < 0.001$). Both having a schizophrenia diagnosis, age and duration of education significantly predicted ER40 efficiency scores (Table 3).

3.4. Correlation of facial memory and emotion recognition scores with PANSS scores in SCZ group

For SCZ group, PANSS negative scores correlated negatively with CPF total correct responses and efficiency (P.C. coefficient: −0,33, $p = 0.03$ and P.C. coefficient: −0,37, $p = 0.014$, respectively). PANSS positive scores slightly and negatively correlated with CPF efficiency (P.C. coefficient: −0,3, $p = 0.047$). PANSS total scores also significantly and negatively correlated with CPF total correct responses and efficiency (P.C. coefficient: −0,30, $p = 0.045$ and P.C. coefficient: −0,36, $p = 0.015$, respectively).

For the SCZ group, PANSS positive scores significantly correlated with total correct responses and efficiency in ER40 (P.C. coefficient: −0,38, $p = 0.01$ and P.C. coefficient: −0,39, $p = 0.008$, respectively).

Table 1
Sociodemographic variables of participant groups.

Groups	[1]Schizophrenia	[2]UHR	[3]Siblings	[4]Controls	Total	P1-2-3-4
N	45	14	45	62	166	
Gender (female %)	20	21.4	28.9	29	25.9	0.685, $\chi2 = 1.488$
Age (mean ± s.d.)	35.73 ± 5.61	20.79 ± 4.1	34.04 ± 6.66	31.71 ± 7.38	32.51 ± 7.55	<0.001
Education (years)	7.27 ± 3.19	9.57 ± 2.44	11.22 ± 3.45	11.53 ± 2.69	10.13 ± 3.51	<0.001

Note: UHR: Ultra-high risk for psychosis.

Table 2
Comparison of participant groups for CPF and ER40 variables.

	[1]Schizophrenia (n = 44)	[2]UHR (n = 14)	[3]Siblings (n = 45)	[4]Controls (n = 62)	Total (n = 165)	P1-2-3-4	P1-2	P1-3	P1-4	P2-3	P2-4	P3-4
CPF-TP	12,59 ± 4,03	14,86 ± 3,21	15,42 ± 2,94	16,06 ± 2,89	14,86 ± 3,54	<0,001	0,079	<0,001*	<0,001*	0,57	0,18	0,26
CPF-EFF	3,4 ± 0,58	3,85 ± 0,72	3,94 ± 0,53	4,24 ± 0,5	3,9 ± 0,64	<0,001	0,14	<0,001*	<0,001*	0,87	0,06	0,008*
IFAC_TOT	26,93 ± 3,77	28,86 ± 5,1	29,78 ± 3,44	31,89 ± 3,61	29,73 ± 4,21	<0,001	0,04	0,002*	<0,001*	0,89	0,04	0,004*

	[1]Schizophrenia (n = 45)	[2]UHR (n = 12)	[3]Siblings (n = 45)	[4]Healthy (n = 62)	Total (n = 164)	P1-2-3-4	P1-2	P1-3	P1-4	P2-3	P2-4	P3-4
ER40_CR	27 ± 5,84	32,83 ± 2,79	33,38 ± 3,19	35,13 ± 2,9	32,25 ± 5,17	<0,001	0,01	<0,001*	<0,001*	0,5	0,015	0,005*
ER40_EFF	3,3 ± 0,77	4,28 ± 0,37	4,29 ± 0,46	4,47 ± 0,42	4,09 ± 0,73	<0,001	0,001*	<0,001*	<0,001*	0,6	0,11	0,09
ER40_NEUTRAL	5,04 ± 2,73	6,5 ± 1,88	7,07 ± 1,34	7 ± 1,44	6,45 ± 2,07	<0,001	0,08	<0,001*	<0,001*	0,3	0,38	0,74
ER40_POSITIVE (HAPPY)	7,27 ± 1,16	7,42 ± 0,79	7,87 ± 0,34	7,92 ± 0,33	7,69 ± 0,75	<0,001	0,95	<0,001*	<0,001*	0,03	0.005*	0,44
ER40_NEGATIVE (ANGRY + FEAR + SAD)	14,69 ± 3,7	18,92 ± 3	18,44 ± 2,74	20,21 ± 2,41	18,12 ± 3,67	<0,001	0,002*	<0,001*	<0,001*	0,61	0,15	0,002*
ER40_ANGRY	4,22 ± 1,29	5,75 ± 1,14	4,69 ± 1,31	5,76 ± 1,54	5,04 ± 1,53	<0,001	0,002*	0,14	<0,001*	0,03	0,99	<0,001*
ER40_FEAR	4,58 ± 2,29	6,83 ± 1,27	6,71 ± 1,49	7,02 ± 1,14	6.25 ± 1,91	<0,001	0,002*	<0,001*	<0,001*	0,84	0,73	0,37
ER40_SAD	5,89 ± 1,48	6,33 ± 1,72	7,04 ± 1,07	7,44 ± 0,95	6,82 ± 1,36	<0,001	0.23	<0,001*	<0,001*	0,22	0,012	0,04

Note: Pairwise comparisons are not adjusted for multiple comparison. UHR: Ultra-high risk for psychosis, CPF: Penn Facial Memory Test, TP: true positive, EFF: efficiency, IFAC_TOT: Total Correct Response, ER40: Penn Emotion Recognition Task, CR: correct responses.
* Significant after Bonferroni correction for multiple comparison.

PANSS negative and total scores were also significantly correlated with ER40 efficiency (P.C. coefficient: −0,37, p = 0.012 and P.C. coefficient: −0,34, p = 0.02, respectively), and total correct responses (P.C. coefficient: −0,34, p = 0.025 and P.C. coefficient: −0,33, p = 0.03, respectively) to a lower extent.

4. Discussion

In this study where we investigated face memory and emotion recognition across four groups, we found that, SCZ was significantly different compared to SIB and HC in face recognition. SIB were also

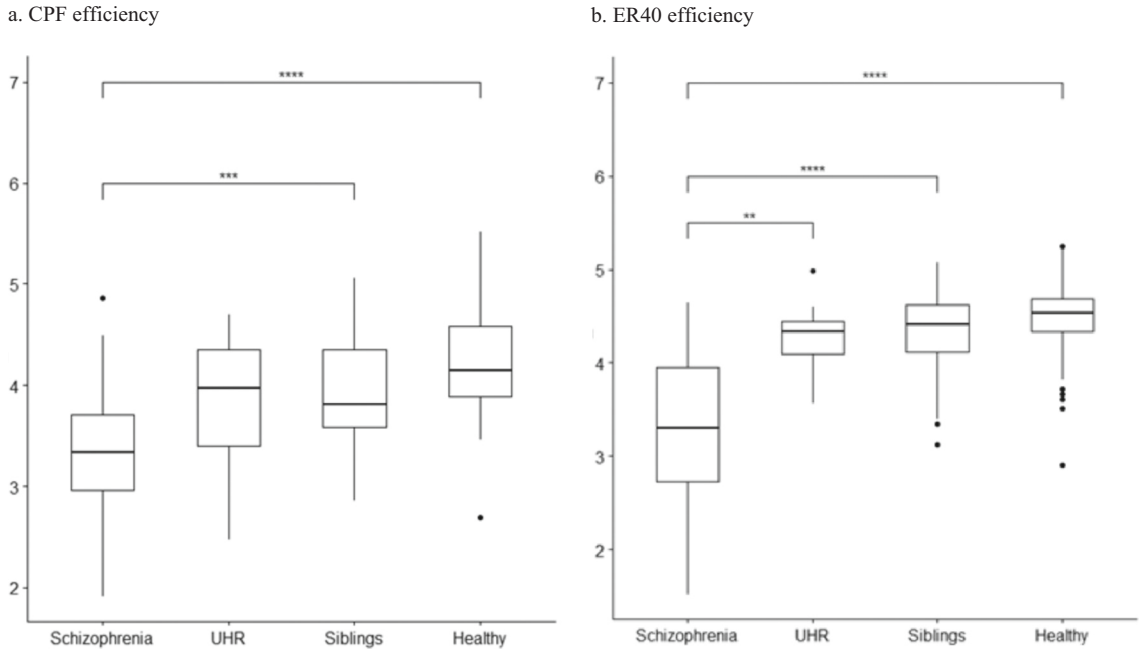

Fig. 1. Face memory and emotion recognition task score distributions across groups. a. CPF efficiency scores across groups; b. ER40 efficiency scores across groups. **: p = 0.007, ***: p = 0.001, ****: p < 0.001, p adjusted Bonferroni. Note: CPF: Penn Facial Memory Test, ER40: Penn Emotion Recognition Task, UHR: Ultra-high risk for psychosis.

Table 3
Age, education and schizophrenia diagnosis effects on CPF and ER40 efficiency (multivariate linear regression analysis).

	β coefficient	Std. error	Confidence Interval		p value
			Lower bound	Upper bound	
CPF efficiency					
Constant	3,31	0,25	2,83	3,81	<0,001
Age	0,005	0,006	−0,006	0,017	0,38
Education (years)	0,054	0,014	0,027	0,08	<0,001
Having SCZ diagnosis	−0,5	0,11	−0,72	−0,28	<0,001
ER40 efficiency					
Constant	4,37	0,25	3,87	4,87	<0,001
Age	−0,015	0,006	−0,03	−0,003	0,01
Education (years)	0,042	0,014	0,015	0,07	0,002
Having SCZ diagnosis	−0,85	0,1	−1.06	−0,63	<0,001

Note: CPF: Penn Facial Memory Test, ER40: Penn Emotion Recognition Task, SCZ: Schizophrenia.

significantly different compared to HC for total correct responses in face recognition. The sample size of UHR group was small, and the statistical comparisons did not reach a significance, however the analysis showed a trend towards decreased performance in between the SCZ and SIB groups. This highlights a pivotal aspect of our study: the pronounced deficits in face recognition present within affected individuals and their unaffected siblings.

In line with established literature (Gur et al., 2001; Conklin et al., 2002; Sachs et al., 2004; Calkins et al., 2005; Gur et al., 2007; Silver et al., 2009; Li et al., 2010), our findings validate previous observations of impaired face recognition among SCZ and SIB individuals compared to HC. As reported in the other study by Tikka et al., which compared first episode SCZ clinical at-risk and familial at risk groups, familial and clinical risk groups could not be discriminated using these tasks (Tikka et al., 2020). Similarly, the examination of emotion recognition revealed consistent deficits across SCZ, UHR, and SIB groups compared to HC, consistent with prevailing studies in schizophrenia and emotion recognition (Kee et al., 2004; Bediou et al., 2007; Erol et al., 2010; Lee et al., 2010; Lahera et al., 2014; Corcoran et al., 2015; Yang et al., 2015; Ay et al., 2016). However, while some studies on siblings reported that unaffected siblings performed similarly to healthy individuals (Kee et al., 2004; Li et al., 2010), some other studies revealed that siblings also had impaired emotion recognition skills, like our results (Bediou et al., 2007; Erol et al., 2010; Ay et al., 2016).

In the SCZ group, the lowest performance was observed in recognizing angry and fearful expressions, while the highest performance was in recognizing happy facial expressions. This suggests that SCZ individuals performed better at recognizing happy facial expressions compared to angry and fearful ones. Previous research has implicated abnormal amygdala activation in schizophrenia patients, which may contribute to misrecognition of negative emotions such as fear and anger in facial expressions (Gur et al., 2002; Pinkham et al., 2007a). Divergent findings exist, with some studies reporting increased amygdala activity in response to both fearful and neutral faces (Holt et al., 2006; Hall et al., 2008), while others report lower amygdala activity in SCZ during facial emotion recognition tests. Gur et al. observed decreased activity in the left amygdala and bilateral hippocampus in SCZ during tests designed to distinguish negative from positive emotions, while healthy controls showed increased activity, suggesting difficulties in limbic region activation in schizophrenia (Gur et al., 2007). Additionally, studies by Kosaka et al. revealed differing patterns of amygdala activation in positive and negative facial discrimination tasks, further underscoring the complexity of emotion recognition in schizophrenia patients (Kosaka et al., 2002).

In emotion recognition, individuals with schizophrenia (SCZ) showed significant differences from healthy controls (HC) and unaffected siblings (SIB) in all domains, except for the insignificant findings in angry emotion recognition between SIB and SCZ. Additionally, the SIB group differed significantly from HC in recognizing angry, negative, and total emotions. The ultra-high risk (UHR) group was similar to the SCZ group in recognizing happy emotions and significantly different from HC in this aspect. Importantly, the impairment in facial and emotion processing skills observed in SCZ worsened with increased positive and negative symptoms, and similar deficits were observed in unaffected siblings who do not have confounding factors such as medication and chronicity (Kee et al., 2003; Addington et al., 2006; Pinkham et al., 2007b). These data support the view that impairment in emotion processing is a disorder that exists independently of the drugs used, although they may be related to the severity of the disorder.

When we analyzed our results based on emotion types, SCZ patients had worse performance in all emotion types than HC. This indicates the deficit observed in SCZ is not specific to an emotion category. However, the UHR group was different from HC in happy and sad emotion recognition and the SIB group presented worse performance than the HC only in angry and overall total negative facial expressions. Another study where UHR group was compared to HC, most significant finding was also increased reaction time to happy faces in UHR group (Haining et al., 2020). The EU-GEI High Risk Study examined the accuracy differences of each emotion in individuals with clinical high risk for psychosis and found no significant difference compared to controls, but the high-risk group included participants with very low scores (Modinos, Kempton et al., 2020). Another study added to this finding by increased response latency in all emotion types and decreased total emotion recognition accuracy compared to HC (Glenthoj et al., 2019). These studies point out that in addition to focusing on the accuracy, including reaction times and efficiency scores in the analysis is important to show the differences among the groups.

Even when correcting for age and education, the effect of SCZ diagnosis on efficiency scores of CPF and ER40 remained significant. Given that the SCZ groups had lower education levels and the UHR group was younger than others in the study, education and age were included as covariates in the regression model. Previous literature has also recognized education level as a potential confounding factor in emotion processing processes (Conklin et al., 2002, Bediou et al., 2007, Erol et al., 2010, Lee et al., 2010). There are also studies showing that age does not affect performance (Bediou et al., 2005). However, some studies have shown a strong correlation between age increase and deterioration in emotion recognition skills in the patient and healthy control groups (Edwards et al., 2002; Kohler et al., 2010; Amminger et al., 2012; Leszczynska, 2015). In our study, age significantly affected decreased emotion recognition even when controlled for diagnosis, however the effect was small.

Previous research has shown that individuals with schizophrenia experiencing acute exacerbation had lower negative emotion perception scores compared to chronically stable outpatients (Penn et al., 2000). Additionally, improvements in positive and negative symptoms in schizophrenia patients in the 3-month follow-up period after discharge did not lead to changes in emotion recognition skills (Addington and Addington, 1998). Even after one year in remission, the deterioration in emotion recognition remained stable (Kee et al., 2003). In a study by Gur et al., inadequacies in emotion recognition from facial expressions in patients diagnosed with schizophrenia in the first episode and remission were independent of the disease phase and the effects of treatment (Gur et al., 2007). In this study, both positive and negative symptom scores in SCZ were negatively correlated with face and emotion recognition. Given that the patient group was in remission for six months, this suggests ongoing deficits compared to controls.

In the study by Amminger et al., there were significant impairments in recognizing facial expressions of fear and sadness and recognizing anger from sounds in the high-risk of psychosis and the first episode

schizophrenia patients compared to the healthy controls (Amminger et al., 2012). A study comparing emotion recognition performances in ultra high-risk individuals, first-episode and chronic schizophrenia patients, and a healthy control group revealed that individuals with schizophrenia failed to recognize all emotions. In contrast, ultra high-risk individuals were inadequate in identifying sad and disgusted facial expressions (Comparelli et al., 2013).

A systematic review focusing on genetic risk for schizophrenia and facial emotion recognition stated that first-degree relatives of SCZ patients may perform worse in recognizing angry faces compared to controls (Martin et al., 2020). Although some studies, such as Bölte et al., found no difference between unaffected relatives of patients and the control group for facial emotion recognition (Bolte and Poustka, 2003), more studies support the opposite. Leppänen et al. demonstrated a deterioration in recognizing negative facial expressions in unaffected siblings of schizophrenia patients (Leppanen et al., 2008). In Bediou et al.'s study, emotion recognition was evaluated in drug-naive first-episode schizophrenic patients, their unaffected siblings, and the control group. While there was a difference in emotion recognition in patients and their unaffected siblings compared to healthy controls, there was no significant difference in gender recognition. Despite clinical stabilization, no improvement was observed in the emotion recognition performance of the patients (Bediou et al., 2007). These findings collectively suggest that impaired facial emotion recognition may be an endophenotype candidate for schizophrenia.

There are also findings supporting the emotion processing-specific flaw approach. For example, it is known that the definition of negative emotion is more complicated than neutral facial expressions or positive emotions, while negative emotions can be confused with other negative emotions; this is not seen in positive emotions (Johnston et al., 2001). Accordingly, avoidance behavior from negative stimuli may interfere with the correct processing of negative stimuli (Gallese, 2003). On the other hand, the disturbance observed in schizophrenia patients might be related to either misprocessing of visual stimuli (Williams et al., 1999) or a deficit in top down control of the processed visual stimuli (Caruana and Seymour, 2021).

For the SCZ group, PANSS scores also significantly affected face recognition and emotion recognition scores (Mandal et al., 1999). In general, patients with negative symptoms have greater difficulty recognizing facial expressions (Tsoi et al., 2008). Some studies have associated emotion recognition deficits with specific negative symptoms, such as anger (Mueser et al., 1996), alogia (Gaebel and Wolwer, 1992; Kohler et al., 2000), affect blunting, and anhedonia (Phillips et al., 2003), as well as the overall severity of negative symptoms (Baudouin et al., 2002). However, other studies have found associations with odd behavior (Schneider et al., 1995), thought disorder (Kohler et al., 2000; Phillips et al., 2003), and overall positive symptoms (Lewis and Garver, 1995). One study reported that emotion recognition scores from combined voice and facial expression were associated with positive and disorganized symptoms but not with negative symptoms (Poole et al., 2000). General cognitive function, including defects in classification, discrimination, and identification of facial stimuli, can contribute to these problems. Issues related to working memory and attention may also negatively impact these functions and mediate the relationship between symptom severity and face and emotion recognition (Gallese, 2003).

Our study has many strengths as high sample size and including four groups for different vulnerability levels for schizophrenia symptoms. In addition, it is the first study from Turkey that evaluated the changes in emotion processing across different vulnerability groups and it could show that the findings in face and emotion recognition could be a universal endophenotype that could be generalized across cultures. We utilized tasks that evaluate not only emotion recognition but also face recognition to assess the relationship between recognition deficits related to specific emotions. However, the limitations of our study can be listed as the small number of UHR group, heterogeneity of our patient group included in the study. The distribution of the genders of the participants did not allow us to conduct in-group analyses. Although the effect of participants' education level was evaluated, the intelligence quotients (IQ) were not measured separately. Also, we did not analyze the effect of duration of illness and current medication on the findings. Finally, UHR group had relatively a small sample size.

5. Conclusion

In conclusion, we found that face recognition in SCZ, was significantly different compared to siblings and HC. Siblings were also significantly different compared to healthy controls for total correct responses in face recognition. The sample size of UHR group was small, and the statistical comparisons did not reach a significance, however the analysis showed a trend towards decreased performance in between the SCZ and sibling groups. In emotion recognition, SCZ group was significantly different from HC and SIB at all domains, except for the insignificant findings for angry emotion recognition between SIB and SCZ. As expected, SIB were also significantly different compared to HC for angry, negative and total ER. UHR was similar to SCZ for happy ER and significantly different than controls for happy ER. The effect of SCZ diagnosis on efficiency scores of CPF and ER40 were still significant when corrected for age and education. For SCZ group, PANSS scores also significantly affected the face recognition and emotion recognition scores.

Role of funding source

Authors have no specific funding source to declare.

CRediT authorship contribution statement

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Declaration of Generative AI and AI-assisted technologies in the writing process

To shorten some parts of the manuscript, authors used OpenAI ChatGPT, all modified text has been re-edited by the authors and checked for correctness.

Declaration of competing interest

Authors have no declaration of interest.

Acknowledgements

The authors gratefully acknowledge the use of the services and facilities of the Marmara University, Istanbul University and Koç University Research Center for Translational Medicine (KUTTAM), funded by the Republic of Türkiye Ministry of Development. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Ministry of Development. HYE's studies are partially supported by Science Academy Türkiye. We would also like to thank all our patients and participants who contributed to the study.

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