Mental Imagery in First-Degree Relatives of Patients with Schizophrenia

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Abstract

Background: Implicit mental rotation has been studied in patients with schizophrenia; however, no research has examined it in relatives of the patients.

Objectives: This study compared the performances of schizophrenia patients with their unaffected relatives to shed further light on the nature of cognitive functioning in schizophrenia relatives.

Materials and Methods: We examined mental rotation in 25 schizophrenia patients, 25 of their first-degree relatives and 25 controls, using the Hand Rotation Task. In this task, the participants had to determine the laterality of hands showed in various orientations.

Results: The results of this study revealed that the mean error rate of the relatives was significantly different between patients and healthy controls (all P < 0.03), ii), the mean response times of both patients and relatives were significantly slower than controls (all P < 0.004).

Conclusions: These findings suggest that mental rotation may be a trait marker for schizophrenia.

Keywords: First-Degree Relatives, Hand Rotation, Mental Imagery, Schizophrenia, Trait

1. Background

Mental rotation is the ability to imagine how a mis-oriented object would emerge if it was rotated away from the existing orientation (1). In Parson’s hand rotation task, participants should judge the laterality of the pictures or hands in various rotation angles (2). Typically, error rates and reaction times increase as a function of the rotation angle of the stimulus, indicating that participants engage in a cognitive process of mental rotation. Moreover, mental rotation is a complex cognitive process and is associated with core psychological process such as perception, speed of spatial processing, executive function, and working memory (1). At electrophysiological level, ERP studies have found a modulated positive wave of about 300 - 700 ms, rotation-related negativity (RRN), reflecting the mental rotation process, with decreasing amplitudes for increasing angles of rotation (3, 4).

Using hand rotation tasks, studies have shown that patients with schizophrenia were slower and less accurate than controls. However, they displayed the same decrease in reaction time and accuracy with increasing the angles of rotation in control participants (5-8). Moreover, inaccuracy in the test of hand rotation was associated with speed of information processing and executive dysfunction in patients with schizophrenia (9). In an ERP study, Mazhari et al. (2013) (10) found significantly reduced rotation-related negativity amplitude for mental rotation effect in patients with schizophrenia. Altogether, the above-mentioned studies showed an impaired mental rotation of hand at both behavioral and neural levels.

Factors associated with schizophrenia, particularly medication effects, and positive and negative symptoms influence patients’ performances, making interpretation become difficult. These factors potentially affect task performance and are not easy to separate from the effects of basic psychopathology. As cognitive impairments show the underlying genetic risk for schizophrenia, it is important to study the unaffected first-degree relatives of the patients as they have some common genetic vulnerability without presenting the similar experimental problems. Although there are evidences of impaired performance of schizophrenia in mental rotation tasks, to our knowledge, no study has examined this ability in first-degree relatives of the patients.

Mental rotation can be fractioned into sub-processes that are responsible for inspection and active manipula-
tion of internal representations (1). In fact, it is well recog-
nized that mental rotation is closely interrelated to work-
ing memory ability (11). Deficits in working memory are
among the most replicated findings in schizophrenia and
considered as a core feature of this disorder (12, 13). More-
over, the working memory deficits have been found in
healthy first-degree relatives of schizophrenia (14, 15).

2. Objectives

Therefore, it is worthy to study the mental rotation in
the first-degree relatives of schizophrenia patients. This
study compared the performances of schizophrenia pa-
tients and their unaffected relatives to that of a control
group on the hand rotation task to shed further light
on the nature of cognitive functioning in the relatives
of schizophrenia patients.

3. Materials and Methods

3.1. Participants

A group of 25 patients with schizophrenia (20 Males)
selected from the outpatients of a psychiatric hospital, and
25 first-degree relatives (17 Males) of the patients partici-
pated in this study. All patients had DSM-IV criteria for a
lifetime diagnosis of schizophrenia. They were examined,
using the positive and negative syndrome scale (PANSS) for
schizophrenia (16). Patients continued their antipsychotic
medications, and the mean chlorpromazine (CPZ) equiva-

cent dose was 401 mg (17). Patients did not have a history of
electroconvulsive therapy within six months prior to the
testing time.

The control group consisted of 25 individuals (20
Males) screened for a personal and family history of psy-
chotic illnesses. Exclusion criteria for all participants were
a history of head injury, neurological disorders, and cur-
rent substance abuse. All participants were right-handed
and had normal vision. After explaining the experiment,
a written informed consent was obtained from all the par-
ticipants. The Ethics Committees of Kerman University of
Medical Sciences, Iran, approved the study.

3.2. Hand Rotation Task (HRT)

The Parson's classical hand-rotation task was applied.
In this task, the laterality of the pictures, representing
right or left hands in different rotation angles is judged
by participants. The participants were seated on a chair in
front of a table. The stimuli included line drawings of the
right and left hands in palm and back view (Figure 1), pre-
sented in random order. Hand pictures were rotated in six

3.3. Data Analyses

Analysis of variance (for continuous variables) and Chi-
square (for dichotomous variables) were used to examine
between-group differences in demographic variables.

Because our focus was on the difference between per-
formances of the three groups, various rotations were col-
lapsed into two angles of rotation: Small rotation angle
(0°, 60°, and 300°), and large rotation angle (120°, 180°, and
240°). A repeated-measures ANOVA with group (patient,
relatives, control) as between-subject, and hand rotation
angles (small, large) as within-subject was used to exam-
ine accuracy and response time of HRT between groups in
different angles.

4. Results

Table 1 demonstrates the demographic characteristics
of the total study sample. The three groups did not signifi-
cantly differ in sex, age, and years of education. Table 2 dis-

4.1. Response Accuracy

The mean accuracy rates among the two degrees of ro-
tations were calculated (Table 2). The results of repeated
measure ANOVA revealed a significant effect of group (F (3,
65) = 13.6, P < 0.001, \( \eta^2 = 0.3 \)), suggesting that accuracy rates
were significantly different between the three groups. Bon-
ferroni corrected post-hoc comparisons indicated signifi-
cant differences between the patients and both relatives
and controls (all P < 0.009), and a significant difference be-
tween relatives and controls (all P < 0.03) on both small
and large angles (Figure 2). There was a significant main
effect of the stimulus angle (F (1, 65) = 61.6, P < 0.001, \( \eta^2 = 0.48 \)), indicating a decrease in accuracy with increased an-
gle of rotation. The interaction effects between group and
the stimulus angle were not significant (F (2, 65) = 0.73, P
= 0.48, \( \eta^2 = 0.02 \)), suggesting similar performances of the
three groups across different stimulus angles.
Table 1. The Demographic and Clinical Characteristics of the Participants

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
<th>Relatives</th>
<th>Controls</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>33.4 ± 8.2</td>
<td>35.2 ± 10.6</td>
<td>33.4 ± 9.1</td>
<td>0.8</td>
</tr>
<tr>
<td>Sex, No. (%) of male</td>
<td>20 (80)</td>
<td>17 (68)</td>
<td>20 (80)</td>
<td>0.1</td>
</tr>
<tr>
<td>Education, y</td>
<td>10.6 ± 4.2</td>
<td>12.4 ± 3.6</td>
<td>12.0 ± 1.8</td>
<td>0.2</td>
</tr>
<tr>
<td>Handedness</td>
<td>95.3 ± 6.6</td>
<td>97.7 ± 1.2</td>
<td>98.7 ± 1.2</td>
<td>NS</td>
</tr>
<tr>
<td>Length of illness</td>
<td>10.5 ± 4.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mean chlorpromazine equivalent, mg</td>
<td>401 ± 180.9</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PANSS&lt;sup&gt;a&lt;/sup&gt; positive</td>
<td>23 ± 6.7</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PANSS-negative</td>
<td>13 ± 7.4</td>
<td>-</td>
<td>-</td>
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</table>

<sup>a</sup>Positive and negative syndrome scale.

Table 2. The Means and SD of the Accuracy Rate and Response Time of Performance on the Hand Rotation Task

<table>
<thead>
<tr>
<th></th>
<th>Patients</th>
<th>Relatives</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy (total)</td>
<td>67.9 ± 14.4</td>
<td>79.3 ± 13.2</td>
<td>87.7 ± 9.2</td>
</tr>
<tr>
<td>Small angle</td>
<td>71.6 ± 14.5</td>
<td>84.0 ± 10.7</td>
<td>91.5 ± 8.3</td>
</tr>
<tr>
<td>Large angle</td>
<td>62.3 ± 15.7</td>
<td>74.6 ± 17.6</td>
<td>83.8 ± 10.9</td>
</tr>
<tr>
<td>Response time (total)</td>
<td>1796 ± 309</td>
<td>1772 ± 291</td>
<td>1543 ± 193</td>
</tr>
<tr>
<td>Small angle</td>
<td>1658 ± 264</td>
<td>1656 ± 326</td>
<td>1397 ± 217</td>
</tr>
<tr>
<td>Large angle</td>
<td>1936 ± 359</td>
<td>1859 ± 307</td>
<td>1689 ± 186</td>
</tr>
</tbody>
</table>

4.2. Response Time

The analyses were repeated for response times among the two angles of rotation (Table 2). The results revealed a significant effect of group \(F(1, 67) = 6.4, P = 0.003, \eta^2 = 0.16\), indicating that response times were significantly different between the three groups. On both angles of rotation, post-hoc comparisons indicated significant differences between the patients and controls (all \(P < 0.004\)), while the difference between patients and relatives was not significant (all \(P > 0.3\)). Moreover, a significant difference was obtained between relatives and controls (all \(P < 0.004\)). There was a significant main effect of the stimu-
lus angle \((F (1, 67) = 161.3, \ P < 0.001, \ \eta^2 = 0.70)\), indicating that response times significantly increased with increased angle of rotation. The interaction effects between groups and the stimulus angle were not significant \((F (1, 67) = 161.3, \ P = 0.2, \ \eta^2 = 0.70)\), suggesting a similar performance of the three groups across different stimulus angles (Figure 3).

5. Discussion

This study aimed to compare mental rotation abilities in schizophrenia patients and their first-degree relatives and to that of the controls, measured with HRT. In agreement with previous studies, our results demonstrated that the pattern of performances of patients was similar to that of the controls (same effects of angle of rotation). However, the patients displayed higher error rate and slower response time compared to controls, which was similar to the findings reported by other studies (5-10). These results suggest that patients with schizophrenia have difficulty in performing mental imagery tasks, and above all in accurately manipulating mental representations of hands. Inconsistent with our finding, Oertel et al., (2009) (18) found higher vividness of mental imagery in relatives of schizophrenia patients, using a self-report questionnaire mental imagery (QMI). The reason for this discrepancy is that they examined explicit mental imagery, while we examined implicit mental imagery. It should be mentioned that the explicit imagery tasks and self-report instruments could not tap into cognitive processes that underlie mental imagery (19). In contrast, we used an implicit imagery task in which individuals were not asked to engage in the imagery, but to solve a tangential task (laterality of the hand).

Spatial working memory is a crucial cognitive process among those involved in mental hand rotation, which requires both online maintenance and manipulation of spatially representations of hands (11). Indeed, information about a mental rotation act should be processed from the long-term to the working memory. The image should not only be transformed within working memory (e.g., by rotating a visual image), but also has to be maintained. An impaired spatial working memory could lead to the breakdown of behaviors guided by internal representation such as mental rotation. Spatial working memory impairments have been well documented in schizophrenia and suggested as an effective endophenotype marker (15-20). Moreover, spatial working memory impairments have been reported in the unaffected relatives of schizophrenia patients, supporting the fact that these impairments may reflect a genetic risk for schizophrenia (14, 15). Unfortunately, we did not assess the spatial working memory in our study, so future studies should examine its impairment and relation to mental rotation in relatives of schizophrenia patients. However, a firm conclusion cannot be drawn yet, and more pending studies examining both working memory and mental rotation processes are available.

It is difficult to draw direct neurophysiological conclusions from behavioral measures, which tap into the multi-cognitive processes. However, this finding may reflect the disruption in primary motor cortex and/or posterior pari-
etal cortex in the pathophysiology of schizophrenia. Posterior parietal cortex is crucial for goal-directed movements and updating spatial representation as a consequence of those actions (6, 21). Studies have suggested that dysfunction of the posterior parietal cortex results in some cognitive impairment in schizophrenia such as impaired spatial attention, deficits in motor control and motor imagery (22, 23). Behavioral, fMRI and TMS studies demonstrate that motor areas, particularly primary motor cortex play an important role in mental imagery (19). Interestingly, the meta-analyses demonstrated that motor symptoms were more prevalent in unaffected first-degree relatives of patients with schizophrenia than in the healthy controls, suggesting that motor symptoms may be associated with the genetic risk of developing schizophrenia (24, 25).

These findings have an important implication. Potentially, the finding of deficit in mental rotation in the first-degree relatives of schizophrenia patients is of interest. This deficit cannot be the result of factors associated with the disorder, like distractibility because of active psychotic symptoms, lack of motivation, medication effects, or lower education levels. Also, the relatives in our study had a mean age of 35 that is above the peak age of risk for schizophrenia. Overall, it seems that mental rotation is a trait rather than a state marker, indicating an underlying vulnerability to the disorder and its relation to genetic liability to develop schizophrenia.

One limitation of our study was sampling bias, as it may be possible that only high functioning relatives agreed to participate. This situation is somewhat common in most studies, but its resolution is beyond the scope of the study.

In conclusion, we demonstrated that implicit mental imagery may be an independent symptom and a trait marker for schizophrenia. This finding that the mental rotation is not preserved in relatives of schizophrenia supports the previous findings of subtle neurological and cognitive changes in high-risk groups.

Acknowledgments

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Footnotes

Authors’ Contribution: Shahrzad Mazhari designed the study and drafted the manuscript. Ali Mohammad Pourrahimi designed the task. Ghodratollah Rajabizadeh and Kianoosh Abasabadi collected the data. Nooshin Parvaresh analyzed the data. All authors read and approved the final manuscript.

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