Fusiform Gyrus Volume Reduction and Facial Recognition in Chronic Schizophrenia

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**Background:** The fusiform gyrus (FG), or occipitotemporal gyrus, is thought to subserve the processing and encoding of faces. Of note, several studies have reported that patients with schizophrenia show deficits in facial processing. It is thus hypothesized that the FG might be one brain region underlying abnormal facial recognition in schizophrenia. The objectives of this study were to determine whether there are abnormalities in gray matter volumes for the anterior and the posterior FG in patients with chronic schizophrenia and to investigate relationships between FG subregions and immediate and delayed memory for faces.

**Methods:** Patients were recruited from the Boston VA Healthcare System, Brockton Division, and control subjects were recruited through newspaper advertisement. Study participants included 21 male patients diagnosed as having chronic schizophrenia and 28 male controls. Participants underwent high-spatial-resolution magnetic resonance imaging, and facial recognition memory was evaluated. Main outcome measures included anterior and posterior FG gray matter volumes based on high-spatial-resolution magnetic resonance imaging, a detailed and reliable manual delineation using 3-dimensional information, and correlation coefficients between FG subregions and raw scores on immediate and delayed facial memory derived from the Wechsler Memory Scale third edition.

**Results:** Patients with chronic schizophrenia had overall smaller FG gray matter volumes (10%) than normal controls. Additionally, patients with schizophrenia performed more poorly than normal controls in both immediate and delayed facial memory tests. Moreover, the degree of poor performance on delayed memory for faces was significantly correlated with the degree of bilateral anterior FG reduction in patients with schizophrenia.

**Conclusion:** These results suggest that neuroanatomic FG abnormalities underlie at least some of the deficits associated with facial recognition in schizophrenia.

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in facial recognition are stable throughout the illness, suggesting it is traitlike. Additional symptoms of delusional misidentification are sometimes observed in patients with schizophrenia. Taken together, these findings suggest that FG might be one of the brain areas underlying impaired facial recognition in schizophrenia.

Magnetic resonance imaging has been useful in revealing subtle structural brain abnormalities in schizophrenia, although there are few studies that have measured the FG. Goldstein et al. measured the entire cerebral cortex and found no difference in FG volumes between patients and normal controls. Paillère-Martinet et al. investigated gray and white matter volumes in early-onset schizophrenic patients using voxel-based morphometry. They reported significant gray matter reductions in medial frontal gyri, left insula, left parahippocampus, and left FG in patients. Our group measured FG volumes and reported bilateral FG reduction, which was specific to first-episode schizophrenia compared with first-episode manic psychosis. One research group has measured FG volume in a postmortem study of schizophrenia. These investigators measured the anterior portion of FG (their posterior boundary of FG was the most posterior temporal lobe slice where the hippocampus was visible), finding smaller left FG volume and a reversal of the normal left-greater-than-right volume asymmetry in patients with schizophrenia.

In the present study, we investigated FG and facial recognition in a sample of patients with chronic schizophrenia. It has been our experience that anatomic-clinical symptom correlations are more evident in patients with chronic schizophrenia, and thus, although we did not evaluate facial recognition in our earlier study of first-episode schizophrenia, we included an evaluation of facial recognition in the present study, in accord with the many reports of impairment of facial recognition in chronic schizophrenia.

Accordingly, we measured FG gray matter volume using high-spatial-resolution MRI (0.9375-mm voxels in resampled slices) and 3-dimensional information to provide reliable measures for evaluation of the FG. We also evaluated immediate and delayed memory scores for faces using the Wechsler Memory Scale III (WMS-III). As noted herein, we reported bilateral FG reduction in first-episode schizophrenia; thus, we hypothesized that FG volume reduction might be associated with poor performance for memory for facial recognition in patients with chronic schizophrenia. The goal of the current study was to determine whether FG abnormalities are present in chronic schizophrenia.

**SUBJECTS**

Twenty-one male patients with chronic schizophrenia and 28 male, normal control subjects participated in this study. All MRIs were acquired between 1996 and 2001. Subjects in the present study included 21 new subjects and 28 subjects common (14 patients and 14 normal controls) to our most recently published region of interest (ROI) study in chronic schizophrenia (that of superior temporal gyrus [STG], amygdala-hippocampal complex, and parahippocampal gyrus). The age range for inclusion in the study was 20 to 55 years. Subjects were included if they had no history of (1) neurologic illness or major head trauma, (2) electroconvulsive therapy, (3) alcohol or other drug dependence, or (4) alcohol and other drug abuse within the past 5 years. Patients were recruited from the Boston VA Healthcare System, Brockton Division, Brockton, Mass. All patients were diagnosed as having schizophrenia based on the DSM-III-R criteria, using information from the Structured Clinical Interview for DSM-III-R by trained interviewers (M.E.S. and P.G.N.). All patients were receiving neuroleptic medication, with a mean ± SD daily dose equivalent to 576 ± 257 mg of chlorpromazine. The mean ± SD age of patients was 42.7 ± 8.4 years, their mean ± SD age at symptom onset was 22.0 ± 2.9 years, and their mean ± SD duration of illness was 20.7 ± 8.3 years.

Normal control subjects were recruited through newspaper advertisement and screened to exclude neurologic and psychiatric illness and alcohol abuse in them or in their first-degree relatives. The mean ± SD age of the normal control group was 42.0 ± 7.5 years.

Handedness was assessed using the Edinburgh inventory (mean ± SD scores, 0.77 ± 0.20 for patients and 0.80 ± 0.18 for normal controls), and socioeconomic status (SES) of subjects was measured by the Hollingshead 2-factor index (1 = highest, 5 = lowest; mean ± SD scores, 4.2 ± 0.6 for patients and 2.0 ± 1.1 for normal subjects). Parental SES was also measured (mean ± SD scores, 3.0 ± 1.2 for patients and 2.3 ± 1.0 for normal subjects). All subjects were given the Wechsler Adult Intelligence Scale–Revised (WAIS-R) information subtest (mean ± SD scores, 10.2 ± 2.1 for patients and 11.0 ± 1.8 for normal subjects) as an estimate of gross fund of information. After complete description of the study, written informed consent was obtained from all participants.

**CLINICAL EVALUATIONS**

The Positive and Negative Syndrome Scale (PANSS) was administered to patients. Mean ± SD PANSS scores on the positive symptom scale, the negative symptom scale, and the general psychopathologic scale were 19.9 ± 2.2, 20.9 ± 6.9, and 36.9 ± 10.5, respectively. Raw scores on immediate and delayed facial memory in WMS-III (perfect score, 48) were available for 14 normal controls and 14 patients with schizophrenia. The scores were obtained within 1 year of MRI acquisition. Subjects were shown a series of 24 photographs of faces, one at a time, and asked to remember each one. Subjects were then shown a second series of 48 photographs, one at a time, half of which included photographs of faces already shown that subjects were instructed to remember. Subjects were instructed to respond “yes” if the face was one that they had been instructed to remember or “no” if it was not. At the completion of this immediate recognition test, subjects were instructed to remember the first group of 24 photographs of faces. Approximately 30 minutes later, subjects were given a delayed recognition test of 48 photographs of faces, one at a time, half of which included those photographs of faces first presented. Subjects were again instructed to respond “yes” if the face was one that they were instructed to remember earlier or “no” if it was not. Immediate and delayed memory tests were scored by subtracting the total number of incorrect responses from the total responses.

**MRI ACQUISITION AND PROCESSING**

The MRIs were acquired with a 1.5-T General Electric scanner (GE Medical Systems, Milwaukee, Wis) at the Brigham and Women’s Hospital in Boston. The scanning and image methods are described in detail elsewhere. The acquisition protocol included...
2 MRI pulse sequences. The first sequence resulted in contiguous spoiled gradient-recalled images. The imaging variables were as follows: repetition time, 35 milliseconds; echo time, 5 milliseconds; repetitions, 1; mutation angle, 45°; field of view, 24 cm; number of excitations, 1, 0; and matrix, 256 × 256 (192 phase-encoding steps) × 124. Voxels were 0.9375 × 0.9375 × 1.5 mm. Data were formatted in the coronal plane and analyzed as 124 coronal 1.5-mm-thick slices. This protocol was used for delineating and measuring the FG. The second acquisition sequence resulted in an axial series of contiguous double-echo (proton density and T2-weighted) images. The imaging variables were as follows: repetition time, 3000 milliseconds; echo time, 30 and 80 milliseconds; field of view, 24 cm; and an interleaved acquisition with 3.0-mm slice thickness. The voxel dimensions were 0.9375 × 0.9375 × 3.0 mm. This latter pulse sequence was used to measure the volume of the total intracranial contents (ICC) (brain, cerebrospinal fluid, connective tissue, and blood vessels). An anisotropic diffusion filter was applied to the images to reduce noise before processing each set of scans. The intensity information from both the spoiled gradient-recalled and T2-weighted images was then used in a fully automated segmentation program to classify tissue into gray matter, white matter, and cerebrospinal fluid. An iterative expectation-maximization algorithm initially estimated image intensity inhomogeneities, applied intensity corrections based on these estimates, and then classified tissue based on the same set of signal intensity parameters for all subjects. As described previously, images were aligned using the line between the anterior and posterior commissures and the sagittal sulcus to correct head tilt and were also resampled to make voxels isotropic (sides measured 0.9375 mm). Segmented voxels were used to assist in the manual definition of the ROIs.

DEFINITION OF FG

In the present study, we used criteria similar to both our previous work and to the work of Kim et al., who provided detailed guidelines for FG measurement in the parcellation of the temporal lobe. Manual drawings of the FG were performed on the coronal plane, blind to diagnoses. We always referred to both the axial and sagittal slices. The anterior landmark was reliably defined by the first slice posterior to the appearance of the mammillary body. The posterior landmark was determined by the anterior tip of the parieto-occipital sulcus in the mid-sagittal plane. The last slice, including the crus of the fornix, provided the boundary for subdivision of the FG into anterior and posterior (this boundary was almost identical with the last slice that included hippocampus). The collateral sulcus was used as the medial border. The occipitotemporal sulcus was used to determine the lateral border. This sulcus is interrupted frequently (the proportion of the FG that has a single continuous sulcus is 48% for the right side and 24% for the left side). In such interrupted cases, the border was decided as the prominent sulcus on the coronal and axial slices. Figure 1 shows the ROIs of the FG in axial, sagittal, and coronal slices and a 3-dimensional reconstruction of the FG.

Interrater reliability was computed for the ROIs by 3 independent raters (T.O., K.K., and S.K.T.), who were blind to group membership. Five cases were selected randomly for intrarater reliability. Three raters measured the FGs on every third slice. An intraclass correlation coefficient was used to compute interrater reliability. For the 3 raters, the intraclass correlations were 0.95 for the left FG and 0.96 for the right.

STATISTICAL ANALYSES

We used t tests to assess group differences in age, handedness score, and total ICC. Mann-Whitney U tests were used to assess differences in WAIS-R information subscale scores, SES, and parental SES. To correct for variations in brain size, we used relative volumes of FG computed as \( \left( \text{absolute FG volume} / \text{ICC} \right) \times 100 \) for ROI analysis. To determine whether certain ROIs were more affected than other ROIs, the ROI volumes were first converted to z scores so that all the ROIs would be on the same scale. The mean and SD of the control group were used to calculate the z scores. For ROI analysis, the standardized scores were submitted to a mixed-model, repeated-measures analysis of variance with group (schizophrenia or controls) as a between-subjects factor and hemisphere (left or right) and subdivision (anterior or posterior) as within-subjects factors. We also performed repeated-measures analyses of covariance using ICC as a covariate for ROI analysis; statistical results were the same using both methods.

Exploratory analyses of the relationship between volumes of FG and the psychopathology scales were evaluated using Spearman \( \rho \) to diminish the effect of any outliers. The relationship between volumes of FG and demographic data were also evaluated using Spearman \( \rho \). Mann-Whitney U tests were used to assess group differences in raw scores on immediate and delayed facial memory. The relationship between volumes of FG and these scores was evaluated using Spearman \( \rho \). Herein, all correlations were considered significant only if they reached \( P \leq .05 \) (2-tailed) for both relative and absolute volumes.

RESULTS

There were no significant group differences in age, handedness score, parental SES, or WAIS-R information subscale score. Patients with schizophrenia showed significantly lower SES than normal control subjects (Mann-Whitney U test, \( z = -5.36, P < .001 \)), consistent with reduced functioning due to the disorder.

VOLUME OF FG

Table 1 presents absolute and relative FG volumes of patients with schizophrenia and normal controls. The 3-factor (2 groups × 2 sides × 2 subdivisions) analysis of variance of standardized ROI values (Z scores) revealed a significant main effect of group (F1,47 = 7.00, \( P = .01 \)), with no group × side × subdivision interaction (F1,47 = 0.04, \( P = .84 \)), no significant group × side interaction (F1,47 = 0.17, \( P = .68 \)), and no significant group × subdivision interaction (F1,47 = 0.12, \( P = .73 \)). These results indicated that schizophrenic patients had bilaterally reduced anterior and posterior FG gray matter volumes compared with control subjects. The percentage of overall relative FG reduction of patients relative to control subjects was 10% (Table 1 and Figure 2). The results did not change when ICC was used as a covariate instead of using relative volume for ROI analysis. The statistically significant results also did not change when we limited the statistical comparisons to the 14 patients with schizophrenia and the 14 normal controls whose scores on facial memory were available.

Age, SES, and parental SES did not correlate statistically significantly with FG volumes in normal controls (P values were .09-.99). Age, SES, parental SES, duration of illness, and dose (chlorpromazine equivalent) of medication also did not correlate statistically significantly with FG volumes in patients with schizophrenia (P values were .06-.98).
In an exploratory analysis of correlations between FG gray matter volume and psychopathologic measures, we found no significant correlations between FG gray matter volume and PANSS scores on the positive symptom scale, the negative symptom scale, or the general psychopathology scale.

**SCORES ON IMMEDIATE AND DELAYED MEMORY FOR FACES**

Scores are presented as mean ± SD. The mean score for immediate memory for faces was 36.8 ± 3.5 in normal controls. In patients with schizophrenia, the mean score was 32.3 ± 2.9, a significantly lower score than normal control subjects (Mann-Whitney U test, z = −3.0, P = .002). The mean score for delayed memory for faces was 39.1 ± 4.4 in normal controls. In patients with schizophrenia, the mean score was 34.4 ± 3.5, a statistically significantly lower score than normal control subjects (Mann-Whitney U test, z = −2.68, P = .007).

**Table 2** presents Spearman ρ correlations between FG absolute volumes and scores for immediate and delayed memory for faces in patients with schizophrenia and normal controls. In normal controls, there were no statistically significant correlations between anterior or posterior FG gray matter volume and scores for immediate memory. There were also no statistically significant correlations between anterior or posterior FG gray matter volume and scores for delayed memory.

In patients with schizophrenia, there were no statistically significant correlations between anterior or posterior FG gray matter volume and scores for immediate memory for faces. There were also no statistically significant correlations between posterior FG gray matter volume and scores for delayed memory.

**Figure 1.** Delineation of the anterior and posterior fusiform gyrus regions of interest in coronal (A), sagittal (B), and axial images (C). The gray matter of the anterior fusiform gyrus is shown in red (subject left) and green (subject right). The gray matter of the posterior fusiform gyrus is shown in orange (subject left) and blue (subject right). D, A 3-dimensional reconstruction of the fusiform gyrus.
for delayed memory for faces. However, there were statistically significant positive correlations between left anterior FG gray matter absolute volume and scores for delayed memory for faces ($p_{13}=0.640$, $P=.01$). There were also statistically significant positive correlations between right anterior FG gray matter absolute volume and scores for delayed memory for faces ($p_{13}=0.658$, $P=.01$).

Since the score for delayed memory for faces was significantly correlated with bilateral anterior FG volumes in patients, we thus compared the group difference in these correlation coefficients using the Fisher $r$-to-$z$ transformation. Given the directional nature of our hypothesis, 1-tailed tests were warranted here. Based on the Fisher $z$ transformation, there was a significant group difference in the relationship between left anterior FG gray matter absolute volume and scores for delayed memory for faces ($z=-1.69$, $P=.046$). There was also a significant group difference in the relationship between right anterior FG gray matter absolute volume and scores for delayed memory for faces ($z=-1.85$, $P=.03$). Additionally, analyses of the relationship between volumes of other ROIs and the score were evaluated using the Spearman $\rho$. Volumes for STG, middle temporal gyrus, inferior temporal gyrus, and anterior or posterior amygdala-hippocampal complex were available for 14 patients with scores for faces. There were no statistically significant correlations between these ROIs and scores for delayed memory for faces in patients with schizophrenia. Finally, using the Spearman $\rho$, we evaluated the relationship between anterior or posterior FG volumes and the scores on the items of Family Pictures I and II, which are the other scales for memory using visual stimuli in WMS-III. There were no statistically significant correlations between anterior or posterior FG volumes and these scores in 14 patients with schizophrenia.

**COMMENT**

The current study examined gray matter volume in anterior and posterior FG by using high-resolution MRI and neuroanatomically based, reliable boundary definitions. The major findings of this study were as follows: (1) patients with schizophrenia showed bilateral anterior and posterior FG gray matter volume reduction, (2) patients with schizophrenia performed more poorly than normal controls in both immediate and delayed facial memory tests, and (3) performance on delayed memory for faces was correlated bilaterally with anterior FG volume in patients with schizophrenia.

The present data are consistent with our earlier findings of overall 9% smaller relative FG volumes in first-episode schizophrenia when compared with controls. The literature reports of MRI findings on FG in patients with schizophrenia are, nonetheless, mixed. Goldstein et al. measured the entire cerebral cortex in 29 patients with schizophrenia and 26 control subjects, where they divided the entire neocortex into 48 topographically defined brain regions and found no difference in FG volumes between groups. Pailhère-Martinet et al. investigated gray and white matter volumes in 20 male patients with early-onset schizophrenia using voxel-based morphometry. They reported significant gray matter reductions in medial frontal gyri, left insula, left parahippocampus, and left FG in patients.

**Table 1. Absolute and Relative Volumes for Fusiform Gyrus Gray Matter in Chronic Schizophrenia Patients and Normal Controls$^*$**

<table>
<thead>
<tr>
<th>Volume Area</th>
<th>Patients With Schizophrenia (n = 21)</th>
<th>Normal Controls (n = 28)</th>
<th>$t$ Test</th>
<th>df</th>
<th>$P$ Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total ICC</td>
<td>1518.3 ± 110.0</td>
<td>1566.4 ± 140.7</td>
<td>1.30</td>
<td>47</td>
<td>.20</td>
</tr>
<tr>
<td>Left total FG</td>
<td>5.63 ± 0.98</td>
<td>6.56 ± 1.02</td>
<td>3.23</td>
<td>47</td>
<td>.002</td>
</tr>
<tr>
<td>Left anterior FG</td>
<td>2.58 ± 0.45</td>
<td>3.00 ± 0.59</td>
<td>2.73</td>
<td>47</td>
<td>.009</td>
</tr>
<tr>
<td>Right total FG</td>
<td>5.92 ± 1.36</td>
<td>6.66 ± 0.90</td>
<td>2.28</td>
<td>47</td>
<td>.03</td>
</tr>
<tr>
<td>Right anterior FG</td>
<td>2.54 ± 0.50</td>
<td>2.93 ± 0.55</td>
<td>2.49</td>
<td>47</td>
<td>.02</td>
</tr>
</tbody>
</table>

$^*$Data are presented in milliliters as mean ± SD. Relative volumes (percentage of total ICC) are in parentheses. Statistical significance levels were computed using $t$ tests. Abbreviations: FG, fusiform gyrus; ICC, intracranial contents.

The postmortem study by McDonald et al. reported 13.2% smaller left FG gray matter volume in 31 patients with schizophrenia, whereas there was no statistically significant volume decrease for the right FG. They further reported a reversal of the normal left-greater-than-right volume asymmetry in patients with schizophrenia and also reported that female subjects had 15%
smaller FG volumes than male subjects in normal subjects and in patients with schizophrenia. Their FG volume measures corresponded most closely to the anterior FG in the present study, since their posterior boundary of FG was near to our posterior boundary of the anterior FG. In our study, the schizophrenia group showed a relative gray matter volume reduction of 11% for left anterior FG and 10% for right anterior FG.

Thus, in the present study, we found bilateral FG reduction in patients with schizophrenia. This finding suggests that patients may have the bilateral impairment in the ventral visual pathway. Previous studies from our laboratory revealed left lateralized gray matter volume reductions for posterior STG, medial temporal lobe, and pnuma temporale in patients with chronic schizophrenia. Left lateralized functional dominance is present in languagespecific areas of right-handed individuals. However, the presence of hemispheric dominance in FG is unclear. In functional neuroimaging studies of normal subjects, it has been reported that face perception involves bilateral ventral pathways but with a tendency for right-lateralized activations for faces but not for objects. Thus, it may be that temporal areas with left lateralized functional dominance may show more preferential left-sided reduction, whereas areas with less left lateralized dominance may show bilateral reduction in patients with schizophrenia.

In the present study, patients with schizophrenia performed more poorly than normal controls in both immediate and delayed facial memory tests, which is consistent with findings from other visual memory tests. For example, Dougherty et al reported that schizophrenic patients performed poorly on immediate and delayed visual memory tests, which were variants of developed continuous performance tests. Of particular note, however, in the present study, performance on delayed memory for faces was significantly correlated bilaterally with anterior FG volume in patients with schizophrenia. Additionally, the present study demonstrated specificity in the relationship between anterior FG and delayed memory for faces by showing that delayed memory for faces was correlated with anterior FG but not other ROIs, whereas anterior FG volume was not correlated with immediate memory for faces or with other, nonfacial visual stimuli. This supports the hypothesis that neuroanatomic FG abnormalities underlie the deficit of delayed memory for facial recognition in patients with schizophrenia and are not part of a more generalized processing deficit.

The literature supports our finding of an association between face processing and FG. Recent functional neuroimaging studies have revealed that neuronal activity in the FG changes with memorizing faces. More specifically, Kuskowski and Pardo reported that the FG was activated while memorizing pictures of unfamiliar human faces presented one at a time and that the right middle FG activity was correlated with postscan facial recognition scores, leading them to suggest that the FG is involved in deep processing and memory encoding of face stimuli. Wiser et al reported a contribution of the FG while recognizing faces learned a week before and for faces seen a minute before. They suggested that novel memory for faces was primarily a frontal lobe task, whereas well-learned recognition memory for faces was related to more visual areas, including the FG, which seemed to serve as memory storage sites. In congruence with our findings of an association between anterior FG and delayed memory for faces, it has been suggested that the anterior portion of the ventral temporal lobe is more involved in visual mnemonic processes. Tran et al reported that defective recognition of persons was associated with the right anterior temporal regions in patients with brain damage, which is partially compatible with our finding of the association between anterior FG reduction and poor performance on delayed memory for faces in patients with schizophrenia. Finally, Hudson and Grace, in their discussion of a case of misidentification syndrome caused by an infarction in what we define as anterior FG, suggested that, in addition to possible interference with face processing, interference with specific past visual memories might result in impaired associations for human faces.

We found no statistically significant correlations between FG gray matter volume and PANSS scores, perhaps reflecting a more immediate association of FG volume with the simpler process of face recognition than with the more complex features of clinical abnormalities.

In summary, in the present study, we used consistent neuroanatomic boundaries for defining FG and found bilateral gray matter FG volume reduction in patients diagnosed as having schizophrenia compared with normal controls. Functionally, FG is implicated in structural encoding and learning of faces, which may be deficient in patients with chronic schizophrenia. The latter is further suggested by the observed poor performance in delayed memory for faces in the patients, which was significantly correlated with bilateral volume reduction of anterior FG in patients with schizophrenia. These

<table>
<thead>
<tr>
<th>Volume Area</th>
<th>Immediate Recognition</th>
<th>Delayed Recognition</th>
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<tbody>
<tr>
<td></td>
<td>Patients With Schizophrenia</td>
<td>Normal Controls</td>
</tr>
<tr>
<td></td>
<td>(P Value) (n = 14)</td>
<td>(P Value) (n = 14)</td>
</tr>
<tr>
<td>Left anterior FG</td>
<td>-0.004 (.98)</td>
<td>-0.108 (.71)</td>
</tr>
<tr>
<td>Right anterior FG</td>
<td>0.038 (.90)</td>
<td>0.210 (.47)</td>
</tr>
<tr>
<td>Left posterior FG</td>
<td>-0.169 (.56)</td>
<td>0.499 (.07)</td>
</tr>
<tr>
<td>Right posterior FG</td>
<td>-0.373 (.19)</td>
<td>0.389 (.17)</td>
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*P < .05.
results suggest that neuroanatomic FG abnormalities underlie at least some of the deficits associated with facial recognition in schizophrenia.

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REFERENCES