Original Research

Facial Expression and Sex Recognition in Schizophrenia and Depression

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Background: Impaired facial expression recognition in schizophrenia patients contributes to abnormal social functioning and may predict functional outcome in these patients. Facial expression processing involves individual neural networks that have been shown to malfunction in schizophrenia. Whether these patients have a selective deficit in facial expression recognition or a more global impairment in face processing remains controversial.

Objective: To investigate whether patients with schizophrenia exhibit a selective impairment in facial emotional expression recognition, compared with patients with major depression and healthy control subjects.

Methods: We studied performance in facial expression recognition and facial sex recognition paradigms, using original morphed faces, in a population with schizophrenia (n = 29) and compared their scores with those of depression patients (n = 20) and control subjects (n = 20).

Results: Schizophrenia patients achieved lower scores than both other groups in the expression recognition task, particularly in fear and disgust recognition. Sex recognition was unimpaired.

Conclusion: Facial expression recognition is impaired in schizophrenia, whereas sex recognition is preserved, which highly suggests an abnormal processing of changeable facial features in this disease. A dysfunction of the top-down retrograde modulation coming from limbic and paralimbic structures on visual areas is hypothesized.

(Can J Psychiatry 2005;50:525–533)

Information on funding and support and author affiliations appears at the end of the article.

Clinical Implications

- Facial expression recognition predicts social, behavioural, and functional outcome in patients with schizophrenia.
- Better understanding of social message recognition deficit in schizophrenia will help the care of these patients and improve their quality of life.
- Several emerging rehabilitation strategies that improve emotion recognition in schizophrenia patients have yielded hopeful results.

Limitations

- The sex morphing may not be as ecologic as the expressions morphing.
- The sex recognition task requires a 2-choice judgment, whereas the expression task requires a 4-choice judgment.
- Age and educational level differed between control subjects and both patient groups, although these 2 patient groups did not differ significantly from each other.

Key Words: *emotion, sex, morphed faces, psychosis*

Human faces convey important messages, such as identity, age, sex, eye gaze, and emotional expression, that are relevant for social communication. Among the dynamic facial features, facial expressions play a crucial role in interpersonal interaction. Impairments in facial expression recognition have been demonstrated in neurologic pathologies such as frontotemporal dementia (1) and Parkinson's disease (2) and in psychiatric disorders such as depression (3) and schizophrenia (4). Conversely, recognition of invariant facial features such as age and identity may not be impaired in schizophrenia (5). Poor emotion recognition in schizophrenia (6) may contribute to aberrant interpersonal interactions and poor social functioning (7,8) and may be a predictor of functional outcome in these patients (9). Consistently, performance in facial and vocal emotion recognition correlates with social dysfunction in schizophrenia (10). Moreover, performance in facial expression recognition relates to negative symptoms of schizophrenia, implying poor socialization (11).

The cognitive model of face perception developed by Haxby and colleagues (12) emphasizes a distinction between the neural processes involved in the recognition of invariant and changeable facial features. The region of the lateral fusiform gyrus is particularly involved in the recognition of identity, whereas the region of the superior temporal sulcus and gyrus participates in the recognition of face-changeable aspects (13). This distinction is supported by several behavioural studies that show double dissociation between facial identity and facial expression recognition in patients with focal brain damage (14). Imaging studies also support the existence of distinct neural systems involved in the recognition of identity and expression, eye gaze, and lip-reading (13). Studies in primates have shown that some neurons respond selectively to identity in the inferior temporal gyrus, whereas others respond preferentially to emotional expression in the superior temporal sulcus (15). Scalp (16) and intracranial (17) event-related potential studies in humans also support the existence of distinct pathways. Considering Haxby's model, a deficit in facial expression recognition may imply a dysfunction of the corticolimbic network involved in emotion processing. Numerous studies have demonstrated structural and histological abnormalities in several brain regions in schizophrenia, including those that are involved in facial expression processing, for example, the temporal and frontal cortices, the superior temporal gyrus, and the thalamus (18).

Studies addressing facial expression recognition deficit in schizophrenia patients have almost always been based on prototypic facial expressions of emotions. It was recently suggested that increasing test sensitivity by including different emotion intensities may be more appropriate for studying emotional facial expression processing deficit in schizophrenia patients (19). Such highly sensitive methods have only been used once in patients with schizophrenia (4). However, as was discussed in a methodological review, the authors did not include a control task or a psychiatric control group (20). Studies including psychiatric control subjects are rare.

Whether a comparable deficit in facial emotional expression recognition can be observed in another psychiatric disorder involving social and communication impairments (for example, major depression) is controversial (21). Whether this impairment is selective of facial emotional expression recognition in contrast to invariant facial feature recognition remains unclear and not directly investigated.

In this study, we first addressed the question of the specificity of facial expression recognition deficit in schizophrenia compared with major depression—another psychiatric affection involving social behaviour impairments. Second, we compared it with sex recognition, an invariant facial feature. We engaged schizophrenia patients and depression patients in a facial emotional expression task and in a facial sex recognition task with an innovating and sensitive technique built with morphed faces depicting various degrees of expression and sex. We used various intensities of both expression and sex, obtained by morphing techniques, to improve the sensitivity and specificity of the tests (22).

Abbreviations used in this article

F	female
L	left
MADRS	Montgomery–Asberg Depression Rating Scale
mg CPz eq	milligram chlorpromazine equivalent
M	male
ns	not significant
PANSS	Positive and Negative Symptom Scale
R	right
SD	standard deviation

Method

Subjects

The study sample comprised patients with schizophrenia ($n = 29$) or major depression ($n = 20$), diagnosed according to DSM-IV criteria and with no concurrent diagnosis on Axis I, and healthy control subjects ($n = 20$).

We used the PANSS (23) to assess schizophrenia symptoms and the MADRS (24) to assess depressive symptoms.

Control subjects ($n = 20$) were healthy volunteers recruited within the hospital staff. They were free from DSM-IV Axis I diagnosis and from a history of psychiatric illness. None of them had ever received psychotropic medication.

Table 1 Demographic, clinical, and treatment data of 29 schizophrenia patients, 20 major depression patients, and 20 control subjects; mean (SD)

	Schizophrenia patients (*n* = 29)	Depression patients (*n* = 20)	Control subjects (*n* = 20)
Age (years)	34.6 (9.67)[a]***	38.6 (10.3)[a]***	25.5 (9.47)[a]***
Illness duration (years)	9.5 (10)	0.48 (0.81)	—
Sex (M/F)	16/13	13/7	13/7
Handedness (R/L)	28/1	19/1	19/1
Education level (years)	11.3 (2.84)[a]**	12.1 (2.98)[a]**	13.3 (1.62)[a]**
PANSS total score (out of 210)	92.86 (16.87)	—	—
MADRS score (out of 60)		23.53 (8.61)	—
Antipsychotic treatment (mg CPz eq)	614.10 (337.60)		
Antidepressant treatment (mg)			
Paroextine (*n* = 7)		42.9 (7.56)	
Sertraline (*n* = 1)		150.0 (0.0)	
Fluoxetine (*n* = 3)		40.0 (0.0)	
Citalopram (*n* = 2)		40.0 (0.0)	
Citalopram (*n* = 2)		10.0 (0.0)	
Venlafaxine (*n* = 2)		75.0 (25.0)	
Amitryptiline (*n* = 1)		150.0 (0.0)	
Clomipramne (*n* = 1)		75.0 (0.0)	
No treatment (*n* = 2)		—	

[a]Between-group comparisons were performed with Kruskal–Wallis analyses of variances for age and educational level.

** = $P < 0.01$

*** = $P < 0.001$

In all groups, major medical illness, neurologic disorder, current substance abuse, severe head injury, and visual impairment were exclusion criteria. The study was conducted in accordance with the latest version of the Declaration of Helsinki (see www.wma.net/e/policy/b3.htm), and its design has been approved by the local ethical committee. We obtained informed consent from all participants. Table 1 summarizes demographic, clinical, and treatment characteristics of the population.

Stimuli

Static colour photographic images of 3 basic facial emotional expressions (disgust, fear, and happiness) were morphed with neutral faces to create an expression continuum. We did not include sadness, anger, and surprise because these facial expressions have often been confounded with others (sadness with neutral, anger with disgust, and surprise with fear; 20). The morphed faces depicted disgust, fear, or happiness of different intensities for 2 men and 2 women. For each emotional category and for each individual face, a range of 9 intensity levels was obtained by computer graphical manipulation (25). The 10% through 90% emotional expression faces were interpolated with computer morphing procedures to shift the shape and pigmentation of the 0% emotion face (neutral) toward the 100% emotion photograph (disgust, fear, and happiness). Likewise, photographic images of the 2 sexes (male and female) were morphed with a face depicting "no sex" to create a sex continuum. The "no sex" face was obtained by averaging 20 male and 20 female faces. For each male and each female face, a range of 9 intensity levels of sex features was obtained by computer graphical manipulation. The 10% through 90% sex faces were interpolated with computer morphing procedures to shift the shape and pigmentation of the "no sex" face toward the 100% male or female prototype. All faces were successively flashed on a computer screen during 400 ms and followed by a black screen lasting 1600 ms. Presentation order was randomized within and across subjects. Stimulus examples are presented in Table 2 and Table 3.

Table 2 Example of morphed photographic images from neutral expression to 100% disgusted face in continuous various degrees

Photograph	1	2	3	4	5	6	7	8	9	10	11
Neutral face (%)	100	90	80	70	60	50	40	30	20	10	0
Disgusted face (%)	0	10	20	30	40	50	60	70	80	90	100

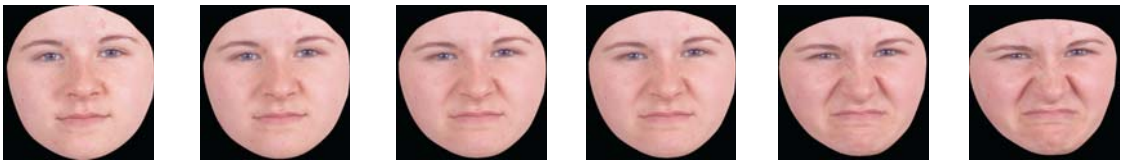
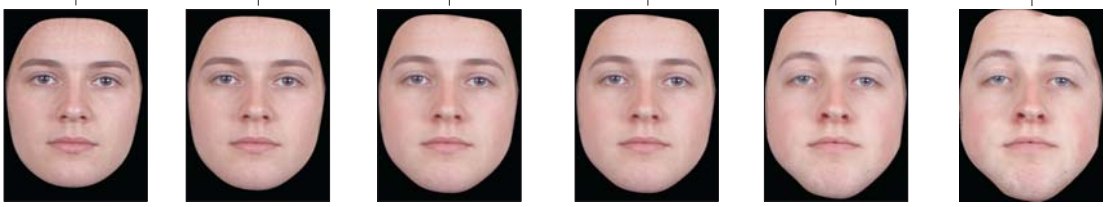


Table 3 Example of morphed photographic images from "no sex" to 100% male face in continuous various degrees

Photograph	1	2	3	4	5	6	7	8	9	10	11
"No sex" face (%)	100	90	80	70	60	50	40	30	20	10	0
Male face (%)	0	10	20	30	40	50	60	70	80	90	100



Tasks

Subjects were engaged in 2 successive facial feature recognition tasks. The order of task completion was randomized across subjects.

Expression Recognition Task. Subjects viewed the 132 expression-morphed images introduced above. After each face presentation, subjects had to report which facial expression was depicted by choosing among disgust, fear, happiness, and neutral and pressing the corresponding key.

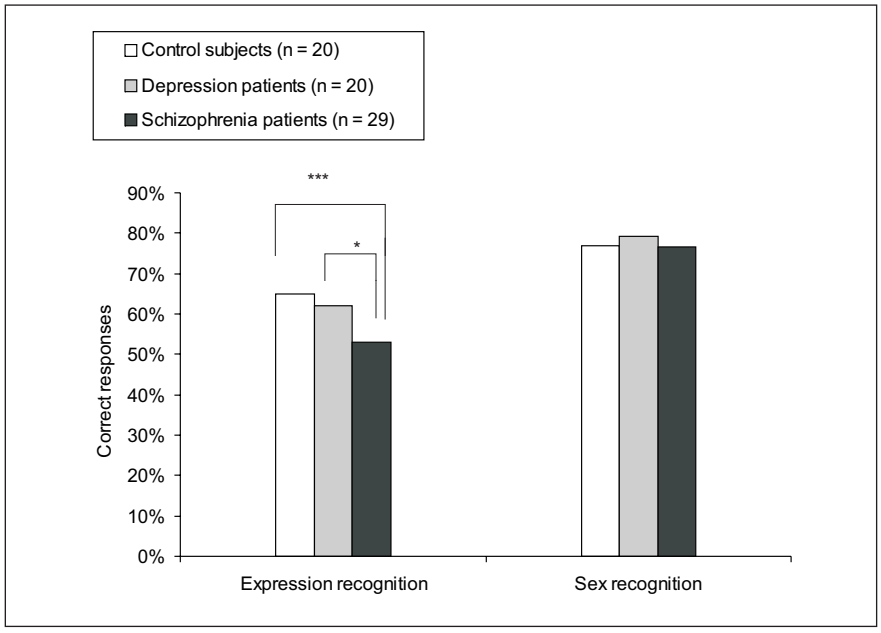
Sex Recognition Task (Control Task). Subjects viewed the 132 sex-morphed images introduced above. After each face presentation, subjects had to report which sex was depicted by choosing between man and woman and pressing the corresponding key.

Statistical Analyses

Correct response rates were included in statistical analyses. For each emotion and sex morphing, trials were gathered into 3 ranges of intensity: Trials containing morphed faces with 10% through 30% of facial expression or sex were pooled in a mild intensity range. Trials containing morphed faces with 40% to 70% of facial expression or sex were pooled in a moderate intensity range. Trials containing morphed faces with 80% to 100% of facial expression or sex were pooled in a high intensity range.

Since conditions for parametric statistics were not reached, we performed nonparametric analyses.The factors were group (patients with schizophrenia vs depression patients vs control subjects), task (emotion recognition vs sex recognition), emotion (disgust, fear, and happiness), sex (male vs female), and intensity (mild, moderate, and high). The first

Figure 1 Correct responses in the facial expression and sex recognition tasks



Asterisks indicate statistical differences with post hoc Mann–Whitney tests
*$P < 0.05$
***$P < 0.005$

factor was a between-subject factor, and the other 4 were within-subject factors. Dependent variables were a percentage of correct responses; level of significance was retained at 0.05.

A 3 (group) × 2 (task) Kruskal–Wallis 1-way variance analysis was performed to compare participants' performances in the emotion recognition and sex recognition tasks. Then, the following Kruskal–Wallis 1-way variance analyses were conducted: a 3 (group) × 3 (emotion) followed by a 3 (group) × 3 (emotional intensity) and a 3 (group) × 2 (sex) analysis followed by a 3 (group) × 3 (sex intensity) analysis. Post hoc Mann–Whitney tests were performed to compare schizophrenia patients with control subjects, major depression patients with control subjects, and schizophrenia patients with depression patients, when variance analyses were significant.

Uncorrected Spearman coefficients of correlations were calculated between performances and either clinical (illness duration, PANSS or MADRS scores, or treatment dosage) or demographic (age, education level, or sex) characteristics of each group.

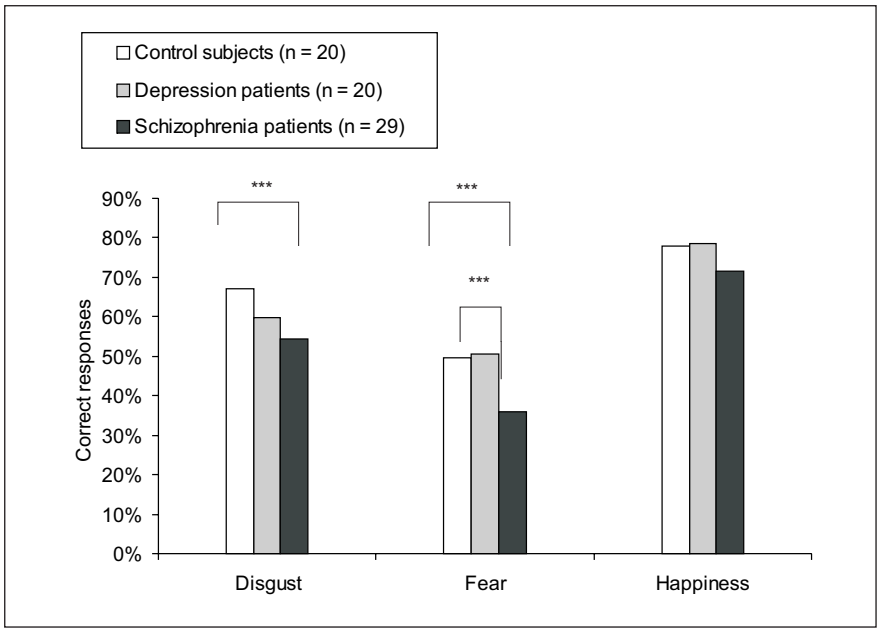
Results

Performances in the expression recognition task and in the sex recognition task are presented in Figures 1, 2, and 3.

Schizophrenia Patients Have a Selective Impairment in Facial Expression Recognition. The group × task Kruskal–Wallis 1-way analysis revealed a significant main effect in the expression recognition task ($H_2 = 10.072$, $P = 0.007$) but not in the sex recognition task ($H_2 = 0.299$, $P = 0.8$). Post hoc Mann–Whitney revealed that patients with schizophrenia achieved significantly lower scores than both control subjects ($U = 147$; $z = 2.91$; $P = 0.003$) and depression patients ($U = 178.5$; $z = 2.269$; $P = 0.02$) in the expression recognition task. Differences between depression patients and control subjects in the expression recognition task, as well as all other group differences in the sex recognition task, were not significant.

Schizophrenia Patients Are Impaired in the Recognition of Specific Emotions. The group × emotion Kruskal–Wallis 1-way analysis revealed a significant main effect for disgust ($H_2 = 8.960$, $P = 0.01$) and for fear ($H_2 = 16.536$, $P = 0.0003$) but not for happiness. Post hoc Mann–Whitney revealed significant group differences. For disgust, schizophrenia patients achieved lower scores than healthy control subjects ($U = 145.5$, $z = 2.74$, $P = 0.003$). For fear, patients with schizophrenia achieved lower scores than both control subjects ($U = 135.5$, $z = 3.14$, $P = 0.002$) and depression patients ($U = 111.00$, $z = 3.643$, $P = 0.0002$). No difference was found between depression patients and control subjects in the

Figure 2 Correct responses as a function of emotion in the facial expression recognition task



Asterisks indicate statistical differences with post hoc Mann–Whitney tests
*** $P < 0.005$

recognition of disgust and fear. Likewise, group differences in the recognition of happiness were not significant.

Facial Expression Recognition Is Impaired at Moderate and High Intensities in the Schizophrenia Group. The group × intensity Kruskal–Wallis 1-way analysis for expression recognition revealed a significant main group effect for moderate ($H_2 = 9.971$, $P = 0.007$) and high-intensity ($H_2 = 11.843$, $P = 0.003$) facial expressions. Post hoc Mann–Whitney revealed that patients with schizophrenia achieved significantly lower scores than both healthy control subjects ($U = 142.5$, $z = 3.004$, $P = 0.003$ for moderate intensity; $U = 136.00$, $z = 3.148$, $P = 0.002$ for high intensity) and depression patients at both intensities ($U = 183.50$, $z = 2.170$, $P = 0.03$ for moderate intensity and $U = 165.00$, $z = 2.552$, $P = 0.01$ for high intensity). Depression patients did not differ from control subjects in the recognition of moderate and high-intensity facial expressions. No difference was found between groups in the recognition of mild-intensity expressions.

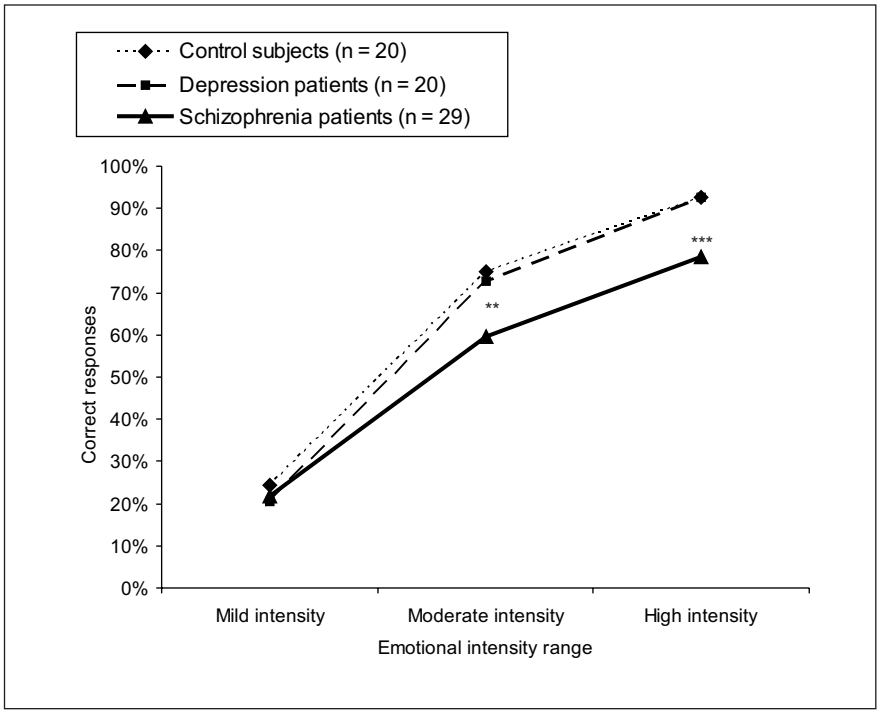
Discussion

This study used varying intensities of facial features to provide evidence for the following: 1) schizophrenia patients but not depression patients are selectively impaired in facial emotional expression recognition, whereas no deficit is observed in an invariant facial feature recognition (for example, sex); 2) fear and disgust recognition but not happiness recognition are impaired in schizophrenia; and 3) facial expression recognition is impaired at moderate and high intensities in the schizophrenia group.

Schizophrenia Patients Have a Selective Impairment in Facial Expression Recognition. Our study demonstrates that the facial expression recognition deficit observed in schizophrenia (6) does not affect major depression patients also showing social dysfunctions. It is unlikely that behavioural disorders observed in psychiatric diseases, such as poor motivation, attention deficit, or disturbed social interactions, mainly account for this impairment. Rather, our results reinforce the assumption that the deficit relies on neuronal abnormalities not encountered in major depression.

Impairment in the recognition of emotional expression, considered a changeable social facial feature, contrasts with preserved sex recognition, considered an invariant facial feature. These 2 facial features seem to be processed partly in different occipitotemporal areas. Sex processing is thought to involve posterior occipitotemporal regions, particularly in the right hemisphere (26), whereas expression processing involves the right superior temporal cortex (12). Our results reinforce the hypothesis of a dysfunction of downstream visual structures in patients with schizophrenia rather than of occipital areas involved in early visual processing (27). A failure in the retrograde neuromodulation coming from limbic and paralimbic structures on visual extrastriate areas, particularly the

Figure 3 Correct responses as a function of emotion intensity in the facial expression recognition task



Asterisks indicate statistical difference between groups with the Kruskal–Wallis test.
***P* < 0.01
****P* < 0.005

superior temporal sulcus and gyrus, can be hypothesized. Rosse and colleagues (28) found that gaze discrimination, another changeable social facial feature in Haxby's model, was impaired in schizophrenia, strengthening the hypothesis of a dysfunction of the superior temporal sulcus and gyrus in schizophrenia (29). However, this point is still controversial (30). Having used a control task involving sex recognition, we show that schizophrenia patients are selectively impaired in facial emotional expression recognition and not in the recognition of an invariant facial feature, for example, sex.

Schizophrenia Patients Are Impaired in the Recognition of Specific Emotions. Patients with schizophrenia were impaired in fear and disgust recognition but not in happiness recognition, which is in accordance with previous studies (31). Recent studies have shown that individual networks are involved in specific facial emotional expression processing. The occipitotemporal cortex, particularly the superior temporal sulcus and gyrus, seems to participate in the processing of changeable facial features, including facial emotional expression (32,33). The amygdala is involved in processing threat-related stimuli such as fear and anger (34), whereas the ventral anterior insula deals with disgust processing (17,35). The amygdala may participate in both automatic unconscious and attention-driven fear processing (36). The ventral anterior insula, a multimodal area particularly connected to gustatory, olfactory, and viscero-motor networks (37), may participate in the conceptual knowledge of disgust. Moreover, the ventral prefrontal cortex plays an important role in facial expression processing and emotional context processing in general (38,39). Thus all these structures seem to belong to an interconnected system that constructs a perceptual representation and knowledge of emotional messages. Aversive stimuli may induce an early amygdala reaction interacting with prefrontal context-related activity (36). These prefrontal, limbic, and paralimbic structures may modulate visual extrastriate areas to enhance emotion-related information extraction from facial features (40). This stage may be impaired in schizophrenia, since the prefrontal cortex is known to be particularly affected in these patients (41). A dysregulation between the prefrontal cortex and the amygdala may occur in emotion-related arousal in schizophrenia (42). Consistently, impaired facial expression recognition in schizophrenia patients relates to hypoactivation of distributed brain regions, including the inferior prefrontal cortex (27). Interestingly, following histological, anatomical, and functional arguments, authors have reported insular and amygdalar involvement in schizophrenia pathophysiology (43). Consistent with this, patients with schizophrenia are impaired in processing negative emotions from

several sensorial modalities: facial expressions, prosody (20), and olfactory stimuli (44).

Facial Expression Recognition Is Impaired at Moderate and High Intensities in the Schizophrenia Group. To our knowledge, this is the first study confirming a selective impairment in facial expression recognition, compared with preserved sex recognition, in schizophrenia patients. Of particular interest is the inclusion of different intensities of facial features that increase test sensitivity. Considering this, patients with schizophrenia achieved lower scores than both other groups in the recognition of moderate- and high-intensity facial expressions. Moreover, the difference between groups was more significant with high intensities than with moderate ones, although this last condition may be reasonably more difficult. With mild intensities, all groups were at chance level. This result suggests that schizophrenia patients do not benefit from increased intensity of emotional expression. Therefore, it is unlikely that task difficulty accounts solely for schizophrenia patients' deficit in processing facial expressions. The use of morphed faces simulating increasing intensities of facial features may render the test more sensitive and probably more appropriate for subjects who may have intermediate performance between patients and control subjects, such as subjects at risk for schizophrenia (45–49). The use of morphed images depicting various intensities of facial features may be useful for future research.

Limitations

Some limitations should be discussed. First, differences in age and in education level might explain significant group differences (20). However, statistical analyses did not reveal any influence of age or education on performance, and no significant correlation was found between performance in facial expression or facial sex recognition and clinical or demographic characteristics. Moreover, demographic characteristics (for example, age and education level) do not affect facial expression recognition (50). Second, all patients with schizophrenia, as well as most depression patients, were under medication. However, many reports have failed to find any influence of medication on facial expression recognition (51).

Conclusions

Patients with schizophrenia exhibit a deficit in fear and disgust recognition, whereas sex recognition is unimpaired. This confirms a selective impairment in the recognition of changeable facial features that are particularly involved in social cognition. Schizophrenia patients' deficit in facial expression recognition may rely on a dysfunction of the corticolimbic neural network subserving facial expression recognition, whereas posterior ventral occipitotemporal regions processing invariant facial features may function adequately. Top-down retrograde modulation coming from downstream prefrontal cortex, amygdala, and insula may also malfunction. The absence of deficit in major depression patients further reinforces the idea of a neural dysfunction rather than a pure behavioural disorder in schizophrenia.

Funding and Support

We sincerely thank the Conseil Scientifique de la Recherche from Centre Hospitalier Le Vinatier for their financial support.

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Manuscript received October 2004, revised, and accepted January 2005.
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Résumé : La reconnaissance de l'expression du visage et du sexe dans la schizophrénie et la dépression

Contexte : La reconnaissance déficiente de l'expression du visage dans la schizophrénie contribue au fonctionnement social anormal et peut prédire le bilan fonctionnel chez ces patients. L'interprétation de l'expression du visage fait appel à des réseaux neuronaux individuels dont le dysfonctionnement a été démontré dans la schizophrénie. La controverse demeure à savoir si ces patients ont un déficit sélectif de la reconnaissance de l'expression du visage ou une incapacité plus globale d'interpréter l'expression du visage.

Objectif : Examiner si les patients souffrant de schizophrénie présentent un déficit sélectif de la reconnaissance de l'expression du visage comparativement à des patients souffrant de dépression majeure et à des sujets témoins en santé.

Méthodes : Le rendement de la reconnaissance de l'expression du visage et des paradigmes de la reconnaissance du sexe par le visage, à l'aide de visages originaux créés par morphage, a été étudié dans une population schizophrène (n = 29) et a été comparé avec des patients dépressifs (n = 20) et des sujets témoins (n = 20).

Résultats : Les patients souffrant de schizophrénie ont obtenu des scores moins élevés que ceux des deux autres groupes en ce qui concerne la reconnaissance de l'expression, particulièrement celle de la peur et du dégoût. La reconnaissance du sexe n'était pas déficiente.

Conclusion : La reconnaissance de l'expression du visage est déficiente dans la schizophrénie, alors que la reconnaissance du sexe est préservée, ce qui suggère fortement une interprétation anormale des traits changeants du visage dans cette maladie. Un dysfonctionnement de la modulation rétrograde descendante provenant des structures limbiques et paralimbiques sur les zones visuelles est une hypothèse.