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Masked ambiguity – Emotion identification in schizophrenia and major depressive disorder

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ABSTRACT

Both patients with schizophrenia and with a major depressive disorder (MDD) display deficits in identifying facial expressions of emotion during acute phases of their illness. However, specific deficit patterns have not yet been reliably demonstrated. Tasks that employ emotionally ambiguous stimuli have recently shown distinct deficit patterns in patients with schizophrenia compared to other mental disorders as well as healthy controls. We here investigate whether a task which uses an ambiguous Japanese (Noh) mask and a corresponding human stimulus generates distinctive emotion attribution patterns in thirty-two Caucasian patients with schizophrenia, matched MDD patients and healthy controls. Results show that patients with schizophrenia displayed reaction time disadvantages compared to healthy controls while identifying sadness and anger. MDD patients were more likely to label stimuli with basic compared to subtle emotional expressions. Moreover, they showed more difficulties assigning emotions to the human stimulus than to the Noh mask. IQ, age and cognitive functioning did not modulate these results. Because overall group differences were not observed, this task is not suitable for diagnosing patients. However, the subtle differences that did emerge might give therapists handles that can be used in therapy.

1. Introduction

Specific impairments in patients with schizophrenia have been identified in tasks that employ the identification of emotions diverging from prototypical, basic expressions of emotion (Burch, 1995), such as subtle (Tremeau et al., 2015) and ambiguous emotions (Ketteler et al., 2012; Tsui et al., 2013). Tasks that use facial stimuli with (morphed) faces showing different degrees of emotional intensity have been proposed to aid the identification of differential deficits because of their ambiguous nature, leaving some room for a different interpretation (Huang et al., 2011; Moritz et al., 2012). However, apart from a few exceptional studies, conventional emotion identification tasks employ full-strength emotional expressions which might be identified more easily than ambiguous (Tsui et al., 2013) or more subtle emotion expressions (Tremeau et al., 2015) and thus yield ceiling effects.

Emotion recognition deficits may relate to the specific symptomatology of patients with schizophrenia and, including ideas of reference (Frith, 2004) may presumably lead to an interference of symptoms with emotion identification, e.g., the disturbance of cognitive processing of emotions due to hallucinations or thought disorders (Park et al., 2011). Moreover, disorganized symptoms have been found to correlate with lower abilities to identify negative emotions (Comparelli et al., 2014). These findings are in line with the findings of studies demonstrating that patients with schizophrenia have deficits identifying negative emotions (Bell et al., 1997) and thus tend to perceive ambiguous emotions as more positive (Tsui et al., 2013). However, studies on facial emotion recognition in schizophrenia observed an interpretation bias toward negative emotions in patients with paranoid symptoms (Pinkham et al., 2011). Further, other work showed that patients with schizophrenia and concurrent depression recognized sadness more

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accurately compared to those patients with no additional depressive symptoms (Herniman et al., 2017). This is in line with findings that have reported a bias toward negative emotions in patients with an MDD (Hale, 1998). Ventura et al. (2013b) found negative associations between emotion recognition abilities and reality distortion, negative symptoms and disorganization. Finally, another study on patients with schizophrenia, divided by their either positive or negative symptoms in comparison to healthy controls, observed a recognition bias toward positive emotional expressions in patients with predominantly positive symptoms and a generalized emotion recognition deficit in negative symptom schizophrenia (Mandal et al., 1999). Thus, the literature is not conclusive regarding the putative emotion processing deficits on explicit, prototypical facial expressions. As expressions in daily life are hardly ever as clear and unambiguous as the prototypes used in the laboratory (Kret, 2015), we here propose to use an alternative paradigm to shed some new light onto this discussion.

Minoshita and colleagues (1999) introduced a novel paradigm, the Noh mask test, which demands the identification of ambiguous emotions. The stimuli consist of photos of a female wooden mask, taken from the Japanese Noh theatre (for examples of the stimuli see **Supplement 1**). Making use of differences in lighting and flipping angle (Kawai et al., 2013), the mask displays changing emotional expressions, thus creating ambiguity (Miyata et al., 2012). On this task, Japanese patients with schizophrenia showed an emotion identification pattern different from that of healthy controls, including a reduced sensitivity to negative emotions (Minoshita et al., 2005). As the Noh mask represents a single non-human object, the stimulus material is homogeneous and biases due to subjective feelings toward the face models are reduced (Yrizarry et al., 1998). Moreover, in the context of an unfamiliar cultural group (out-group), emotion identification is generally more difficult (Adams et al., 2010) while subcategories of emotions are identified more easily in members of the own cultural group (Russell, 1991). The Noh mask with its out-group features creates a homogeneous, ambiguous emotional stimulus, which might therefore serve as a beneficial instrument for the diagnosis of schizophrenia, e.g. in the early stages of the illness. Moreover, its more dynamic approach with different view angles might be beneficial, as it has been shown that manipulations of viewing perspectives, e.g. presenting in peripheral visions (Goren and Wilson, 2006), compromises the identification of emotions. Studies directly comparing patients with schizophrenia and affective disorders are rare. One study, however, is particularly informative in this respect. In this study, in which the Noh mask test was given to healthy German volunteers (Koelkebeck et al., 2015), a bias towards positive emotions over all participants was shown. However, there were also reaction time disadvantages present on the Noh mask test as compared to standard emotion identification tasks in healthy participants with relatively high alexithymic and anxious traits. Whether these findings would be amplified in clinical patients is still an open question. In this respect, general reaction time slowing (Braff, 1993) and deficits in emotion perception in patients with schizophrenia in comparison to healthy controls have also been shown (Baudouin et al., 2002; Belge et al., 2017). A pattern of reaction time slowing has also been found in patients with schizophrenia with an additional affective flattening (Suslow et al., 2003), but see Derntl et al. (2012).

In the current study, the Noh mask test will be used to investigate potential deficits in the perception of ambiguous expressions of emotion in schizophrenia and major depressive disorder (MDD) patients in comparison to healthy controls. We expect that this task will allow us to tap into these deficits better than conventional tasks and help to solve the ambiguity in the literature. With our study, we aim to validate several hypotheses. We predict that patients with schizophrenia have an overall reaction time slowing as compared to both patients with an MDD and healthy controls. We moreover hypothesize that this effect would be more prominent in the Noh mask stimuli than in a condition involving human Asian faces. We furthermore predict that patients with schizophrenia would show a bias toward positive emotional expressions. In patients with an MDD, we hypothesize a bias toward negative emotions. In healthy controls, we expect an overall general positive bias regarding the Noh masks. In addition, we investigate individual differences in cognitive functioning (Ventura et al., 2013a), IQ (Andric et al., 2016) and age (West et al., 2012) and their putative modulatory effects on task performance.

2. Materials and methods

2.1. Participants

All patients were recruited from the Department of Psychiatry and Psychotherapy of the University of Muenster. In total, 115 participants were assessed. Due to high scores in the Beck Depression Inventory (BDI-r; Beck et al., 1961) (patients with schizophrenia > 19 points (cut-off: medium severity), healthy controls > 9 points (cut-off: mild severity)), concurrent Structured Clinical Interview (SCID; APA, 1994) diagnoses, severe neuropsychological abnormalities or an Asian background, eleven patients with schizophrenia, two patients with an MDD and six healthy controls had to be excluded. The final sample consisted of 32 in- and out-patients diagnosed with schizophrenia or psychotic spectrum disorder, 32 patients with an MDD and 32 physically and mentally healthy German residents matched on age, gender and education. All participants completed the BDI and the Montgomery-Asberg Depression Rating Scale (MADRS; Montgomery and Asberg, 1979). Both patient groups were assessed with the Clinical Global Impression (CGI; Guy, 1976) and the Global Assessment of Functioning (GAF; APA, 1987) instruments and patients with schizophrenia were additionally assessed on the Positive and Negative Syndrome Scale (PANSS; Kay et al., 1987). Diagnoses were made according to the DSM IV criteria as assessed by a trained and experienced interviewer with the SCID I interview. All data presented in the following refer to the final sample of participants.

Diagnoses included paranoid (n = 19), disorganized (n = 2), residual (n = 3) and undifferentiated schizophrenia (n = 2) as well as schizoaffective disorder (n = 6). All patients with schizophrenia or psychotic spectrum disorder were treated with antipsychotic medication. Two patients received lorazepam and one patient diazepam. Benzodiazepine treatment, however, was restricted to a maximum of 5 mg diazepam or 1 mg lorazepam prior to 48 hours before the testing. For details on medication, see **Supplement 2**.

Patients with depression were not included if they had a previous treatment with electroconvulsive therapy. Diagnoses included a single depressive episode of medium severity (n = 1) as well as recurrent depressive episodes with medium (n = 18) and severe characteristics (n = 13). All patients were treated with antidepressant medication. One patient was treated with 1 mg lorazepam. For details on medication, see **Supplement 2**.

All patients were clinically stabilized during the time of the testing and within the age of 18–55 years. Participants with any history of other psychiatric disorders, neurological or severe internal medical disorders, serious head injuries, acute alcohol or illegal drug abuse or dependence were not included in the study. Healthy controls were not included if they reported a present or a previous mental disorder or a first-grade relative with a mental disorder. None of the participants had ever seen the Noh mask stimulus before or were engaged in Japanese or other Asian culture. The visual acuity of all participants was sufficient for participation in the study and all had good command of the German language.

Written informed consent was obtained from all participants. The design of this study was approved by the Ethics Committee of the University of Muenster and the Westphalian State Chamber of Physicians (2013-104-f-S). The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and

with the Helsinki Declaration of 1975, as revised in 2008 (https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/; last access to all websites October 27, 2018).

2.2. Procedure and apparatus

All computer-assisted tasks were presented on a notebook using the program Inquisit 4 (http://www.millisecond.com/). First, color photographs of a painted wooden female mask were presented to participants (Minoshita et al., 2005; see **Supplement 1** for examples). The photos showed the mask in nine different inclination angles, eight tilted in angular degrees of 10 (10°−40°) up (u)- and downwards (d) on the vertical line as well as one photo showing a full-frontal view of the mask. In addition, we used a set of nine photos of a tilted neutral Japanese female face (10°, 20°, 25°, 30° up- and downward, one frontal view; please refer to Lyons et al. (2000); see **Supplement 1** for examples). For each photo, participants were asked to consider one out of ten emotion expressions (e.g., "does this person look sad?"). Five basic emotions (sad, angry, fearful, disgusted, happy) and five subcategories or subtle emotions (gloomy, relaxed, shy, startled, apathetic) were presented in written form for 500 ms. Participants were to answer spontaneously "yes" or "no" with a digital key press and were, after six seconds, reminded to answer. Ten blocks (i.e., different emotion expressions) were presented with nine trials (i.e., different inclination angles of the Noh mask and Japanese female face) each, with a short break after 90 trials. All stimuli were presented in random order. In total, 180 trials were presented. Prior to the session, two additional blocks served as practice trials to introduce the task to patients, using Noh masks and Japanese female faces not included in the main task, which presented two additional emotions (hope, ecstasy). After each trial, a pixelated distractor in gray scale was shown. For both tasks, reaction times (in ms) as well as the rates of confirmation of the emotion expression was recorded. The performance duration on the computer-assisted task was about 10–15 min, depending on the condition of the participant.

2.3. Questionnaires, psychopathology ratings and cognitive tests

Participants completed the Empathy Quotient (EQ; Baron-Cohen and Wheelwright, 2004), which is a 60-item questionnaire that measures empathic abilities with a four-point response format (from "I strongly agree" to "I strongly disagree"). Moreover, the Toronto Alexithymia Scale (TAS-26; Taylor et al., 2003), a self-report instrument that detects difficulties in identifying (subscale 1) and describing (subscale 2) emotions and a tendency to externally focus attention (subscale 3) was used. It presents 26 items which have to be answered on a five-point scale (from "1 = certainly does not apply to me" to "5 = certainly does apply to me"). To characterize participants by their cognitive functioning, we assessed crystallized intelligence by means of the Multiple Choice Vocabulary Intelligence Test (MWT-B; Lehrl, 2005). The Trail-Making Test (TMT A and B; Reitan, 1958) was used as a cognitive flexibility measure assessing visual attentional abilities and processing speed as well as executive functioning. Lastly, clinical (e.g., medication) and social (e.g., education) data were assessed.

2.4. Statistical analyses

All data were processed with IBM SPSS Statistics 25.0. There were two dependent variables: (1) Reaction times; (2) Emotion Confirmation. For the analysis of these dependent variables we used a multilevel mixed model for nested data with trials (180) nested in subjects (96) (see also Kret and de Gelder, 2013; Kret and de Dreu, 2013). Fixed factors included Experimental Condition (2: Noh Mask; Japanese Female Face), Emotion Category (2: Basic Emotion; Subtle Emotion), Group (3: Schizophrenia; MDD; Control Group) and their interactions. This multi-level method allows for the inclusion of all data without first having to average unique datapoints over trials (and losing important variance in the data). Thus, each single datapoint (reaction time or emotion confirmation on a single trial) was fed into the analysis. Moreover, this method has the advantage of including a random intercept per subject, accounting for individual variability in the responses. Starting from a full model, non-significant factors were excluded one by one, beginning with three-way interactions until the most parsimonious, best-fitting model was reached. This bottom-up and data-driven approach is especially preferred because of the large inconsistencies in findings that have been described in the literature. For example, instead of conducting a repeated measures ANOVA where the researcher predetermines the design of the statistical model, our model-selection procedure allows the data more room to speak for itself and enables the researcher to select the model that best fits the data. Still, the model will never be able to explain all of the variance that is present in the data and, as a consequence, will never be perfect. For that reason and since for the computation of an effect size one assumption is that the statistical model is (impossibly) a perfect fit, effect sizes cannot be computed with this procedure.

Prior to analysis, **reaction times** were filtered to exclude extreme responses exceeding 8.000 ms, which led to the exclusion of 0.08% of all trials. For the analysis of reaction times, a gamma distribution was used to allow for the skewness of the data (skewed, non-normal data is typical for reaction times). In a first generalized mixed model, we aimed to predict reaction times by including the fixed factors Group (Schizophrenia; MDD; Control Group), Condition (Noh Mask; Japanese Female Face), Emotion Type (Basic Emotion; Subtle Emotion) and their interactions. We used this latter emotion categorization in consistence with previous studies using the Noh mask, where a difference was made between subtle and basic emotion (Minoshita et al., 1999, 2005). However, in a follow-up analysis we also analyze the effects of the ten unique expressions (sad, angry, fearful, disgusted, happy, gloomy, relaxed, shy, startled, apathetic). The follow-up simple contrasts were adjusted for multiple comparisons using Fisher's Least Significant Difference Test, also known as LSD.

For the analysis of **confirmation rates**, a binary distribution function (0 = no; 1 = yes) was chosen. For the rest, the statistical procedure was identical to the procedure regarding the reaction times. As the first model of the confirmation rates did not show any interaction effect of Emotion Type (Basic Emotion and Subtle Emotion) and Group, we did not follow this model up with a model that included all ten emotions.

For the analysis of **questionnaire and social data**, χ^2*-tests* or *Mann-Whitney-U tests* were used where appropriate.

As the main focus of the study was the investigation of differences between patients with schizophrenia, MDD and healthy controls, we only report significant effects involving factors that include "Group" in the analyses below. All other effects are reported in the tables (see Tables 3–5).

3. Results

3.1. Questionnaires and assessment of clinical variables

Overall, participants did not reach the cut-off scores for pathological values on the TAS and EQ. Patients with an MDD had the lowest values on the EQ and the highest values on the subscales identifying and describing emotions as well as the sum score of the TAS. The healthy controls scored highest on the externally oriented thinking subscale of the TAS. IQ was significantly different between groups and lowest in the schizophrenia sample. Reduced intellectual abilities in patients with schizophrenia have been described repeatedly and this intellectual decline is a problem immanent to the disorder (Keefe et al., 2005; Koelkebeck et al., 2005). On the TMT, the patients with schizophrenia were slowest. As expected, BDI and MADRS values were highest in MDD patients and intermediate in patients with schizophrenia (see Table 1

Table 1
Social and clinical data (means and standard deviations)* indicates significant results. [1] $n = 31$; **Abbreviations:** *BDI* = Beck Depression Inventory; *CGI* = Clinical Global Impression; *CPZ* = chlorpromazine equivalents; *GAF* = Global Assessment of Functioning; *MADRS* = Montgomery-Asberg Depression Rating Scale; *EQ* = Empathy Quotient (cut-off score ≤ 30); *MDD* = major depressive disorder; *MWTB* = Multiple Choice Vocabulary Intelligence Test; *PANSS* = Positive and Negative Syndrome Scale; *TAS* = Toronto-Alexithymia-Scale (cut-off score ≥ 54); *TMT* = Trail Making Test, we here present results as transformed IQ scores.

	Schizophrenia ($n = 32$)	MDD ($n = 32$)	Healthy ($n = 32$)	Statistics
Age (years)	36.6 (10.6)	31.7 (10.0)	36.5 (8.9)	$F(2,93) = 2.5$; $p = 0.08$
Gender	12 ♀, 20 ♂	16 ♀, 16 ♂	12 ♀, 20 ♂	$\chi^2 = 1.357$; $p = 0.3$
Education (years)	11.8 (1.5)	12.2 (1.2)	12.0 (1.4)	$F(2,93) = 0.8$; $p = 0.4$
Duration of illness (years)	9.4 (8.4)	2.8 (4.7)	–	$U = -3.9$; $p < 0.001$
Verbal IQ (MWT-B)	106.9 (15.0)	110.7 (14.2)	117.3 (16.0)	$F(2,93) = 3.9$; $p = 0.02$
TMT – A	87.1 (16.7)	109.8 (18.9)[1]	104.3 (14.8)	$F(2,92) = 15.7$; $p < 0.001$*
TMT – B	88.2 (17.7)	111.9 (14.1)[1]	109.3 (15.0)	$F(2,92) = 21.9$; $p < 0.001$*
BDI	10.6 (5.4)	22.06 (8.2)	1.3 (2.1)	$F(2,93) = 103.5$; $p < 0.001$*
MADRS	11.9 (6.5)[1]	25.2 (7.1)[1]	0.7 (1.6)	$F(2,90) = 144.5$; $p < 0.001$*
EQ	38.4 (11.1)	32.3 (9.5)	42.6 (10.3)	$F(2,93) = 8.2$; $p < 0.001$*
TAS Sum score	47.3 (8.8)	50.5 (8.2)	37.3 (5.3)	$F(2,93) = 26.6$; $p < 0.001$*
TAS subscale 1	16.0 (5.2)	19.0 (5.7)	9.6 (2.2)	$F(2,93) = 34.6$; $p < 0.001$*
TAS subscale 2	15.1 (4.2)	15.7 (3.3)	10.9 (3.3)	$F(2,93) = 16.3$; $p < 0.001$*
TAS subscale 3	16.2 (2.8)	15.8 (3.3)	16.8 (0.6)	$F(2,93) = 0.9$; $p = 0.4$
GAF	56.5 (11.8)[1]	56.8 (8.5)[1]	–	$U = -0.9$; $p = 0.9$
CGI	5.4 (0.9)[1]	5.6 (0.8)[1]	–	$U = -0.6$; $p = 0.6$
PANSS Sum	59.5 (15.1)	–	–	–
PANSS +	13.5 (4.6)	–	–	–
PANSS -	15.2 (6.8)	–	–	–
PANSS General	31.6 (7.4)	–	–	–
PANSS anxiety	2.6 (1.3)	–	–	–
CPZ	870.1	–	–	–

for all results). In Table 2 we present the mean reaction time results and confirmation rates of all groups as well as the standard deviations.

3.2. Generalized mixed model analyses

3.2.1. Reaction times

The results showed an interaction effect between Group (Schizophrenia, MDD or Healthy Controls) * Experimental Condition (Noh Mask or Japanese Female Face, $F(17.077) = 5.112$, $p = 0.006$), showing that patients with an MDD, compared to those with schizophrenia or healthy controls, displayed a somewhat blunted pattern of the typically much faster responses following the categorization of emotions from naturalistic faces relative to ambiguous stimuli (contrast Noh Mask versus Japanese Female Face for MDD $t(17.077) = 2.226$, $p = 0.026$; schizophrenia $t(17.077) = 5.201$, $p < 0.001$; healthy controls $t(17.077) = 6.252$, $p < 0.001$) (see Table 3). Further, a significant interaction was observed between Emotion Type (Basic or Subtle) * Group ($F(17.077) = 3.614$, $p = 0.027$), showing that, on similar lines, patients with an MDD were characterized by the least typical pattern. Specifically, although the three groups were generally faster in categorizing basic compared to subtle emotions, the difference in their response times following the categorization of basic compared to subtle emotions was somewhat smaller compared to the other two groups (contrast Basic versus Subtle Emotion for MDD $t(17.077) = 5.211$, $p < 0.001$; schizophrenia $t(17.077) = 5.954$, $p < 0.001$; healthy controls $t(17.077) = 8.257$, $p < 0.001$). After additionallycontrolling for IQ, EQ and TAS, these results remained unchanged ($ps \geq 0.171$) (also see **Supplement Table 1**).

Since the observed interaction between Group and Emotion Type might be modulated by the specific emotion that was presented, we investigated this possibility in a model that instead of the factor Emotion Type (basic or subtle) contained the factor Emotion (sad, angry, fearful, disgusted, happy, gloomy, relaxed, shy, startled, apathetic). In this model, the interactions between Group * Emotion ($F(17.077) = 2.392$, $p < 0.01$) and Group * Experimental Condition ($F(17.077) = 5.286$, $p = 0.005$)) remained significant (also see Table 4). Compared to healthy controls, patients with schizophrenia specifically, were slower than controls when recognizing anger and sadness (angry: $t(17.007) = 2.242$, $p = 0.025$; sad: $t(17.007) = 2.048$, $p = 0.041$) (also see Fig. 1**a**). Their response times did not significantly differ from the depressed group in any of the conditions (stats $p \geq 0.09$).

3.2.2. Confirmation rates of emotions

In a generalized mixed model that was similar to the reaction time model, but included a binomial distribution instead, we analyzed participants' responses to the question of whether a certain emotion label matched with the expression on the observed face (Noh Mask or Japanese Female Face). Similar to the reaction times results, an interaction between Group * Experimental Condition was observed ($F(17.272) = 4.257$, $p = 0.014$) and again the MDD patients were most deviant (also see Table 5). Specifically, in contrast to healthy controls and patients with schizophrenia, who tended to report "yes" more often when the question concerned a real facial expression compared to an expression from a Noh mask, MDD patients tended to give more "yes" responses following the Noh mask stimuli (see also Fig. 1**b**). Please note that although the interaction was significant, none of the follow-up simple contrasts were significant ($ps \geq 0.056$). Again, we verified that TAS, EQ or IQ were not modulating any of these effects and did not predict responses in general either ($ps \geq 299$) (see **Supplement Table 2**).

Summarizing the present results, all groups were slower to react on the Noh mask condition. Patients with schizophrenia were significantly slower than healthy controls only on the emotions anger and sadness. Patients with an MDD showed less difference in reaction times between the Noh mask and the Japanese female face stimuli and also showed fewer differences in reaction to basic versus subtle emotions. MDD patients also confirmed emotional expressions more often on the Japanese female face stimulus. IQ, age and cognitive function did not have a relevant impact on the results.

4. Discussion

In the current study we used a novel neuropsychological task to investigate the perception of ambiguous expressions of emotions in patients with schizophrenia in comparison to patients with an MDD and healthy controls, evaluating performance and characterizing group differences. We employed a task with a singular stimulus of East-Asian origin (Noh mask), which may have specific advantages over standard

Table 2
Means and standard deviations for reaction times and percentage of positive confirmation rates over the experimental groups.

Condition	Schizophrenia	MDD	Healthy
Mean reaction times and confirmation rates over all conditions			
Reaction times			
Noh mask	2,210.99 (1,468.440)	1,962.43 (1,155.601)	2,046.03 (1,113.817)
Japanese female face	2,358.47 (1,423.411)	2,147.80 (1,244.095)	2,115.77 (1,189.297)
Confirmation rates			
Noh mask	25.1%	28.9%	28.3%
Japanese female face	28.6%	27.9%	27.9%
Mean reaction times and confirmation rates over basic and subtle emotions			
Reaction times			
Noh mask			
Basic	2,069.99 (1,466.613)	1,979.76 (1,153.356)	1,830.51 (1,112.686)
Subtle	2,287.15 (1,465.155)	2,090.23 (1,084.740)	2,050.63 (1,175.513)
Japanese female face			
Basic	2,262.55 (1,425.638)	2,009.90 (1,192.303)	1,981.39 (1,168.377)
Subtle	2,422.28 (1,418.757)	2,186.67 (1,182.330)	2,259.49 (1,280.690)
Confirmation rates			
Noh mask			
Basic	24.6%	26.6%	27,5%
Subtle	25.5%	29.3%	29.7%
Japanese female face			
Basic	20.7%	19.8%	22.0%
Subtle	33.9%	33.3%	39.7%
Mean reaction times and confirmation rates over all emotion items			
Reaction times			
Noh mask			
Sad	2,107.24 (1,469.018)	1,979.53 (1,139.118)	1,685.82 (945.705)
Angry	2,262.13 (1,595.482)	1,913.99 (1,088.795)	1,744.61 (974.818)
Fearful	2,048.95 (1,463.928)	1,907,71 (1,171.615)	1,792.73 (1,138.989)
Happy	2,212.23 (1,547.668)	2,225.71 (1,212.871)	2,072.01 (1,256.627)
Disgusted	2,021.60 (1,383.777)	1,805.49 (1,047.094)	1,771.12 (1,052.924)
Gloomy	2,487.73 (1,482.928)	2,165.16 (1,017.336)	2,072.71 (1,079.655)
Relaxed	2,263.45 (1,399.870)	2,143.41 (1,075.784)	2,284.05 (1,276.744)
Shy	2,297.09 (1,473.785)	2,203.55 (1,124.095)	2,180.37 (1,267.586)
Startled	2,132.09 (1,312.718)	1,892.76 (926.972)	1,842.68 (1,122.316)
Apathetic	2,280.42 (1,501.689)	2,223.86 (1,213.192)	2,183.25 (1,216.840)
Japanese female face			
Sad	2,175.96 (1,363.574)	1,982.45 (1,159.721)	1,900.80 (1,030.713)
Angry	2,290.20 (1,413.217)	2,011.96 (1,192.397)	2,052.05 (1,205.105)
Fearful	2,439.54 (1,587.482)	2,075.71 (1,258.549)	2,031.80 (1,273.775)
Happy	2,290.56 (1,400.571)	2,083.06 (1,197.626)	2,086.79 (1,201.915)
Disgusted	2,144.17 (1,326.136)	1,896.99 (1,146.409)	1,905.60 (1,148.743)
Gloomy	2,652.63 (1,456.287)	2,311.66 (1,173.954)	2,409.46 (1,187.231)
Relaxed	2,444.63 (1,485.960)	2,284.01 (1,242.567)	2,338.76 (1,388.959)
Shy	2,367.48 (1,305.356)	2,222.79 (1,216.835)	2,222.12 (1,209.215)
Startled	2,371.00 (1,400.435)	2,145.71 (1,223.081)	2,168.24 (1,287.550)
Apathetic	2,410.42 (1,430.901)	2,144.14 (1,013.278)	2,367.68 (1,367.069)
Confirmation rates			
Noh mask			
Sad	11.1%	19.8%	13.2%
Angry	5.9%	6.3%	12.8%
Fearful	11.1%	13.9%	16.0%
Happy	67.4%	62.2%	68.8%
Disgusted	8.7%	10.8%	12.2%
Gloomy	18.1%	16.3%	18.8%
Relaxed	65.6%	74.4%	63.9%
Shy	31.6%	36.5%	40.6%
Startled	10.4%	12.5%	12.8%
Apathetic	21.5%	29.9%	29.5%
Japanese female face			
Sad	15.6%	17.7%	20.1%
Angry	16.0%	20.1%	21.9%
Fearful	22.2%	28.5%	28.1%
Happy	32.6%	26.7%	30.2%
Disgusted	12.5%	6.3%	9.4%
Gloomy	41.0%	36.8%	37.8%
Relaxed	51.7%	48.3%	57.6%
Shy	33.0%	32.6%	39.9%
Startled	31.3%	31.9%	31.3%
Apathetic	30.6%	30.2%	49.7%

emotion identification tasks and might serve as a diagnostic tool for detecting schizophrenia. In addition, we investigated the perception of emotions from a human face as a control task, adopting a similar presentation mode. In addition to basic expressions of emotion, more subtle or complex expressions were investigated.

Our results showed subtle differences between patients with

Table 3
Fixed and random effects in a generalized linear mixed model of reaction times (Basic vs. Subtle Emotions) (df = degrees of freedom). Significant *p*-values shown in bold. Fixed factors included Group (3: Schizophrenia; MDD; Control Group), Emotion Type (2: Basic Emotion; Subtle Emotion) and Experimental Condition (2: Noh Mask; Japanese Female Face).

Fixed factors	Df	*F* value	Significance level			
Group	2,17.1	1.038	0.354			
Emotion type	**1,17.1**	**141.065**	**< 0.001**			
Experimental Condition	**1,17.1**	**63.576**	**< 0.001**			
Emotion type * Experimental Condition	1,17.1	0.188	0.665			
Emotion type * Group	**2,17.1**	**3.610**	**0.027**			
Experimental Condition * Group	**2,17.1**	**5.442**	**0.004**			
Emotion type * Experimental Condition * Group	2,17.1	1.103	0.332			
Random effect	**Estimate**	**Standard error**	***Z***	***p*-value**	**95% Confidence interval**	
					Lower	**Upper**
Variance	**0.265**	**0.003**	**92.209**	**< 0.001**	**0.260**	**0.271**
Intercept	**0.082**	**0.012**	**6.695**	**< 0.001**	**0.061**	**0.109**

schizophrenia, MDD and healthy controls over both tasks that became visible in interaction effects. Specifically, the factor group (the two patient groups or controls) interacted with emotion type (basic or subtle) regarding the reaction times. An interaction between group and experimental condition was observed in the analyses of both reaction times and the confirmation rates of emotions. In the section below, we elaborate on these findings.

For the reaction times, the two interactions with group were mainly driven by patients with an MDD. First, although all groups were slower following the Noh mask stimuli than real facial expressions, this difference was much less prominent in the MDD group compared to the two other groups. Moreover, in comparison to patients with schizophrenia and healthy controls, patients with an MDD showed smaller differences in reaction times following basic (typically faster, see also Dai et al., 2015) compared to subtle emotions (typically slower).

When investigating emotion items specifically, patients with schizophrenia were slower than controls to recognize anger and sadness, while the reaction times were not significantly different from those of patients with an MDD. None of these results were modulated by cognitive functioning, IQ or age.

Although our hypothesis of a general reaction time slowing in schizophrenia was not verified, the results show that specific emotion items pose a larger burden for patients with schizophrenia. In previous studies patients with schizophrenia were shown to exhibit an emotion identification bias, with a deficit in detecting negative emotions (Takahashi et al., 2004). This was also corroborated in a study by Minoshita and colleagues (2005), in which patients rated the stimulus more pleasantly than healthy controls. However, the deficits have to be considered small. Specific reaction time slowing on certain facial expressions might lead to impairments in the recognition of specific emotions and might also lead to interruptions in mutual communication.

Contrary to our prediction and other findings not verifying reaction time disadvantages in depression as compared to healthy controls (Sfärlea et al., 2018), we found larger differences for patients with MDD in reaction time on one of the experimental tasks and also a larger effect of subtle and basic emotion items in this patient group. Deficits in the recognition of ambiguous emotions have been shown in relatives of depressed patients (Dearing and Gotlib, 2009). On a task with simple and more complex emotions, patients with a depression had more difficulties to identify complex emotions as compared to healthy controls (Yoon et al., 2016). Leppänen et al., (2004) found that patients with a depression were slower to label neutral faces, which was hypothesized to present an ambiguous stimulus for patients.

For the confirmation rates of emotion items, again, a significant interaction effect was observed, while no main group effect was present. However, this interaction was, again, driven by MDD patients, whose responses did not differ between the Noh mask and the Japanese female face. Healthy controls and schizophrenia patients more often indicated an emotion item positively when the real human face was presented. However, in patients with an MDD no such difference seems to be present. In fact, the numbers point to the opposite. Here, our hypothesis that patients with schizophrenia identify negative items less frequently was not corroborated. While patients with an MDD have been shown to display a bias toward negative emotions (Hale, 1998), it was also not corroborated in our study.

We did not succeed in identifying meaningful group differences with the task, but we were able to show interaction effects with group. As hypothesized taking into account our previous work, we think that the stimuli of Asian origin were probably not suitable for use in a cross-cultural sample. It may be assumed that both patient groups and healthy controls might have had difficulties in assessing the stimuli rather than inducing a stronger effect on patients with schizophrenia, as previously hypothesized. In a study investigating patients with

Table 4
Fixed and random effects in a generalized linear mixed model of reaction times (all emotions included) (df = degrees of freedom). Significant *p*-values shown in bold. Fixed factors included Group (3: Schizophrenia; MDD; Control Group) and Emotion (10: sad, angry, fearful, disgusted, happy, gloomy, relaxed, shy, startled, apathetic) and Experimental Condition (2: Noh Mask; Japanese Female Face).

Fixed factors	Df	*F* value	Significance level			
Group	2,17.1	1.007	0.365			
Emotion	**1,17.1**	**36.190**	**< 0.001**			
Experimental Condition	**1,17.1**	**72.130**	**< 0.001**			
Emotion * Experimental Condition	**1,17.1**	**2.372**	**0.001**			
Emotion * Group	**2,17.1**	**2.292**	**0.001**			
Experimental Condition * Group	**2,17.1**	**5.286**	**0.005**			
Emotion * Experimental Condition * Group	2,17.1	0.927	0.545			
Random effect	**Estimate**	**Standard error**	***Z***	***p*-value**	**95% Confidence interval**	
					Lower	**Upper**
Variance	**0.082**	**0.012**	**6.698**	**< 0.001**	**0.061**	**0.110**
Intercept	**0.262**	**0.003**	**92.152**	**< 0.001**	**0.256**	**0.267**

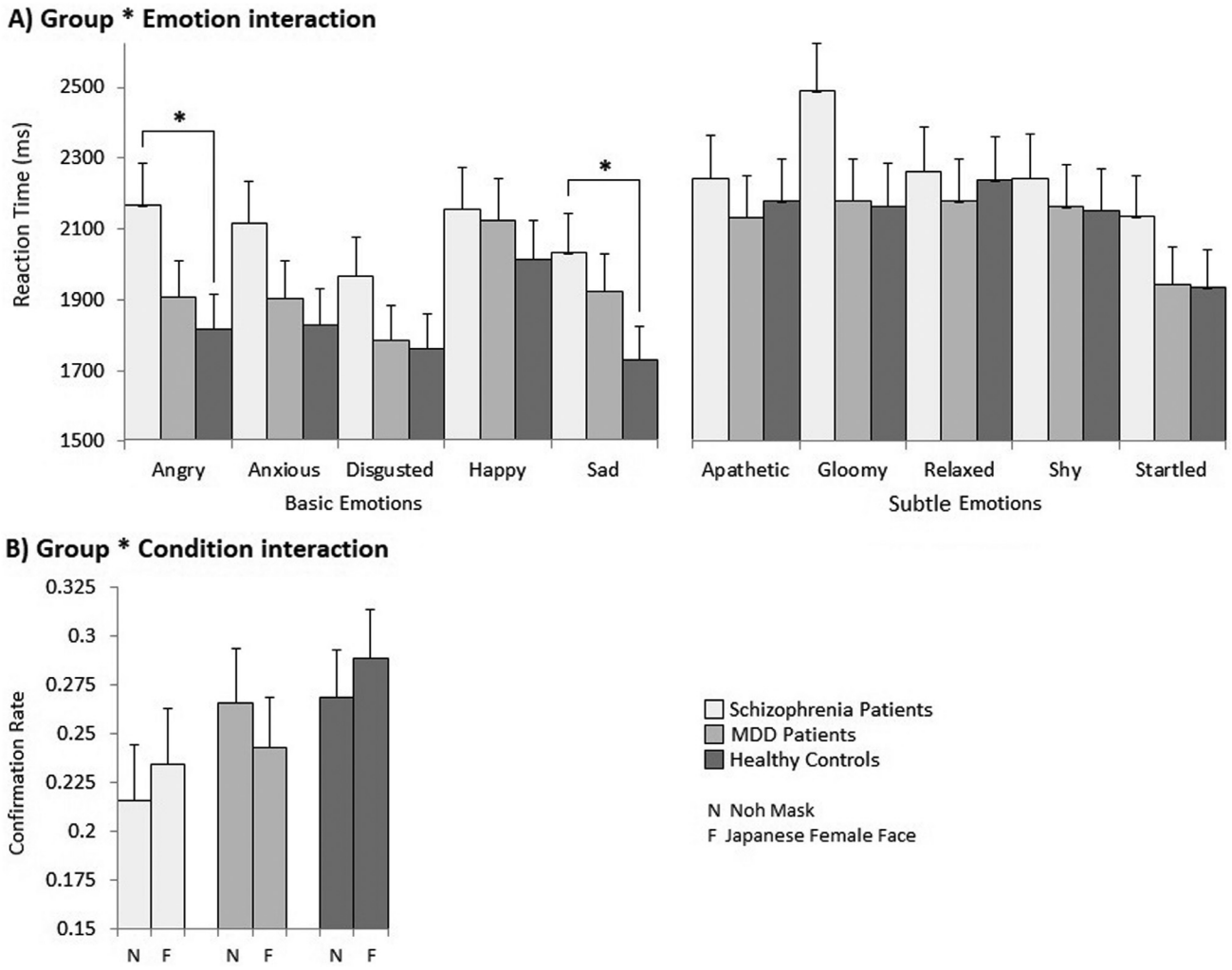

Fig. 1. **(a) Interaction Group * Emotion:** Reaction time of three groups over all emotion items. *indicates significant group effects.
(b) Interaction Group * Experimental Condition: Emotion confirmation rates over the three groups over both experimental conditions.

schizophrenia, researchers found a small effect of culture, with Caucasian patients recognizing disgust in Caucasian face models better than in models of Asian origin (Okada et al., 2015).

However, we still think that our task might be of a diagnostic value. A potential utility of the Noh mask test could lie in a transdiagnostic capacity, adopting a phenomenological approach. Here, patients with certain symptom constellations might react more similarly, independent of the disease category. Assessing patients within the spectrum of mental disorders could be a meaningful approach, e.g., assessing patients with psychotic mania or psychotic depression. On the basis of patients' reaction times and/or emotion confirmation patterns it might also be possible to predict whether patients are more likely to fall in the depression or schizophrenia group, or might be more likely to experience a particular type of psychopathology or a social disadvantage (e.g., social isolation). Whether that is the case needs to be determined in further research, using these measures to predict diagnosis/group from the data. Such methods are not only cost-effective, e.g., compared to genetic investigations, but might also lead to

Table 5
Fixed and random effects in a generalized linear mixed model of confirmation rates of emotions (df = degrees of freedom). Significant *p*-values shown in bold. Fixed factors included Group (3: Schizophrenia; MDD; Control Group), Emotion Type (2: Basic Emotion; Subtle Emotion) and Experimental Condition (2: Noh Mask; Japanese Female Face).

Fixed factors	Df	*F* value	Significance level			
Group	2,17.268	0.930	0.394			
Emotion type	**1,17.268**	**151.742**	**<0.001**			
Experimental Condition	1,17.268	0.523	0.470			
Emotion type * Experimental Condition	**1,17.268**	**89.644**	**<0.001**			
Emotion type * Group	2,17.268	1.035	0.355			
Experimental condition * Group	**2,17.268**	**3.214**	**0.040**			
Emotion type * Experimental Condition * group	2,17.268	0.671	0.511			
Random effect	**Estimate**	**Standard error**	***Z***	***p*-value**	**95% Confidence interval**	
					Lower	**Upper**
Variance	**1.000**	**–**	**–**	**–**	**–**	**–**
Intercept	**0.575**	**0.094**	**6.150**	**< 0.001**	**0.418**	**0.791**

transdiagnostic concepts, modeling complex relationships among categories contributing to the etiology of mental disorders (Miller and Rockstroh, 2013). The Noh mask test might also be used in larger packages of cognitive tasks to address a variety of cognitive functioning, as, for instance, in the MATRICS Consensus Cognitive Battery (Kern et al., 2008; Nuechterlein et al., 2008) which targets multiple cognitive domains. Future studies could also complement the investigation of emotion identification strategies using e.g., eye-tracking or functional imaging methods. Eye-tracking methods, in particular, provide the opportunity to identify (aberrant) visual exploration paths in patients with schizophrenia and might thus find abnormal eye movement when scanning the mask in contrast to healthy controls or other patient groups (Loughland et al., 2002). Moreover, emotion identification in morphed faces investigated with functional neuroimaging methods suggested that sensitivity of emotion identification was altered in patients with schizophrenia (Maher et al., 2016).

As a limitation of our study, all patients with schizophrenia received medication. It must be assumed that cognitive functioning of patients (with a neuroleptic) impacts the test results in emotion identification. However, recent studies on the impact of antipsychotic treatment on cognitive performance support the idea that negative effects on emotion identification are negligible (Gabay et al., 2015). Moreover, in this task we used emotion-labeling, which has been shown to be deficient in patients with affective disorders and schizophrenia (Feinberg et al., 1986). In a study by Romero-Ferreiro et al., (2015) for example, patients with schizophrenia who had to assign emotions to facial expressions less frequently labeled negative emotions correctly. However, in our task at hand, there were no right or wrong answers, which makes the process of data analysis more complex. Consequently, the results need to be interpreted with more caution.

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Conflict of interest

None

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.psychres.2018.10.042.

References

Adams Jr, R.B., Rule, N.O., Franklin Jr, R.G., Wang, E., Stevenson, M.T., Yoshikawa, S., et al., 2010. Cross-cultural reading the mind in the eyes: an fMRI investigation. J. Cognit. Neurosci. 22, 97–108.
Andric, S., Maric, N.P., Mihaljevic, M., Mirjanic, T., van Os, J., 2016. Familial covariation of facial emotion recognition and IQ in schizophrenia. Psychiatry Res. 30 (246), 52–57.
APA, 1994. Diagnostic and Statistical Manual of Mental Disorders, fourth ed. American Psychiatric Press, Washington, DC.
APA, 1987. Diagnostic and Statistical Manual of Mental Disorders (DSM-III-R), third ed., Washington DC.
Baron-Cohen, S., Wheelwright, S., 2004. The empathy quotient: an investigation of adults with Asperger syndrome or high-functioning autism, and normal sex differences. J. Autism Dev. Disord. 34, 163–175.
Baudouin, J.Y., Martin, F., Tiberghien, G., Verlut, I., Franck, N., 2002. Selective attention to facial emotion and identity in schizophrenia. Neuropsychologia 40, 503–511.
Beck, A.T., Ward, C., Mendelson, M., 1961. Beck Depression Inventory (BDI). Arch. Gen. Psychiatry 4, 561–571.
Belge, J.B., Maurage, P., Mangelinckx, C., Leleux, D., Delatte, B., Constant, E., 2017. Facial decoding in schizophrenia is underpinned by basic visual processing impairments. Psychiatry Res. 255, 167–172.
Bell, M., Bryson, G., Lysaker, P., 1997. Positive and negative affect recognition in schizophrenia: a comparison with substance abuse and normal control subjects. Psychiatry Res. 73, 73–82.
Braff, D.L., 1993. Information processing and attention dysfunctions in schizophrenia. Schizophr. Bull. 19 (2), 233–259.
Burch, J.W., 1995. Typicality range deficit in schizophrenics' recognition of emotion in faces. J. Clin. Psychol. 51, 140–152.
Comparelli, A., De Carolis, A., Corigliano, V., Di Pietro, S., Trovini, G., Granese, C., et al., 2014. Symptom correlates of facial emotion recognition impairment in schizophrenia. Psychopathology 47 (1), 65–70.
Dai, B., Li, J., Chen, T., Li, Q., 2015. Interpretive bias of ambiguous facial expressions in older adults with depressive symptoms. Psych J. 4 (1), 28–37.
Dearing, K.F., Gotlib, I.H., 2009. Interpretation of ambiguous information in girls at risk for depression. J. Abnorm. Child Psychol. 37, 79–91.
Derntl, B., Seidel, E.-M., Schneider, F., Habel, U., 2012. How specific are emotional deficits? A comparison of empathic abilities in schizophrenia, bipolar and depressed patients. Schizophr. Res. 142 (1-3), 58–64.
Feinberg, T.E., Rifkin, A., Schaffer, C., Walker, E., 1986. Facial discrimination and emotional recognition in schizophrenia and affective disorders. Arch. Gen. Psychiatry 43, 276–279.
Frith, C.D., 2004. Schizophrenia and theory of mind. Psychol. Med. 34, 385–389.
Gabay, A.S., Kempton, M.J., Mehta, M.A., 2015. Facial affect processing deficits in schizophrenia: a meta-analysis of antipsychotic treatment effects. J. Psychopharmacol. 29, 224–229.
Goren, D., Wilson, H.R., 2006. Quantifying facial expression recognition across viewing conditions. Vis. Res. 46 (8-9), 1253–1262.
Guy, W., 1976. Clinical Global Impressions. National Institute for Mental Health, Rockville, MD.
Hale 3rd, W.W., 1998. Judgment of facial expressions and depression persistence. Psychiatry Res 80, 265–274.
Herniman, S.E., Allott, K.A., Killackey, E., Hester, R., Cotton, S.M., 2017. The effect of comorbid depression on facial and prosody emotion recognition in first-episode schizophrenia spectrum. J. Affect. Disord. 208, 223–229.
Huang, J., Chan, R.C., Gollan, J.K., Liu, W., Ma, Z., Li, Z., et al., 2011. Perceptual bias of patients with schizophrenia in morphed facial expression. Psychiatry Res. 185, 60–65.
Kawai, N., Miyata, H., Nishimura, R., Okanoya, K., 2013. Shadows alter facial expressions of Noh masks. PloS One 8, e71389.
Kay, S.R., Fiszbein, A., Opler, L.A., 1987. The positive and negative syndrome scale (PANSS) for schizophrenia. Schizophr. Bull. 13, 261–276.
Keefe, R.S., Eesley, C.E., Poe, M.P., 2005. Defining a cognitive function decrement in schizophrenia. Biol. Psychiatry 57, 688–691.
Kern, R.S., Nuechterlein, K.H., Green, M.F., Baade, L.E., Fenton, W.S., Gold, J.M., et al., 2008. The MATRICS consensus cognitive battery, part 2: co-norming and standardization. Am. J. Psychiatry 165 (2), 214–220.
Ketteler, D., Theodoridou, A., Ketteler, S., Jager, M., 2012. High order linguistic features such as ambiguity processing as relevant diagnostic markers for schizophrenia. Schizophr. Res. Treat. 2012, 825050.
Koelkebeck, K., Kohl, W., Luettgenau, J., Triantafillou, S., Ohrmann, P., Satoh, S., et al., 2015. Benefits of using stimuli with culturally unfamiliar features in ambiguous emotion identification: a cross-cultural study. Psychiatry Res. 228, 39–45.
Koelkebeck, K., Ohrmann, P., Hetzel, G., Arolt, V., Suslow, T., 2005. Visual backward masking: deficits in locating targets are specific to schizophrenia and not related to intellectual decline. Schizophr. Res. 78, 261–268.
Kret, M.E., de Dreu, C.K., 2013. Oxytocin-motivated ally selection is moderated by fetal testosterone exposure and empathic concern. Front. Neurosci. 7, 1.
Kret, M.E., de Gelder, B., 2013. When a smile becomes a fist: the perception of facial and bodily expressions of emotion in violent offenders. Exp. Brain Res. 228, 399–410.
Kret, M.E., 2015. Emotional expressions beyond facial muscle actions. A call for studying autonomic signals and their impact on social perception. Front. Psychol. 6, 711.
Lehrl, S., 2005. Mehrfachwahl-Wortschatz-Intelligenztest. MWT-B. Spitta Verlag, Balingen, DE.
Leppänen, J.M., Milders, M., Bell, J.S., Terriere, E., Hietanen, J.K., 2004. Depression biases the recognition of emotionally neutral faces. Psychiatry Res. 128 (2), 123–133.
Loughland, C.M., Williams, L.M., Gordon, E., 2002. Schizophrenia and affective disorder show different visual scanning behavior for faces: a trait versus state-based distinction? Biol. Psychiatry 52, 338–348.
Lyons, M.J., Campbell, R., Plante, A., Coleman, M., Kamachi, M., Akamatsu, S., 2000. The Noh mask effect: vertical viewpoint dependence of facial expression perception. Proc. Biol. Sci. 267, 2239–2245.
Maher, S., Ekstrom, T., Chen, Y., 2016. Impaired visual cortical processing of affective facial information in schizophrenia. Clin. Psychol. Sci. 4, 651–660.
Mandal, M.K., Jain, A., Haque-Nizamie, S., Weiss, U., Schneider, F., 1999. Generality and specificity of emotion-recognition deficit in schizophrenic patients with positive and negative symptoms. Psychiatr. Res. 87, 39–46.
Miller, G.A., Rockstroh, B., 2013. Endophenotypes in psychopathology research: where do we stand? Annu. Rev. Clin. Psychol. 9, 177–213.
Minoshita, S., Morita, N., Yamashita, T., Yoshikawa, M., Kikuchi, T., Satoh, S., 2005. Recognition of affect in facial expression using the Noh mask test: comparison of individuals with schizophrenia and normal controls. Psychiatry Clin. Neurosci. 59, 4–10.
Minoshita, S., Satoh, S., Morita, N., Tagawa, A., Kikuchi, T., 1999. The Noh mask test for

analysis of recognition of facial expression. Psychiatry Clin. Neurosci. 53, 83–89.
Miyata, H., Nishimura, R., Okanoya, K., Kawai, N., 2012. The mysterious Noh mask: contribution of multiple facial parts to the recognition of emotional expressions. PloS One 7, e50280.
Montgomery, S.A., Asberg, M., 1979. A new depression scale designed to be sensitive to change. Br. J. Psychiatry 134, 382–389.
Moritz, S., Woznica, A., Andreou, C., Kother, U., 2012. Response confidence for emotion perception in schizophrenia using a continuous facial sequence task. Psychiatry Res 200, 202–207.
Nuechterlein, K.H., Green, M.F., Kern, R.S., Baade, L.E., Barch, D.M., Cohen, J.D., et al., 2008. The MATRICS Consensus Cognitive Battery, part 1: test selection, reliability, and validity. Am. J. Psychiatry 165 (2), 203–213.
Okada, T., Kubota, Y., Sato, W., Murai, T., Pellion, F., Gorog, F., 2015. Common impairments of emotional facial expression recognition in schizophrenia across French and Japanese cultures. Front. Psychol. 6, 1018.
Park, I.H., Ku, J., Lee, H., Kim, S.Y., Kim, S.I., Yoon, K.J., et al., 2011. Disrupted theory of mind network processing in response to idea of reference evocation in schizophrenia. Acta Psychiatr. Scand. 123 (1), 43–54.
Pinkham, A.E., Brensinger, C., Kohler, C., Gur, R.E., Gur, R.C., 2011. Actively paranoid patients with schizophrenia over attribute anger to neutral faces. Schizophr. Res. 125 (2-3), 174–178.
Reitan, R.M., 1958. Validity of the trailmaking test as an indication of organic brain damage. Perc. Mot. Skills 8, 271–276.
Romero-Ferreiro, M.V., Aguado, L., Rodriguez-Torresano, J., Palomo, T., Rodriguez-Jimenez, R., 2015. Patterns of emotion attribution are affected in patients with schizophrenia. Span. J. Psychol. 18, E59.
Russell, J.A., 1991. Culture and the categorization of emotions. Psychol. Bull. 110, 426–450.
Sfärlea, A., Greimel, E., Platt, B., Dieler, A.C., Schulte-Körne, G., 2018. Recognition of emotional facial expressions in adolescents with anorexia nervosa and adolescents with major depression. Psychiatry Res 262, 586–594.
Suslow, T., Roestel, C., Ohrmann, P., Arolt, V., 2003. Detection of facial expressions of emotions in schizophrenia. Schizophr. Res. 64, 137–145.
Takahashi, T., Suzuki, M., Hagino, H., Zhou, S.Y., Kawasaki, Y., Nohara, S., et al., 2004. Bilateral volume reduction of the insular cortex in patients with schizophrenia: a volumetric MRI study. Psychiatry Res. 132, 187–196.
Taylor, G.J., Bagby, R.M., Parker, J.D., 2003. The 20-item toronto alexithymia scale. IV. Reliability and factorial validity in different languages and cultures. J. Psychosom. Res. 55, 277–283.
Tremeau, F., Antonius, D., Todorov, A., Rebani, Y., Ferrari, K., Lee, S.H., et al., 2015. Implicit emotion perception in schizophrenia. J. Psychiatr. Res. 71, 112–119.
Tsui, C.F., Huang, J., Lui, S.S., Au, A.C., Leung, M.M., Cheung, E.F., et al., 2013. Facial emotion perception abnormality in patients with early schizophrenia. Schizophr. Res. 147, 230–235.
Ventura, J., Wood, R.C., Hellemann, G.S., 2013a. Symptom domains and neurocognitive functioning can help differentiate social cognitive processes in schizophrenia: a meta-analysis. Schizophr. Bull. 39 (1), 102–111.
Ventura, J., Wood, R.C., Jimenez, A.M., Hellemann, G.S., 2013b. Neurocognition and symptoms identify links between facial recognition and emotion processing in schizophrenia: meta-analytic findings. Schizophr. Res. 151 (1-3), 78–84.
West, J.T., Horning, S.M., Klebe, K.J., Foster, S.M., Cornwell, R.E., Perrett, D., et al., 2012. Age effects on emotion recognition in facial displays: from 20 to 89 years of age. Exp. Aging Res. 38, 146–168.
Yoon, S., Kim, H.S., Kim, J.I., Lee, S., Lee, S.H., 2016. Reading simple and complex facial expressions in patients with major depressive disorder and anxiety disorders. Psychiatry Clin. Neurosci. 70 (3), 151–158.
Yrizarry, N., Matsumoto, D., Wilson-Cohn, C., 1998. American-Japanese differences in multiscalar intensity ratings of universal facial expressions of emotion. Motiv. Emot. 22, 316–327.