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Perceptual bias of patients with schizophrenia in morphed facial expression

Jia Huang[a,b], **Raymond C.K. Chan**[a,b,*], **Jackie K. Gollan**[d], **Wenhua Liu**[c,e], **Zheng Ma**[f], **Zhanjiang Li**[f], and **Qi-yong Gong**[g]

[a]Neuropsychology and Applied Cognitive Neuroscience Laboratory, Institute of Psychology, Chinese Academy of Sciences, Beijing, China

[b]Key Laboratory of Mental Health, Institute of Psychology, Chinese Academy of Sciences, Beijing, China

[c]Faculty of Life Sciences, Sun Yat-Sen University, Guangzhou, China

[d]Department of Psychiatry and Behavioral Sciences, Northwestern University, Chicago, United States

[e]Faculty of Humanities and Social Sciences, Guangzhou Medical College, Guangzhou

[f]Beijing Anding Hospital, Capital Medical University, Beijing, China

[g]Huaxi MR Research Centre, Department of Radiology, West China Hospital / West China School of Medicine, Sichuan University, Chengdu, China

Abstract

Limited research has specifically examined the nature of the dysfunction in emotion categorization representation in schizophrenia. The current study aimed to investigate the perception bias of morphed facial expression in subjects with schizophrenia and healthy controls in the emotion continua. Twenty-eight patients with schizophrenia and thirty-one healthy controls took part in this study. They were administered a standardized set of morphed photographs of facial expressions with varying emotional intensities between 0% and 100% of the emotion, in 10% increments to provide a range of intensities from pleasant to unpleasant and approach to withdraw. Shift points, indicating the time point that the subjects' emotion identification begins to change, and response slopes, indicating how rapidly these changes have happened at the shift points in the emotion continuum, were measured. Patients exhibited a significantly greater response slope (i.e., patients' perception changed more rapidly) and greater shift point (i.e., patients still perceived mild expressions of anger as happy faces) with increasing emotion signal compared with healthy controls when the facial expression morphed from happy to angry. Furthermore, patients with schizophrenia still perceived mild expressions of fear as angry faces(a greater shift point) and were less discriminative from angry to fearful emotion(a flatter response slope). They were sensitive to sadness (a smaller shift point) and the perception changed rapidly (a sharper response slope) as compared with healthy controls in the emotion continuum of happy to sad. In conclusion, patients with schizophrenia demonstrated impaired categorical perception of facial expressions, with generally 'rapid' but 'late' discrimination towards social threat-related stimuli such as angry facial expression. Compared with healthy controls, these patients have a sharper discrimination perception pattern in the emotion continua from positive valence to negative valence.

*Corresponding author. Institute of Psychology, Chinese Academy of Sciences, 4A Datun Road, Beijing, China. Tel./fax: +86 10 64836274. rckchan@psych.ac.cn, rckchan2003@yahoo.com.hk (R.C.K. Chan). .

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Keywords

Emotion perception; Schizophrenia; Morphed facial expression

1. Introduction

Individuals with schizophrenia demonstrate consistent and pervasive difficulties in their ability to accurately perceive or decode universally recognized facial expressions of emotions(Morrison et al., 1988; Tremeau, 2006; Chan et al., 2008; Kohler et al., 2009). The difficulties in perceiving others' emotion might be associated with the underlying information processing dysfunctions in this clinical population (Gur et al., 2002; Chambon et al., 2006; Bediou et al., 2007).

Previous studies have suggested that schizophrenia have specific deficits in encoding or decoding other's emotion (Bediou et al., 2005). For example, patients with schizophrenia could respond quickly to certain negative emotions of fear and anger (Mandal et al., 1998). Evidence further suggested that patients with schizophrenia could also have spatial bias in response to the positively and negatively valence emotion chimeras (Gooding and Tallent, 2002). However, other studies suggest that schizophrenia might have general deficits in emotion processing because the deficits in emotion perception associated with the disorder are likely to involve the effective integration of emotion and cognition for adaptive functioning in areas such as goal-setting, motivation, and memory (Silver and Shlomo, 2001; Herbener et al., 2008) or attentional abilities (Bruce and Young, 1986; Penn et al., 2001; Combs et al., 2006, 2008). Johnston et al., 2001 suggested that a generalized deficits could explain the differential pattern of impairment in schizophrenia without having to postulate impairment of specific processing modules for negative emotion recognition (Johnston et al., 2001). The general emotion processing deficits could be due to the failure of limbic regions activation (Gur et al., 2002). Bilateral amygdale abnormalities were found in paranoid schizophrenia when probing with morphed dynamic facial expressions (Russell et al., 2007). One of the possible reasons for this controversy could be that schizophrenia individuals are unable to render accurate interpretations when the facial expressions show only subtle changes in eye and mouth positions (low valence)(Kington et al., 2000; Loughland et al., 2002; Zhu et al., 2007).

An alternative perspective to explain this controversy is that schizophrenia might be over-sensitive to some specific emotion salience and have general decoding (inferring) deficits when processing emotion. Specific perception modules were used when processing specific emotion valence. For example, fMRI study indicated that high risk individuals for psychosis exhibited stronger activation related to neutral faces relative to emotional faces in brain activations compared to control subjects, suggesting that these high risk individuals were prone to attribute salience to neutral stimuli (Seiferth et al., 2008).Empirical findings also suggest that schizophrenia patients not only have difficulty decoding facial expressions in general (Kerr and Neale, 1993) but also demonstrate emotion-specific deficits in perception because separate channels might be used for processing positive and negative emotions(Silver et al., 2002).

In order to further clarify the underlying reasons and enrich our understanding on the nature of the emotion perception deficits in schizophrenia, there are two issues, namely the specificity and sensitivity of emotion perception, that we should take into consideration (Schneider et al., 2006). The categorical emotion representation paradigm may enable us to examine more carefully on these two issues (de Gelder et al., 1997; Pollak and Kistler, 2002; Kee et al., 2006; Huang et al., 2009a, b). In the current study, we attempted to find out whether the differential response patterns of facial affect perception between patients with schizophrenia and healthy controls would be due to the perception threshold, the ability of inferring meanings or the perceiving sensitivity. For example, a sharper or shallower discrimination slope when the facial expression morphed from happy to anger. Therefore, the focus of this study was to investigate the discrimination accuracy of emotional stimuli in subjects with schizophrenia and healthy controls using a standardized set of photographs of facial expressions with varying emotional intensities. We would like to clarify the extent to which perception accuracy of a range of positive to negative facial expressions was affected by clinical status for some basic emotions, including happiness, sadness, fear, and anger. A female served as an example of each emotion, morphed to produce an expression between 0% and 100% of the particular emotion, in 10% increments to provide a range of intensities from pleasant to unpleasant, such as happy to angry and happy to sad (Aghevli et al., 2003), and approach to avoidance, such as angry to fearful (Cheung et al., 1997). Our primary questions focused on (a) will the schizophrenia group show a similar or a differential categorical perception threshold compared with normal controls? (b) to what extent do schizophrenia compared with normal controls show a response sensitivity in identifying negative facial affect with increasing emotional valence?

2. Method

2.1. Morphed emotional stimuli

The facial emotional images were created from a set of black and white photographs of Asian people, developed by Ekman & Friesen (Ekman and Friesen, 1976), which depict differing expressions, including happy, sad, fearful, and angry. Using a computer algorithm, the prototype photographs were morphed to create a linear continuum of eleven facial images between two endpoints (e.g. 0% happy and 100% happy). Each intermediate image was transformed by a 10% increment (shown in Fig. 1). Details of the morphing technique were provided in Pollak and Kistler (Pollak and Kistler, 2002). Three continuums (happy to sad, happy to angry, angry to fearful) were selected because they represent two basic dimensions: pleasant-unpleasant (i.e., happy to sad, happy to angry) and approach-avoidance (e.g. angry to fearful). The pleasant-unpleasant was subjective experience dimension of emotion (Aghevli et al., 2003) while the approach–avoidance was behavioral consequence dimension of emotion (Cheung et al., 1997). Use of facial expressions reflected a linear continuum between the prototypes of 100% angry and 100% fearful, 100% happy and 100% angry, and 100% happy and 100% sad. The middle faces were ambiguous images that combined features of both ends in half signal strength. For the present study, we created three continuums as follows:

2.2. Morphed emotion categorization representation task

Prior to testing, definitions of these emotions were presented on the screen to help subjects become familiar with them. As illustrated in Fig. 2, during testing, a facial image was presented in the middle of the screen with two different labels of emotion appearing beneath the image. The subjects selected the one emotion that best described the facial expression by pressing the ‘f’ button for the left label and ‘j’ button for the right label. Although there was no time limit for responses, subjects were prompted to respond as quickly as possible to maintain focus and approximate the real life timing of judgments. The facial image remained in view until a response was made. At the end of each trial, the subjects were told to rest their hands on the table before the next image appeared. Testing took between 20 and 30 minutes to complete. There were 33 facial stimuli (11 images within each of the 3 continua, with 1 female poser) that appeared as targets, each presented 8 times in random order, yielding a total of 264 trials. These trials were administered in two separate blocks of 132, separated by a rest period. For each continuum, we would record the proportion of correct identifications of the eleven signal strengths from one prototypical facial emotion to the other (signal strengths 1-11). The proportion of correct responses was expected to approach 100% near the two endpoints (e.g., 100% angry or 100% fearful) and to 50% of strength along the continuum where the facial expressions “switch” from one category to the other.

2.3. Subjects with schizophrenia

Twenty-eight inpatients with schizophrenia were recruited to this study. The Chinese version of the structural clinical interview of SCID for DSM-IV was administered to assess psychiatric diagnoses. Exclusion criteria included a history of head injury, illicit substance abuse, and co-morbid diagnoses. The clinical characteristics of these patients were summarized in Table 1. All of these patients were native Chinese. Two of them were ambidextral. Three of them were left-handed and twenty-three of them were right-handed. They were all on atypical antipsychotics. Mean dose of typical antipsychotic medication in CPZ equivalents (mg/day) were 380.69±222.01, SEM=42.73. Symptoms were assessed by Positive and negative syndrome scale (PANSS) within the same week of administrating emotion perception task so that the PANSS score should be the current symptom description of these patients.

2.4. Healthy controls

Thirty one subjects served as controls. Structured interview was used to confirm these healthy controls did not have psychiatric or neurologic disorders. These healthy volunteers (healthy controls) were recruited by advertisement on the internet. Informed consents were signed by all the participants in the healthy control group as well as the schizophrenia group. They matched the schizophrenia group in gender, age and education (Table 1). All the controls were native Chinese and were screened for personal or family history of schizophrenia by interview. Only one of them was left-handed and the rest were all right-handed.

2.5. Data analysis

We analyzed the data using the method described by Pollak and Kistler (Pollak and Kistler, 2002) in their study of abused and non-abused children. This approach involved fitting separate logistic function models for each emotion continuum to the data from each individual participant, deriving estimates of category shift points and slopes for each individual, and comparing group means on these parameters. However, visual inspection of the data suggested that a logistic model did not fit some patients in the happy-to-angry and happy-to-sad continuum (about 11%) and some patients in angry-to-fearful continuum (about 47%). The unfitness or invalid data could be due to the careless or randomly response selection of patients and should be excluded to avoid the data contamination. To ensure including valid data for further analysis, we calculated the increment for each signal strength interval in percent of correct responses and the data were judged by two independent raters. After we examined the data pattern for all the subjects, we had a discussion and reached a consensus that 0.4 would be a suitable cutoff. So we excluded the subjects’ data when their groups of increments were not significantly larger than 0 with p-value less than 0.4.

Thus, eighteen patients’ data were included in the angry-to-fearful continuum and twenty-three patients’ data were included in the happy-to-angry continuum and happy-to-sad continuum. They were all male patients. Table 2 illustrates the demographic characteristics of the patients being retained and excluded for the subsequent analysis for each emotion continuum.

Then we used the logistic function ($y=a+b/(1+e^{-[(x-c)/d]})$ (Pollak and Kistler, 2002) to fit the emotion categorization data in the retained subjects. In this equation, y=probability of identification, x=signal strength, a=lower asymptote, b=difference between upper and lower asymptotes, c=signal threshold at midpoint, d=slope, and e=exponential function. The "shift point"–signal threshold at midpoint (c) and the slope (d)–was the parameter we would estimate to characterize the emotion perception performance in the data analysis. The meaning of this parameter was the same as that described elsewhere (Kee et al., 2006). The "signal strength" is the angry emotion signal, increasing steadily in each morphed facial expression. In the current study, for example, in the emotion continua of "happy" to "angry", we regarded the "signal strength" in the "happy" facial expression as 1 and the "angry" facial expression as 11. The "signal strength" in other morphed facial expression between these two ends was an integer value between 1 and 11. The "shift point" is the point on the signal strength continuum at which the most likely choice of emotion shifts from "happy" to "angry". The "slope" indicates how abruptly this change happens. A high value for the slope indicates a clear and relatively abrupt shift from classifying photos as one specific emotion to another. A flatter slope indicates more ambiguity in the shift from one emotional pole to the other.

In the current study, we employed an asymptotic method to generate the mean and the standard error of two parameters, which was based on the 11 data points of the signal strength in each condition. The principle underlying the asymptotic method was to estimate the curve parameters making the curve close to the axles in unlimited way.

3. Results

Patients with schizophrenia were significantly different from healthy control both in shift point and slope (please see Table 3). The slope of patients with schizophrenia were lower than that of the healthy control in the angry to fearful continuum [$t(20)=-3.06$, $P<0.01$, Cohen's $d=-1.34$], but higher than that of the healthy control in both happy to angry continuum[$t(20)=8.92$, $P<0.001$, Cohen's $d=3.87$] and happy to sad continuum[$t(20)=9.79$, $P<0.001$, Cohen's $d=4.12$]. The smaller slope indicates the less sensitive towards the increasing intensity of facial expressions.

For the analysis of the shift points, patients with schizophrenia had a significantly higher shift point than the healthy control in the angry to fearful continuum[$t(20)=36.87$, $P<0.001$, Cohen's $d=15.59$], and in the happy to angry continuum[$t(20)=8.21$, $P<0.001$, Cohen's $d=3.50$], but a lower shift point in the happy to sad continuum[$t(20)=-10.72$, $P<0.001$, Cohen's $d=-4.55$]. A higher categorization threshold indicates the 'late' perception in the emotion continuum.

Fig. 3 illustrated the logistic data pattern in three emotion continua of patients with schizophrenia and healthy control based on their raw data.

4. Discussion

There is increasing support for the existence of erroneous information processing among individuals with psychiatric disorders that are measurable when identifying ambiguous emotional facial expressions. This study examined the group differences in discrimination accuracy of emotional stimuli among patients with schizophrenia compared with healthy controls. Using a standard method to generate the emotional stimuli, this study analyzed the shift points, which indicated when the subjects changed their judgments of emotion representation, and the slope, which indicated how rapidly these changes at the shift point occurred among three emotional continua comprised of positive and negative facial images across the two groups.

Our data showed that there was a differential response pattern between the patients with schizophrenia and healthy control because shift points in the assignment of emotional categories across the three emotional continua differ across groups. Specifically, when facial expressions shift from happy (positive) to angry (negative), subjects with schizophrenia tend to categorize angry expressions as happy, compared with the healthy control. Their perception of subtly negative stimuli is positive, which is incongruent with the stimuli valence and suggests a deficit of accurate categorization of emotional facial cues. Likewise, when the stimuli set initially presented angry (approach) and then shifted to fearful (avoidance), subjects with schizophrenia categorized the fearful expressions as angry compared to the healthy subjects. In the continuum from happy to sad, patients with schizophrenia tended to categorize the facial expression as sad rather than happy. This result provides further information for researchers to understand the cognitive impairment in specific emotions as previous study found (Silver et al., 2009). These responses may reflect a dysregulated affective organization that deviates from healthy responding to facial expressions. This finding might suggest that the deficits of patients with schizophrenia in perceiving emotion could be due to their insensitivity towards the increasing intensity of facial expressions, which was consistent with the previous study (Kohler et al., 2003).

The reason why patients with schizophrenia were less sensitive to the increasing intensity of facial expressions but would engage in some facial expressions once the emotion signal became evident could be due to several possibilities: First, when facial expressions shift from angry (approach) to fearful (avoidant), patients with schizophrenia tended to categorize avoidance signals as approach. One interpretation is that these individuals may be trying to avoid recognizing a social threat signal even in the context of threatening signals, but will ‘dwell on’ the social threat when it cannot be avoided. Supporting data could also be seen in the previous review (Green and Phillips, 2004). Previous findings suggested that anxiety-related attentional biases would vary over time—initial vigilance for high threat cues and followed by avoidance (Mogg et al., 2004). The current study replicates and extends this hypothesis in such a way that the perceptual bias of schizophrenia may vary over emotion intensity – patients would try to avoid perceiving the angry facial expression when it was subtle as manifested in greater shift point and then become highly vigilant to the angry expression as manifested in greater slope. Second, from an emotion regulation perspective, it is possible that, in comparison to healthy controls, subjects with schizophrenia initially underestimate the negative or distressing facial images to limit or distract themselves from the greater negative affect that may be evoked. The current result supports the emotion regulation model proposed by Gross in 1998 that one would move attention away from the negative emotion-eliciting stimulus at the early emotion regulation process (Gross, 1998, 2002). Inactivation of the negativity bias permits the individual to reduce physiological arousal as previous study found increased physiological response in schizophrenia was limited to those with positive emotional content (Hempel et al., 2005). Further evidence should be provided later to have more exploration on the emotion regulation mechanism of schizophrenia.

This data may reveal that schizophrenia subjects engage negative stimuli when it reaches a certain valence threshold (Gooding and Tallent, 2002). In comparison to healthy controls, schizophrenia subjects may endorse lower negativity bias as part of a response strategy: They react to stimuli and select choices that regulate perception of threat. These individuals provide a unique response set as they are attuned to decreasing the valence of the negative facial expression to regulate affect. The current findings may shed light on how patients with schizophrenia regulate their affect when they came across negative stimuli by investigating their perceptual bias in emotion categorization in morphed facial expression. This may be helpful for us to develop any potential intervention for the social-cognitive remediation for schizophrenia. In doing so, we may re-direct their attention to avoid the perceptual bias as previous study has suggested (Russell et al., 2008).

One of the limitations in the current study was the exclusion of invalid data from clinical patients. This would more or less reduce the power of the analysis though the function model might be robust and should not be influenced by individual data too much (Kee et al., 2006). Moreover, we only recruited the inpatients and the groups were not matched for gender. Inpatients might be more impaired than outpatients. Samples with more male controls might be associated with lesser impairment in facial emotion perception in schizophrenia according to a previous meta-analysis study (Kohler et al., 2009). Further studies should recruit outpatients with a balanced gender proportion in the near future.

In summary, the current study was important in demonstrating the specific differential response patterns in schizophrenia. Notably, patients with schizophrenia demonstrated impaired categorical perception of facial expressions, with generally ‘rapid’ or ‘late’ discrimination in the continua of angry to fearful and happy to angry. Compared with the healthy controls, patients with schizophrenia have a different categorical perception pattern in the emotion continua from happy to sad and similar pattern in the emotion continua from angry to fearful and happy to angry.

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References

Aghevli M, Blanchard J, Horan W. The expression and experience of emotion in schizophrenia: a study of social interactions. Psychiatry Research. 2003; 119:261–270. [PubMed: 12914897]

Bediou B, Franck N, Saoud M, Baudouin J-Y, Tiberghien G, Dal y J, d’Amato T. Effects of emotion and identity on facial affect processing in schizophrenia. Psychiatry Research. 2005; 133:149–157. [PubMed: 15740991]

Bediou B, Henaff MA, Bertrand O, Brunelin J, d’Amato T, Saoud M, Krolak-Salmon P. Impaired fronto-tempora processing of emotion in schizophrenia. Clinical Neurophysiology. 2007; 37:77–87. [PubMed: 17540290]

Bruce V, Young A. Understanding face recognition. British Journal of Clinical Psychology. 1986; 77:305–327.

Chambon V, Baudouin JY, Franck N. The role of configural information in facial emotion recognition in schizophrenia. Neuropsychologia. 2006; 44:2437–2444. [PubMed: 16806310]

Chan CCH, Wong R, Wang K, Lee TMC. Emotion recognition in Chinese people with schizophrenia. Psychiatry Research. 2008; 157:67–76. [PubMed: 17928068]

Cheung P, Schweitzer I, Crowley K, Tuckwell V. Violence in schizophrenia: role of hallucinations and delusions. Schizophrenia Research. 1997; 26:181–190. [PubMed: 9323349]

Combs DR, Tosheva A, Penn DL, Basso MR, Wanner JL, Laib K. Attentional-shaping as a means to improve emotion perception deficits in schizophrenia. Schizophrenia Research. 2008; 105:68–77. [PubMed: 18585899]

Combs DR, Tosheva A, Wanner J, Basso MR. Remediation of emotion perception deficits in schizophrenia: The use of attentional prompts. Schizophrenia Research. 2006; 87:340–341. [PubMed: 16809024] de Gelder B, Teunisse J-P, Benson PJ. Categorical perception of facial expressions: categories and their internal structure. Cognition & Emotion. 1997; 11:1–23.

Ekman, P.; Friesen, W. Photographs of facial affect recognition test. Consulting Psychologists Press; Palo Alto: 1976.

Gooding DC, Tallent KA. Schizophrenia patients' perceptual biases in response to postively and negatively valenced emotion chimeras. Psychological Medicine. 2002; 32:1101–1107. [PubMed: 12214789]

Green MJ, Phillips ML. Social threat perception and the evolution of paranoia. Neuroscience & Biobehavioral Reviews. 2004; 28:333–342. [PubMed: 15225975]

Gross J. The emerging field of emotion regulation: An integrative review. Review of General Psychology. 1998; 2:271–299.

Gross J. Emotion regulation: Affective, cognitive, and social consequences. Psycho-physiology. 2002; 39:281–291.

Gur RE, McGrath C, Chan RM, Schroeder L, Turner T, Turetsky BI, Kohler C, Alsop D, Maldjian J, Ragland JD, Gur RC. An fMRI study of facial emotion processing in patients with schizophrenia. American Journal of Psychiatry. 2002; 159:1992–1999. [PubMed: 12450947]

Hempel RJ, Tulen JHM, van Beveren NJM, van Steenis HG, Mulder PGH, Hengeveld MW. Physiological responsivity to emotional pictures in schizophrenia. Journal of Psychiatric Research. 2005; 39:509–518. [PubMed: 15992560]

Herbener ES, Song W, Khine TT, Sweeney JA. What aspects of emotional functioning are impaired in schizophrenia? Schizophrenia Research. 2008; 98:239–246. [PubMed: 17689054]

Huang J, Chan R, Lu X, Tong Z. Emotion categorization perception in schizophrenia in conversations with different social contexts. Australian and New Zealand Journal of Psychiatry. 2009a; 43:438–445. [PubMed: 19373705]

Huang J, Chan RCK, Lu X, Tong Z. Emotion categorization perception in schizophrenia in conversations with different social contexts. Australian and New Zealand Journal of Psychiatry. 2009b; 43:438–445. [PubMed: 19373705]

Johnston P, Katsikitis M, Carr V. A generalised deficit can account for problems in facial emotion recognition in schizophrenia. Biological Psychology. 2001; 58:203–227. [PubMed: 11698115]

Kee KS, Horan WP, Wynn JK, Mintz J, Green MF. An analysis of categorical perception of facial emotion in schizophrenia. Schizophrenia Research. 2006; 87:228–237. [PubMed: 16859896]

Kerr SL, Neale JM. Emotion perception in schizophrenia: Specific Deficit or Further Evidence of Generalized Poor Performance? Journal of Abnormal Psychology. 1993; 102:312–318. [PubMed: 8315144]

Kington JM, Jones LA, Watt AA, Hopkin EJ, Williams J. Impaired eye expression recognition in schizophrenia. Journal of Psychiatric Research. 2000; 34:341–347. [PubMed: 11104848]

Kohler CG, Turner T, Bilker W, Brensinger C, Siegel S, Kanes S, Gur RE. Facial emotion recognition in schizophrenia: intensity effects and error pattern. American Journal of Psychiatry. 2003; 160:1768–1774. [PubMed: 14514489]

Kohler CG, Walker JB, Martin EA, Healey KM, Moberg PJ. Facial Emotion Perception in Schizophrenia: A Meta-analytic Review. Schizophrenia Bulletin. 2009 doi:10.1093/schbul/sbn192.

Loughland CM, Williams LM, Gordon E. Visual scanpaths to positive and negative facial emotions in an outpatient schizophrenia sample. Schizophrenia Research. 2002; 55:159–170. [PubMed: 11955975]

Mandal MK, Pandey R, Prasad AB. Facial Expressions of Emotions and Schizophrenia: A Review. Schizophrenia Bulletin. 1998; 24:399–412. [PubMed: 9718632]

Mogg K, Bradley BP, Miles F, Dixon R. Time course of attentional bias for threat scens: Testing the vigilance-avoidance hypothesis. Cognition & Emotion. 2004; 18:689–700.

Morrison RL, Bellack AS, Mueser KT. Deficits in facial-affect recognition and schizophrenia. Schizophrenia Bulletin. 1988; 14:67–83. [PubMed: 3291095]

Penn, DL.; Combs, DR.; Mohamed, S. Social cogntion and social functioning in schizophrenia. In: Corrigan, P.W., Penn, D.L. (Eds.), Social cognition in schizophrenia. APA Press; Washington, DC: 2001. p. 97-121.

Pollak SD, Kistler DJ. Early experience is associated with the development of categorical representations for facial expressions of emotion. Proceedings of the National Academy of Sciences of the United States of America. 2002; 99:9072–9076. [PubMed: 12072570]

Russell T, Reynaud E, Kucharska-Pietura K, Ecker C, Benson P, Zelaya F, Giampietro V, Brammer M, David A, Phillips M. Neural responses to dynamic expressions of fear in schizophrenia. Neuropsychologia. 2007; 45:107–123. [PubMed: 16814818]

Russell TA, Green MJ, Simpson I, Coltheart M. Remediation of facial emotion perception in schizophrenia: Concomitant changes in visual attention. Schizophrenia Research. 2008; 103:248–256. [PubMed: 18565733]

Schneider F, Gur R, Koch K, Backes V, Amunts K, Shah N, Bilker W, Gur R, Habel U. Impairment in the specificity of emotion processing in schizophrenia. American Journal of Psychiatry. 2006; 163:442. [PubMed: 16513865]

Seiferth NY, Pauly K, Habel U, Kellermann T, Shah JN, Ruhrmann S, Kolsterkotter J, Schneider F, Kircher TT. Increased neural response related to neutral faces in individuals at risk for psychosis. NeuroImage. 2008; 40:289–297. [PubMed: 18187342]

Silver H, Bilker W, Goodman C. Impaired recognition of happy, sad and neutral expressions in schizophrenia is emotion, but not valence, specific and context dependent. Psychiatry Research. 2009; 169:101–106. [PubMed: 19692127]

Silver H, Shlomo N. Perception of facial emotions in chronic schizophrenia does not correlate with negative symptoms but correlates with cognitive and motor dysfunction. Schizophrenia Research. 2001; 52:265–273. [PubMed: 11705720]

Silver H, Shlomo N, Turner T, Gur RC. Perception of happy and sad facial expressions in chronic schizophrenia: Evidence for two evaluative systems. Schizophrenia Research. 2002; 55:171–177. [PubMed: 11955976]

Tremeau F. A review of emotion deficits in schizophrenia. Dialogues in Clinical Neuroscience. 2006; 8:59–70. [PubMed: 16640115]

Zhu C-Y, Lee TMC, Li X-S, Jing S-C, Wang Y-G, Wang K. Impairments of social cues recognition and social functioning in Chinese people with schizophrenia. Psychiatry and Clinical Neurosciences. 2007; 61:149–158. [PubMed: 17362432]

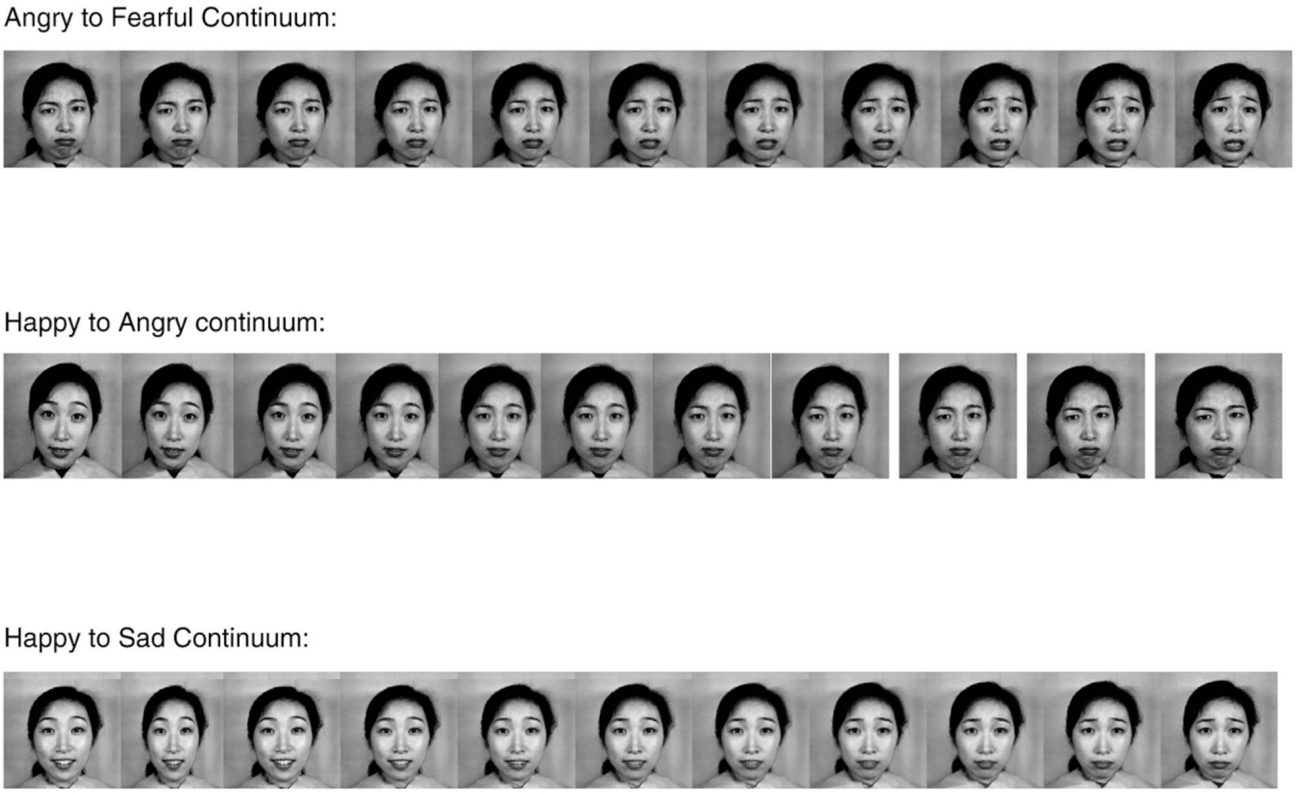

Fig. 1.
Facial images between the prototypes of 100% angry to 100% fearful, 100% happy to 100% angry, 100% happy to 100% sad. The middle faces are ambiguous images that combine features of both two ends in half signal strength.

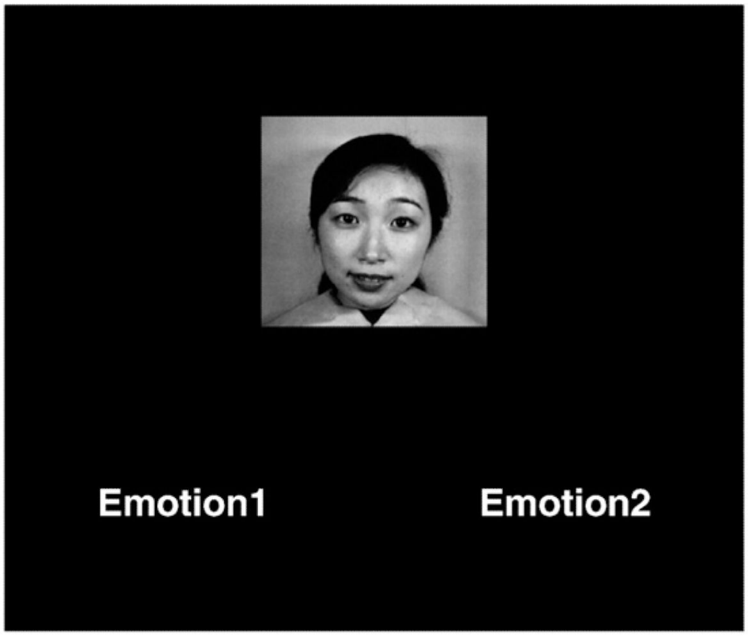

Fig. 2.
Trial illustration in categorical emotion representation paradigm.

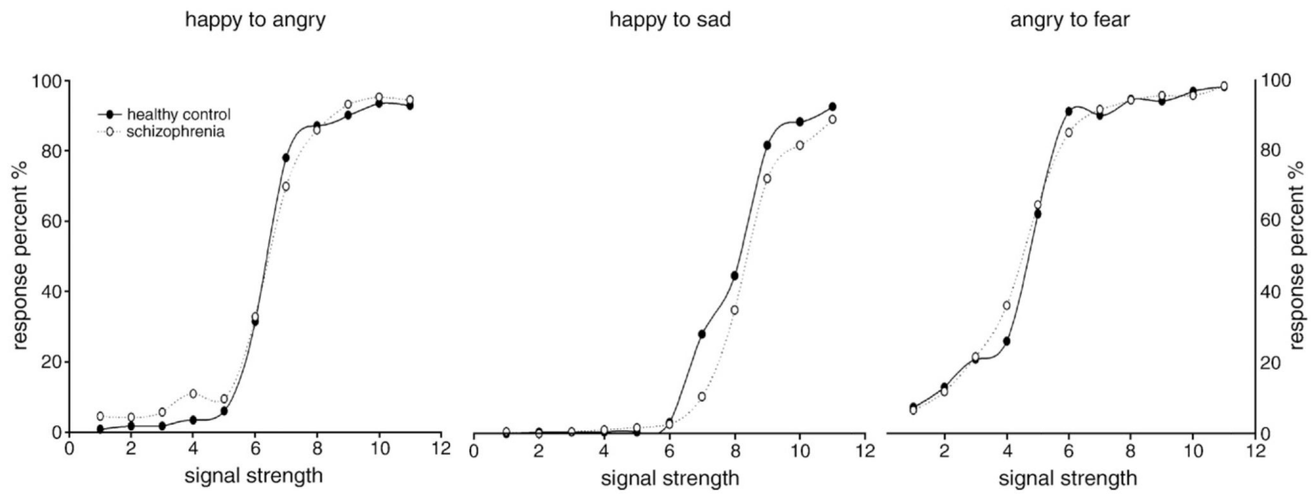

Fig. 3.
Three emotion continua of two groups. Note: ‘Signal strength’ means the ‘angry’ expression signal in happy-to-angry continuum, ‘sad’ expression signal in happy-to-sad continuum, ‘fear’ expression signal in ‘angry-to-fear’ continuum. Response percent means the all photos each signal strength in the group were collapsed into a summary score representing the proportion of times the photo was classified into the higher (right-end) emotional category.

Table 1

Demographic characteristics of schizophrenia, healthy controls.

	Schizophrenia (n = 28)	Healthy control (n = 31)	t-value
Age (years)	34.89(11.82)	30.16(12.02)	t(65) = 1.16, n.s.
Education (years)	11.61(2.62)	11.73(3.28)	t(65) = 0.049, n.s.
WAIS-R, estimated IQ	101.32(20.91)	106.10(17.86)	t(65) = −0.914, n.s.
Gender (m/f), n	28:0	27:4	χ^2 = 3.876, P = 0.049
Illness duration (years)	12.31(8.69)		
PANSS			
Positive symptom	13.24(5.90)		
Negative symptom	15.52(6.14)		
General symptom	28.84(6.33)		
PANSS total score	57.60(13.52)		

Values are given as mean (standard deviation), or n.

n.s.: non-significant.

Table 2

Demographic characteristics of patients with schizophrenia retained and excluded for the slope and shift points analysis in three emotion continua.

Angry to fear continuum	**Patients retained**		**Patients excluded**	
	Mean(std)	**range**	**Mean(std)**	**range**
Age (years)	35.0(12.08)	37.00	34.7(11.98)	36.00
Education (years)	12.17(2.18)	7.00	10.6(3.13)	10.00
Illness duration (years)	13.03(9.22)	26.42	22.0(11.00)	22.00
WAIS-R, estimated IQ	104.28(20.66)	65	96.00(21.35)	57
CPZ(mg/day)	403.72(198.75)	711.16	341.54(263.54)	907.00
PANSS				
Positive symptom	12.38(3.98)	15.00	14.78(8.41)	24.00
Negative symptom	14.88(6.51)	22.00	16.67(5.59)	16.00
General symptom	27.19(5.44)	17.00	31.78(7.05)	23.00
PANSS total score	54.44(11.01)	43.00	63.22(16.28)	54.00
Happy to angry continuum				
Age (years)	34.73(12.28)	37	35.5(10.48)	26
Education (years)	11.73(2.45)	9	11.7(3.37)	10
Illness duration (years)	11.8(8.99)	26.42	14.17(7.96)	23
WAIS-R, estimated IQ	102.00(21.3)	69	98.83(21.10)	49
CPZ(mg/day)	387.08(251.55)	945.16	358.33(49.16)	100
PANSS				
Positive symptom	11.81(3.76)	15	20.75(9.74)	20
Negative symptom	15.43(6.02)	22	16.00(7.70)	16
General symptom	27.33(5.30)	20	36.75(5.85)	13
PANSS total score	54.57(10.73)	48	73.5(17.10)	35
Happy to sad continuum				
Age (years)	34.27(11.77)	37	37.17(12.83)	29
Education (years)	11.55(2.26)	9	11.83(3.92)	10
Illness duration (years)	11.80(8.99)	26.42	14.17(7.96)	23
WAIS-R, estimated IQ	100.91(20.78)	69	102.83(23.30)	49
CPZ(mg/day)	391.84(250.76)	945.16	341.67(49.16)	100
PANSS				
Positive symptom	11.55(3.66)	15	20(8.60)	20
Negative symptom	15.85(5.85)	21	14.2(7.79)	17
General symptom	27.3(5.44)	20	35(6.40)	15
PANSS total score	54.7(10.99)	48	69.2(17.66)	39

Values are given as mean (standard deviation), or n.

Table 3

Slopes and shift points of two groups for each continuum.

	Schizophrenia	**Control**	**t-test (df)**	**Cohen's *d***
Slope				
Angry to fearful	0.84(0.09)	0.99(0.13)	t(20) = −3.06**	−1.34
Happy to angry	0.84(0.08)	0.53(0.08)	t(20) = 8.92***	3.87
Happy to sad	1.12(0.08)	0.81(0.07)	t(20) = 9.79***	4.12
Shift points				
Angry to fearful	6.51(0.11)	4.46(0.15)	t(20) = 36.87***	15.59
Happy to angry	8.52(0.84)	6.43(0.09)	t(20) = 8,21***	3.50
Happy to sad	4.45(1.12)	8.06(0.08)	t(20) = −10.72***	−4.55

Values are given as mean (standard deviation).

Since the mean and std were generated on the basis of 11 data points in each group, degrees of freedom should be calculated as : df = n1 + n2−2 = 11+11−2 = 20.

** $P<0.01$,

*** $P<0.001$.