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Psychiatry Research ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

# Cognitive mapping deficits in schizophrenia: Evidence from clinical correlates of visuospatial transformations

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ARTICLE INFO

*Article history:*
Received 15 August 2014
Received in revised form
21 May 2015
Accepted 24 May 2015

*Keywords:*
Schizophrenia
Allocentric
Egocentric
Perspective taking
Mental rotation
Cognitive mapping

ABSTRACT

The ‘cognitive mapping’ component of spatial cognition, namely – the allocentric/egocentric function and its relation to symptoms in schizophrenia is relatively unexplored. In this study, we compared schizophrenia patients ($N$=44) to demographically-matched healthy controls ($N$=43) using computer-administered visuospatial transformation tasks with egocentric and allocentric components and analyzed their correlation with symptoms. Significant diagnosis X task-type interaction effect was seen on task accuracy. Patients performed significantly worse than controls in the allocentric letter rotation task (LRT) but not in the egocentric people rotation task (PRT). Accuracy in the LRT was significantly lesser than in PRT among patients but not among controls. Patients were significantly slower as compared to controls in both tasks. Both groups took longer to perform PRT as compared to LRT. LRT accuracy showed significant negative correlation with total positive symptoms as well as negative symptoms scores. Angle of rotation, perspective (front-facing/back-facing), orientation (mirrored/normal), and stimulus type (letter/number) were found to significantly influence performance in both groups of subjects. The present data support the finding that there is a differential impairment of allocentric abilities in schizophrenia patients. Further systematic research in this area may facilitate better understanding of schizophrenia pathogenesis.



## 1. Introduction

Schizophrenia is a complex neuropsychiatric disorder characterized by delusions, hallucinations, disorganized behavior and progressive cognitive deficits (Keshavan et al., 2008; van Os and Kapur, 2009). Among several domains of cognitive functions that have been examined in this disorder, spatial cognition is an area of active inquiry (Bose et al., 2014); interestingly, visuospatial abilities have been found to have intriguing interactions with several measures that are related to schizophrenia pathogenesis like empathy (Decety and Lamm, 2007), schizotypy (Thakkar and Park, 2010), and theory of mind (Bosia et al., 2012; Iacoboni and Dapretto, 2006). Models of visuospatial abilities posit two perspectives of visual space: allocentric (object- or environment-centered) reference and egocentric (self-centered or body-centered) reference (O'Keefe and Nadel, 1978). While egocentrism refers to the ability to see the world from one's own perspective, allocentrism refers to the capacity to experience the world from an objective, more impersonal, point of view. Allocentric referencing is promoted by greater familiarity with the environment and distant body displacements while egocentric referencing is important in maintaining a stable moment-to-moment perception (Burgess, 2006).

Studies exploring the neural basis of spatial navigation implicate the hippocampus and other medial temporal structures in allocentric representations while parietal and striatal areas are postulated to be important for egocentric processes (Burgess et al., 2001; Etchamendy and Bohbot, 2007). A more recent view suggests a greater overlap between the two systems of representations; involvement of posterior superior parietal cortex/precuneus

*Abbreviations:* LRT, Letter rotation task; PRT, People rotation task; CPZ, Chlorpromazine; IMAP, Investigation of Mental Rotation, Allocentricity–Egocentricity and Perspective Taking

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http://dx.doi.org/10.1016/j.psychres.2015.05.096
0165-1781/

and its interaction with the hippocampus is understood to be important for allocentric representation (Zhang and Ekstrom, 2013). Contextually, it is important to note that dysfunction in the activity of these brain regions have been associated with the pathogenesis of psychotic symptoms (Frith, 2005; Frith et al., 2000; Torrey, 2007); since these brain regions also have an intricate relationship with visuospatial transformation abilities, the study of perspective-taking offers an attractive avenue to explore for potential pathogenetic underpinnings of schizophrenia (Bose et al., 2014).

Indeed, visuospatial abilities in patients with schizophrenia have been examined in previous studies (de Vignemont et al., 2006; Folley et al., 2010; Girard et al., 2010; Halari et al., 2006; Hanlon et al., 2006; Landgraf et al., 2010; Langdon et al., 2001; Siemerkus et al., 2012; Sorkin et al., 2006; Thakkar and Park, 2012; Villatte et al., 2010; Weniger and Irle, 2008). Many of these studies have shown deficits in allocentric referencing in patients with schizophrenia (Folley et al., 2010; Girard et al., 2010; Hanlon et al., 2006; Landgraf et al., 2010; Langdon et al., 2001; Weniger and Irle, 2008); intriguingly, schizophrenia patients were shown to have preserved egocentric referencing (Landgraf et al., 2010; Weniger and Irle, 2008). These observations are in tune with the *Allocentric simulation hypothesis* which postulates that the pathological referencing in schizophrenia is due to a problem in adopting a "world-centered" – inter-subjective – reference frame (Langdon et al., 2001).

Previous studies have applied several types of spatial cognition tasks to evaluate visuospatial abilities [for example the letter and people rotation task (Thakkar and Park, 2010, 2012), the virtual Morris water task (Folley et al., 2010), the bin task (Girard et al., 2010) and the virtual park and the virtual maze task (Weniger and Irle, 2008)]; replicated observation of deficits through a variety of spatial cognition tasks offers compelling support for allocentric referencing deficits in patients with schizophrenia (i.e. seemingly different tasks have led to the same results in many of the above studies). However, the multitude of tests coupled with the small sample size in many of the studies is probably the reason why there is lack of consistency in findings with a few studies reporting no deficit in allocentric referencing abilities in patients (de Vignemont and Singer, 2006; Thakkar and Park, 2012). However, only a limited number of studies have examined for potential clinical correlates of allocentric referencing in schizophrenia; these studies have reported variable findings: significant positive correlation has been reported between allocentric referencing deficits and severity of psychotic symptoms (Folley et al., 2010), negative symptoms (Folley et al., 2010), positive symptoms (Siemerkus et al., 2012) and disorganization symptoms (Weniger and Irle, 2008). In this context, the current study attempted to understand the links between symptom severity in schizophrenia and deficits in visuospatial abilities in a larger group of patients and controls using the people and letter rotation task (Thakkar and Park, 2010, 2012). Based on the previous works (as reviewed above), it was hypothesized that the schizophrenia patients will have a selective deficit in allocentric referencing and this deficit will positively correlate with symptom severity.

## 2. Materials and methods

### 2.1. Subjects

Patients attending the clinical services of the National Institute of Mental Health & Neurosciences (India), who fulfilled DSM-IV criteria for schizophrenia ($N=44$) were examined in this study. The diagnosis of schizophrenia was established using Mini International Neuropsychiatric Interview (MINI) Plus (Sheehan et al., 1998), and was confirmed by another psychiatrist through an independent clinical interview. The information related to illness onset and treatment was carefully ascertained by information obtained from at least one reliable adult relative. Clinical symptoms were assessed using the Scale for Assessment of Positive Symptoms (SAPS) (Andreasen, 1984), a 34-item tool which scores symptom severity under four domains – hallucinations, delusions, bizarre behavior and formal thought disorder on a 6-point Likert-type scale, and the Scale for Assessment of Negative Symptoms (SANS) (Andreasen, 1983), a 25-item tool which scores symptom severity under six domains – affective flattening or blunting, alogia, avolition–apathy, anhedonia–asociality and attention impairment on a 6-point Likert-type scale. These scales were administered with good inter-rater reliability. Healthy controls ($N=43$) who volunteered for study, were screened to rule out any psychiatric diagnosis using the MINI Plus as well as a comprehensive mental status examination. None of the controls had family history of psychiatric disorder in any of their first-degree relatives. The control group did not differ significantly from the patient group with regard to age, sex distribution and years of education (Table 1). There were no demographic differences between male and female subjects.

Patients and controls did not have features suggestive of alcohol abuse/dependence. None used stimulant or opiate drug. None had history or clinical feature suggestive of neurological/medical disorder. None had abnormal movements as assessed by Abnormal Involuntary Movements Scale (Smith et al., 1979). All study subjects were right-handed (left-handedness or ambidexterity was an exclusion criteria) (Oldfield, 1971). After complete description of study to the subjects, written informed consent was obtained. The Institute's ethics committee approved the study.

### 2.2. Spatial cognition task

The computerized version of the spatial cognition task was designed as per previous description (Thakkar and Park, 2010). The task focused on the ability of the subjects to take perspective from an egocentric or allocentric point of view and to rotate mentally the stimulus or their point of view. Hence, it was named the Investigation of Mental Rotation, Allocentricity–Egocentricity & Perspective Taking [IMAP] task. The task had two sub-components: people rotation & letter rotation. A block design using alternating blocks of people rotation task and letter rotation task was used. The paradigm was designed using E-prime (PST Inc., PA, USA).

#### 2.2.1. People rotation task (PRT)

The stimuli consisted of photographs of two persons (one man and one woman, with faces blurred to hide their identity) dressed in white, with both their arms held straight a small angle away from their body presented in one of six possible angles ranging from 67.5° to 292.5° clockwise, from the upright position, in 45° steps i.e. 67.5°, 112.5°, 157.5°, 202.5°, 247.5° and 292.5° from the upright position (Fig. 1). Positions at angle of 12.5° and 337.5° were very similar to the upright position and hence, were not included in the task. In each stimulus, the person in the photograph faced either towards (front-facing perspective) or away (back-facing perspective) from the subject with one of the hands encircled red. Hence for each angle, four stimuli were possible per person [front and back-facing photographs with the right hand encircled and those with the left hand encircled]. Hence, for the six angles, 24 stimuli were generated per person (six possible angles, either facing towards or away and one of two hands encircled in each stimuli), and 48 stimuli overall for the two persons. Subjects were asked to imagine themselves in the position of the person in the stimulus and indicate whether the circled hand would be their left or right hand by pressing the left arrow key with their right index finger (indicating left hand) or right arrow key with their right middle finger (indicating right hand). Subjects were instructed to respond as quickly and accurately as possible. The stimuli subtended a visual angle of about 12° as described in a previous study (Thakkar and Park, 2010).

#### 2.2.2. Letter rotation task (LRT)

Four characters, two letters (R and F) and two numbers (5 and 4), were presented in either mirror or normal orientation at one of six possible angles, along the same lines as PRT. This arrangement gave a total of 12 possible stimuli per

**Table 1**
Comparison of clinical and socio-demographic characteristics (Mean ± SD) of patients and controls.

| Parameter | Patients ($N=44$) | Controls ($N=43$) | $t/\chi^2$ | $p$ |
|---|---|---|---|---|
| Age (years) | 30.4 ± 7.1 | 28.0 ± 5.2 | 1.8 | 0.074 |
| Sex (male:female) | 31:13 | 22:21 | 3.4 | 0.081 |
| Years of education | 15.2 ± 1.7 | 14.9 ± 2.0 | 0.8 | 0.452 |
| Age at onset (years) | 24.0 ± 5.7 | – | – | – |
| Antipsychotic dose (mg/d, in chlorpromazine equivalents) | 408.0 ± 259.6 | – | – | – |
| SAPS total score | 16.6 ± 20.5 | – | – | – |
| SANS total score | 33.0 ± 29.4 | – | – | – |

Please cite this article as: Agarwal, S.M., et al., Cognitive mapping deficits in schizophrenia: Evidence from clinical correlates of visuospatial transformations. Psychiatry Research (2015), http://dx.doi.org/10.1016/j.psychres.2015.05.096