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Perception of faces in schizophrenia: Subjective (self-report) vs. objective (psychophysics) assessments

Yue Chen^{1,2} and Tor Ekstrom¹

¹McLean Hospital

²Harvard Medical School

Abstract

Objectives—Face perception impairment in schizophrenia has been demonstrated, mostly through experimental studies. How this laboratory-defined behavioral impairment is associated with patients' perceptual experience of various faces in everyday life is however unclear. This question is important because a first-person account of face perception has direct consequences on social functioning of patients. In this study, we adapted and administered a self-reported questionnaire on narrative perceptual experience of faces along with psychophysical assessments of face perception in schizophrenia.

Methods—The self-reported questionnaire includes six rating items of face-related functioning in everyday life, providing a subjective measure of face perception. The psychophysical assessment determines perceptual threshold for discriminating different facial identities, providing an objective measure of face perception.

Results—Compared to controls (n=25), patients (n=35) showed significantly lower scores (worse performance) in the subjective assessment and significantly higher thresholds (worse performance) in the objective assessment. The subjective and objective face perception assessments were moderately correlated in controls but not in patients. The subjective face perception assessments were significantly correlated with measurements of a social cognitive ability (Theory of Mind), again in controls but not in patients.

Conclusion—These results suggest that in schizophrenia the quality of face-related functioning in everyday life is degraded and the role that basic face discrimination capacity plays in face-related everyday functioning is disrupted.

Correspondence: Yue Chen, MS 303, 115 Mill Street, Belmont, MA 02478, ychen@mclean.harvard.edu.

Contributions

The manuscript presents original material and has not been considered for publication elsewhere. Both authors have made substantial contributions to this work. Yue Chen designed the study and prepared the manuscript. Tor Ekstrom performed the surveys, the psychological tests and data analysis, and revised the manuscript. Both authors had full access to the data and approved this manuscript for submission.

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1. Objectives

Schizophrenia patients have severe social functioning problems in everyday life (Green, Penn et al. 2008; Harvey 2013). Given that human faces provide a rich source of social information, understanding social functioning problems in this psychiatric disorder should begin with and focus on face processing. In fact, face perception impairments have been shown in schizophrenia (Phillips and David 1995; Chen 2011; Darke, Peterman et al. 2014; Bortolon, Capdevielle et al. 2015). The impaired perception of faces was largely defined by neuropsychological tests administered in laboratory (Archer, Hay et al. 1992; Whittaker, Deakin et al. 2001; Butler, Tambini et al. 2008; Chen, Norton et al. 2008; Shin, Na et al. 2008; Zivotofsky, Oron et al. 2008). From a neuropsychological perspective, face perception is about identifying a personal identity or recognizing a type of emotion conveyed on faces (Bruce and Young 1986). From an ecological perspective, however, face perception is about extracting and utilizing social signals conveyed on faces to guide social behaviors in everyday life (McArthur and Baron 1983).

It remains an open question to what extent the neuropsychological measures of face perception represent and reflect patients' perceptual experience of various faces in everyday life. Answers are needed here in order to provide an ecologically validated assessment of face perception and face-related everyday functioning in patients, especially in assessment of face-related perceptual and social experience in schizophrenia.

In prosopagnosia, a condition referring to a selective perceptual deficit in recognizing facial identities (Bodamer 1947), face perception problems elicited from neuropsychological tests and in self-reported questionnaires were significantly correlated (Stollhoff, Jost et al. 2011). Face perception training in individuals with prosopagnosia produced not only improved performances assessed using neuropsychological tests but also yielded consistent self-reported diary improvements (DeGutis, Cohan et al. 2014). The findings in this face recognition disorder suggest that comparison of objective measurements from laboratory setting and subjective measurements based on self-reported questionnaire provides a way to link neuropsychological assessment of face perception to face-related perceptual behaviors in everyday life.

In this study, we aimed to evaluate and compare face perceptions in schizophrenia using both subjective and objective assessments. The subjective assessment, geared towards ecological aspects of face perception, was designed and implemented through a self-reported questionnaire (DeGutis, Cohan et al. 2014). The objective assessment, geared towards neuropsychological aspects of face perception, was designed and implemented through a psychophysical test (Chen, Norton et al. 2009). We hypothesized that scores from the self-reported face perception questionnaire and measurements from the laboratory-based psychophysical face perception test are associated in schizophrenia patients.

We also aimed to evaluate the relationship between face perception assessments (both subjective and objective) and social cognitive functioning in patients. Social cognitive functioning was assessed using the Eyes Test (Baron-Cohen, Wheelwright et al. 2001) which measures an important aspect of social cognition - theory of mind. Given the vital

role of face in the social world, we hypothesized that the subjective (self-reported) and objective (psychophysical) measurements of face perception are associated with the measurements of theory of mind in schizophrenia patients.

2. Methods

2.1 Participants

Thirty-five schizophrenia patients (SZ) participated. All patients met DSM-IV criteria for schizophrenia or schizoaffective disorder, based on a standardized interview (First, Spitzer et al. 1994) and a review of all available clinical records. All patients were outpatients when participating in this study with an average illness duration of 20.36 years (std: 13.01 years). All but four patients were medicated with antipsychotic drugs (averaged CPZ dose equivalent = 387.9 mg (std: 359.0 mg)) (Woods 2003). Patients' psychotic status was assessed using the Positive and Negative Syndrome Scales (Kay, Fiszbein et al. 1987). Their scores in positive, negative and general subscales scores were 16.8 (4.4), 13.6 (3.7) and 30.2 (6.1), respectively.

Twenty-five healthy controls (HC) participated. They were screened for exclusion of any Axis One psychiatric disorders using non-patient SCID (First, Spitzer et al. 2002). Controls were also screened to exclude those with family members who had histories of psychosis.

Additional inclusion criteria for both groups were 1) no history of any neurological disorders (such as seizure or stroke) or head injuries, 2) IQ > 75, and 3) no substance dependence within the last six months. The two groups did not differ in age, gender or verbal IQ (Wechsler 1981). The two groups however differed in the Eyes Test score ($p < 0.05$). Table 1 provides detailed demographic and cognitive information for all of the subjects.

The study protocol was approved by the Institutional Research Board (IRB) of McLean Hospital. Written informed consent was obtained from all subjects after the nature of the study protocol had been fully explained. The study was carried out in accordance with the latest version of the Declaration of Helsinki,

2.2 Stimuli

2.2.1 Subjective assessment—The assessment – face perception questionnaire – includes six items. The first five items were presented as

1. I treat strangers as if I know them to avoid offending people I might already know (poor face perception);
2. I find it hard to keep track of characters in TV shows or movies (poor face perception);
3. I try to remember non-facial information about people's appearance (poor face perception);
4. I can recognize family members and close friends out of context (good face perception);

5. I can visualize the faces of family members and close friends (good face perception).

These five items were adopted from a study on prosopagnosia (DeGutis, Cohan et al. 2014). The sixth item was based on Capgras delusion, a face-related delusion that is prevalent in neuropsychiatric disorders including schizophrenia (Phillips and David 1995). It was presented as

6. I feel as though people I know have been replaced by physically identical imposters (poor face perception).

2.2.2 Objective assessment—For this test, face photographs of two individuals (Caucasian men) (Tottenham, Tanaka et al. 2009) were used as original face images after non-facial features such as hair and other body parts were cropped out. Additional face images were created through morphing between the two original face images (Figure 1). The morphed images (using FantaMorphPro (v5.0, 2012)) contained varying proportions of two original face images. Paired images for comparison had six different proportions of two original faces: 2.5, 5, 12.5, 25, 50, and 100%, generating six task difficulty (stimulus difference) levels for face identity discrimination. For example, to create a 5% stimulus difference, the two original face images would be morphed to create two new images: one face containing 47.5% of one individual and 52.5% of the other individual, and the other face containing 52.5% of one individual and 47.5% of the other individual.

Each trial included two sequential presentations with a 500 msec pause in between. The first presentation contained a single image (600 msec). The second presentation contained a pair of images side by side (1200 msec), one of which was identical to that in the first presentation, and the other of which differed in one of the six stimulus difference levels. Participants determined which of the two images in the second presentation was the same as the image in the first presentation. With six levels of stimulus difference and two target locations, each repeating 8 times, the test sessions contained 96 trials. The percents of correct trial or accuracies were used as one primary measure of perceptual performance.

2.3 Procedures

Two assessments of face perception were administered, one using questionnaire (subjective) and the other using psychophysical measurement (objective).

Participants were asked to complete a questionnaire regarding their perceptual experience of faces in everyday life. This assessment includes six question-items (listed above) that require self-reported answers. The first five items were adopted from a face perception study in prosopagnosia (face-blind) (DeGutis, Cohan et al. 2014). Participants gave a rated response to each of the items (1 to 5, 1=never, 2=rarely, 3=sometimes, 4=often, and 5=always). A composite response score for each participant was generated by using combined ratings to the six questions ((1) + (2) + (3) – (4) – (5) + (6) + 12). The scaling factor of 12 was used to ensure the composite score remain 6 (the number of items) or above. The higher a score, the greater extent to which face perception is degraded.

Participants were asked to complete a psychophysical test on facial identity discrimination. The test was designed to measure performance levels under varied levels of task difficulty during facial identity discrimination and to determine a perceptual threshold for this task (Chen, Norton et al. 2009). To obtain a unified measure of face identity discrimination across the varied levels of stimulus difference, perceptual thresholds were derived for each participant. A perceptual threshold was defined as minimum stimulus difference (or maximum task difficulty) level at which a participant achieves a performance level of 80% accuracy, and was computed by fitting accuracy data to a psychometric function (Chen, Bidwell et al. 2005). The derived perceptual thresholds were used as a singular metric of performance to compare with the self-reported questionnaire scores.

3. Results

3.1 Face perception questionnaire (subjective)

Table 2 presents average ratings for each item of the face perception questionnaire as well as composite scores. The composite scores differed significantly between the two participant groups ($t=3.57$, $p<0.001$), indicating degraded quality of everyday face-related experience in the patient group. For the ratings of individual items, the two groups were significantly different in item 1 ($t=2.71$, $p<0.01$), item 2 ($t=2.27$, $p<0.05$) and item 5 ($t=2.43$, $p<0.05$), but not in other items.

3.2 Psychophysical measurements (objective)

Figure 2 shows perceptual thresholds of face identity discrimination for the two participant groups. Performances of two controls and seven patients did not reach the 80% correct criterion level even for the 100% stimulus difference (the easiest task difficulty) so their perceptual thresholds were assigned outliers (100%). The patient group had a significantly higher perceptual threshold (worse performance) than the control group ($t=2.86$, $p=0.006$). When those outliers were removed, the group difference remained significant ($t=2.72$, $p=0.009$).

3.3 Relationship between psychophysical measurements and questionnaire scores

The perceptual thresholds of face identity discrimination were moderately correlated with the composite scores of the face perception questionnaire in controls ($r=0.381$, $p=0.05$), but not in patients (Figure 3). Again in controls, but not in patients, the perceptual thresholds of face identity discrimination were significantly correlated with two individual ratings of the face perception questionnaire (with item 2 (I find it hard to keep track of characters in TV shows or movies), $r=0.63$, $p<0.001$; with item 6 (I feel as though people I know have been replaced by physically identical imposters), $r=0.44$, $p<0.05$). No other correlations were significant in either group. For examination of this and other relationships below, the outliers during the face identity discrimination were excluded from both groups.

3.4 Relationship between face perception assessments and Eyes Test scores

The composite scores of the face perception questionnaire were inversely correlated with the scores of the Eyes Test in controls ($r=-0.538$, $p=0.01$), but not in patients (Figure 4).

There was a non-significant inverse correlation between the perceptual thresholds of face identity discrimination and the scores of the Eye Test in controls ($r=-0.378$, $p=0.06$). No correlation existed in patients.

3.5 Relationship between face perception assessments and clinical scores

In patients, the composite scores of the face perception questionnaire were moderately correlated with the scores of PANSS positive subscale ($r=0.331$, $p=0.05$), but not with scores of PANSS negative or general subscale, nor with CPZ. The perceptual thresholds of face identity discrimination were moderately correlated with the scores of PANSS positive subscale ($r=0.341$, $p=0.05$) and PANSS negative subscale ($r=0.355$, $p=0.04$) and with CPZ ($r=0.564$, $p=0.01$), but not with scores of PANSS general subscale.

4. Discussion

Face perception in schizophrenia patients was degraded, as evaluated by both the subjective and the objective assessments. Unlike in healthy controls, face-related everyday experience in schizophrenia patients is neither associated with the basic perceptual capacity to discriminate facial identities, nor with the social cognitive ability to ascribe a correct emotion state to others (Theory of Mind).

4.1 A first-person account of face perception

Despite that extensive experimental studies have shown deficient perception of faces in schizophrenia, there was little research using a first-person account of face-related perceptual experience by patients. The present study filled this gap via a survey of face perception quality in everyday life. Compared to an experimentally-determined assessment of face identity discrimination, self-report based assessment is subjective and may potentially be influenced by individual biases (Chen, Palafox et al. 1999; Skottun and Skoyles 2014), such as biasing to report more negatively about observations and experiences. Inclusion of reporting both negative and positive responses in self-report assessment may help to overcome this issue. In the questionnaire used in this study, items 1, 2, 3 and 6 were pertinent to negative face perception experiences whereas items 4 and 5 were pertinent to positive face perception experiences. The presence of group differences in responding to both negative (1 and 2) and positive item (5) suggests that such individual biases, if any, were similar in the two groups and did not affect the assessment of group difference in face perception experiences.

The lower scores of self-reported face perception questionnaire in patients indicate that in addition to the impairment in basic face perception assessed experimentally, the quality of their face-related everyday experience is also degraded substantially. In particular, patients more frequently pretended to know strangers to avoid awkwardness during social interactions (item 1), had difficulty in tracking characters through narrative media (item 2), and were less able to visualize faces of familiar people (item 5). These issues reflect a face perception problem across space and time, which presumably serves as a source of information for relevant aspects of social life. This problem is hardly characterized through psychophysical assessments of face perception. Thus, the first person account of face

perception should be included when developing therapeutic interventions to improve and evaluate face-related social functioning in this psychiatric disorder.

4.2 Basic face perception capacity and everyday face perception experience

The lack of association between patients' basic face identity discrimination capacity and face-related everyday experience (Figure 3) is remarkable. Basic face perception capacity presumably plays a supporting role in face-related perceptual experience. In this study, the result from healthy controls was congruent with this presumption, namely, the performance on face identity discrimination is moderately correlated with the score of the face perception questionnaire. The lack of such a correlation in patients suggests that the functional relationship between the processing of basic face information and everyday experience of faces is disrupted in this psychiatric disorder. The disrupted functional relationships between different levels of face perception are somewhat unexpected. Basic capacity of face processing such as face identity discrimination supports face-related functioning in everyday life. In prosopagnosia, for example, face perception impairments in basic perceptual levels (such as those assessed by objective measurements) and in ecological levels (such as those assessed by subjective measurements) are associated (DeGutis, Cohan et al. 2014), indicating a direct connection between these two levels of face perception impairments.

On the other hand, face perception impairments in different brain disorders may each have a distinct nature. Schizophrenia has been theorized as a brain disconnection disorder (Friston 1998; Andreasen 1999; Phillips and Silverstein 2003). One prediction from such a theory would be a disassociation between the functions mediated at different levels of information processing in the brain. To apply this prediction to face perception, a disassociation between the functioning at basic perceptual level and at ecological level would be expected in patients. In this context, the finding of dissociated face identity discrimination and face-related perceptual experience as well as theory of mind may reflect a disrupted functional connection between different levels of face perception and between face perception and relevant social cognition. To improve the quality of face-related social experience in patients, therapeutic efforts should gear not only toward basic face perception but also on its connection to ecological face perception.

Another possible reason for the lack of correlation between different levels of face perception can be related to memory. The psychophysical face perception task employed in this study used a brief temporal delay of 0.5 sec for comparison images, which involves minimal, if any, memory. The face perception questionnaire, on the other hand, involves remembering and recalling past experience with faces. Working memory deficit (on a time scale of seconds) and long-term memory deficit have been shown in schizophrenia (Park and Holzman 1992; Ragland, Cools et al. 2009). It is possible that different memory requirements contribute to the lack of correlation between the outcomes of the two face perception assessments in schizophrenia.

Still another possibility is that patients' cognitive difficulties such as poor mental imaging of faces may contribute to the lack of correlation between self-reported (requiring mental imaging) and psychophysical (not requiring mental imaging) results.

4.3 Face perception in everyday life and theory of mind

The significant correlation between face perception questionnaire and the Eye Test score in controls attests that the first person account of face perception is critical for this aspect of social cognitive functioning – attribution of emotion state to others. It has been shown that social cognition such as theory of mind involves a cortical network including Superior Temporal Sulcus (STS) (Saxe and Kanwisher 2003). STS is also active during gaze perception (Pelphrey, Singerman et al. 2003). As the face perception questionnaire surveys a broad range of face-related functions including perception of gazes, its association with theory of mind is expected. In patients, the lack of a correlation between the scores of the Eyes Test and the face perception questionnaire suggests a disruption of association between these two functional domains.

There were four patients who had a composite score of 17 or higher (very poor scores for the face perception survey assessment). This subgroup of patients had a moderately better eyes test score [80.5 (3.9)] than the rest of the patients [65.5 (15.6)]. The two groups of patients had similar perceptual thresholds for the psychophysical task [the 17 or higher group: 35.5 (28.4); the lower than 17 group: 41.9 (23.5)]. This pattern of results indicates that the few prosopagnosia-like schizophrenia patients have similar face-related perceptual and social cognitive capacities to other patients.

4.5 Face perception and clinical variables

In patients, the moderate but consistent correlations between face perception (both identity discrimination and questionnaire) and PANSS positive subscale suggests that the positive psychotic symptoms may be associated with the face perception problems. Note that Capgras delusion, evaluated in the face perception questionnaire (item 6), did not differ between the two groups. Yet, the scores of this item were correlated with face identity discrimination but only in controls, suggesting that in patients this face-related delusion is not associated with the basic face identity discrimination. One possible explanation is that the formation of this delusion lies at a higher level of cognitive process (Hemsley and Garety 1986) and the distortion in this delusion is mainly influenced by top-down, rather than bottom-up, signals.

The correlations between face identity discrimination and PANSS positive and negative scales, a result also found in a previous face perception study (Chen, Norton et al. 2009), suggests that impairments in the basic face perception capacity may play a role in these two aspects of psychosis. When compared with delusion symptom score (from the PANSS), a weak correlation with the face perception questionnaire score appears ($r=0.28$) and no correlation with the perceptual threshold of face identity discrimination ($r=0.001$). This result suggests that the subjective assessment of face perception may potentially be associated with the delusion symptoms. Further refinement of this assessment such as inclusion of items for facial emotion perception may confirm its value in predicting certain psychotic symptoms.

4.6 Limitations

Several limitations exist in the present study. First, the objective face perception assessment of this study focused on the discrimination of facial identity. Perception of facial emotion was not assessed explicitly either in subjective or objective measures. Facial emotion perception is presumably processed independently of facial identity discrimination (Bruce and Young 1986; Haxby, Hoffman et al. 2002). Yet, facial emotion perception is important for social functioning and experiences with facial expression may implicitly be incorporated in the face perception survey responses. If so, this factor may affect the relationship between self-reported facial perception and the psychophysical test result. Thus, future studies should design and compare subjective and objective assessments of facial emotion perception in schizophrenia. Second, the sample size of the present study was relatively small. Although significant group differences were found in both the subjective and objective assessments, the correlation between the two was moderate. Examining a larger sample size in future studies may increase the power to compare these two face perception assessments. Third, the present study evaluated the relationship between one aspect of face perception (identity discrimination) and one aspect of social cognition (theory of mind). Other aspects of face perception (such as gaze perception) also support social situations. Thus, subjective and objective assessments of these additional aspects of face perception in patients may further our understanding of face processing problem and develop ecologically validated tool to augment the assessment of face-related social functioning in everyday life (Pinkham, Penn et al. 2014). Fourth, this study uses only one objective face perception measure – perceptual threshold for face identity discrimination. It remains unclear whether other objective measures such as visual scanpath of faces (Loughland, Williams et al. 2002) are related to the subjective measures of face perception in schizophrenia. Further study should clarify this possibility.

4.7 Concluding remarks

Subjective (self-reported) and objective (psychophysical) assessments of face perception provide complementary information about face processing and its impairments. While psychophysical measurements define the capacity of basic face processing (discriminating different facial identities) and self-report questionnaire surveys the face-related experience in everyday life, the putative functional association between the two assessments appears to be disrupted in schizophrenia. Thus, both types of assessments are needed in order to fully characterize face perception and related perceptual experience in patients, and to develop more targeted therapies to improve the quality of social life for patients.

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Figure 1.
Schematic illustration of the psychophysical test paradigm

Figure 2.

Summary of the results from the psychophysical test. The x axis indicates groups (HC for healthy control and SZ for schizophrenia patient) and the y axis indicates perceptual thresholds. The filled bars represent the results including outliers and the open bars represent the results excluding outliers. Error bars indicates ± 1 standard error.

Figure 3.

Relationship between perceptual threshold and questionnaire score of face perception. The left panel is for controls and the right panel is for patients. The lower values of perceptual threshold and questionnaire score signify better face perception.

Figure 4. Relationship of the Eyes Test and face perception questionnaire. The left panel is for controls and the right panel is for patients. Higher values of Eye Test score signify better capacity of theory of mind whereas lower values of questionnaire score signify better face perception.

Table 1

Demographic information of sample (Means (Standard Deviations))

	Age (year)	Gender F:female; M:male	Eyes Test *
HC (n=25)	47.2 (15.8)	14 F, 11 M	75.1 (9.96)
SZ (n=35)	43.3 (13.9)	19 F, 16 M	66.6 (15.51)

* A significant group difference at $p < 0.05$.

Table 2
Summary scores from the face perception questionnaire (Mean (Standard Deviation))

	Item 1 [*] (+)	Item 2 [*] (+)	Item 3 (+)	Item 4 (-)	Item 5 [*] (-)	Item 6 (+)	Composite [*] (1)+(2)+(3) - (4) - (5) +(6)+12
HC	1.48 (0.77)	1.60 (0.71)	2.84 (1.34)	4.46 (0.96)	4.84 (0.47)	1.17 (0.56)	9.79 (2.89)
SZ	2.20 (1.16)	2.14 (1.03)	2.85 (1.16)	4.17 (1.17)	4.34 (0.94)	1.56 (1.02)	12.41 (2.66)

* A significant group difference (p<0.05)