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Allocentric memory impaired and egocentric memory intact as assessed by virtual reality in recent-onset schizophrenia

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Abstract

Present evidence suggests that schizophrenia is associated with explicit memory deficits, whereas implicit memory seems to be largely preserved. Virtual reality studies on declarative allocentric memory in schizophrenia are rare, and studies on implicit egocentric memory in schizophrenia are lacking. However, virtual realities have a major advantage for the assessment of spatial navigation and memory formation, as computer-simulated first-person environments can simulate navigation in a large-scale space. Twenty-five subjects with recent-onset schizophrenia were compared with 25 healthy matched control subjects on two virtual reality tasks affording the navigation and learning of a virtual park (allocentric memory) and a virtual maze (egocentric memory). Compared with control subjects, schizophrenia subjects were significantly impaired in learning the virtual park. However, schizophrenia subjects were as able as control subjects to learn the virtual maze. Stronger disorganized symptoms of schizophrenia subjects were significantly related to more errors on the virtual maze. It is concluded that egocentric spatial learning adds to the many other implicit cognitive skills being largely preserved in schizophrenia. Possibly, the more global neural network supporting egocentric spatial learning is less affected than the declarative hippocampal memory system in early stages of schizophrenia and may offer opportunities for compensation in the presence of focal deficits.

Keywords: Explicit memory; Implicit memory; Navigation; Virtual park; Virtual maze

1. Introduction

Currently, spatial navigation and memory is modeled as a process supported by allocentric (i.e., world-centered) spatial representations, being independent to the observer, and egocentric (i.e., body-centered) spatial representations, which relate to the body axes (O'Keefe and Nadel, 1978). Evidence so far suggests that the allocentric representation of spatial context depends on the ventromedial temporal declarative memory system, as individuals with medial temporal lobe damage were shown to be impaired in place learning or in finding their way within their locomotor environment ('topographical disorientation') (Abrahams et al., 1997; Bohbot et al., 1998; Habib and Sirigu, 1987; Maguire et al., 1996; Spiers et al., 2001). On the other hand, posterior and medial parietal cortices and the striatum are thought to provide representation and encoding of egocentric coordinates (Aguirre and D'Esposito, 1997; Burgess et al., 2001; Epstein et al., 2003).

Many features of egocentric navigation and memory formation may recruit implicit processes. Egocentric orientation and memory includes the sensorimotor

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representation of whole-body, head and gaze motion, the mental representation of distance, time and number of routes that have been traveled, and the temporo-spatial relationship of all information. Most of this information is not processed verbally or consciously and does not require selective attention, and therefore may be difficult to translate into an allocentric frame of reference. Empirical evidence so far suggests that implicit memory is largely preserved in schizophrenia whereas declarative memory is consistently impaired (Clare et al., 1993; Danion et al., 2001; Perry et al., 2000; Sponheim et al., 2004). However, the dissociation on declarative and implicit learning processes in schizophrenia has not yet been studied in the context of spatial learning and memory.

The development of virtual reality technology has brought a major progress to the study of spatial navigation and memory. Virtual realities have a major advantage for the assessment of spatial navigation and memory formation, as computer-simulated first-person environments can simulate navigation in a large-scale space. There is now a large number of studies investigating allocentric memory in healthy individuals using virtual reality environments (e.g., Aguirre et al., 1996; Aguirre and D'Esposito, 1997; Burgess et al., 2001; Epstein et al., 2003; Maguire et al., 1997). However, studies on egocentric representation and memory of visual space using virtual reality environments are lacking.

In the present study, 25 subjects with recent-onset schizophrenia were compared with 25 healthy matched control subjects on two virtual reality tasks affording the navigation in a virtual park (allocentric memory) and a virtual maze (egocentric memory). The goals of our study were: a) to test the suitability of virtual reality environments for the assessment of spatial memory in schizophrenia, b) to assess whether schizophrenia subjects are impaired in learning the virtual park, and c) to assess whether schizophrenia subjects are unimpaired in learning the visual maze. A further concern was to investigate whether specific schizophrenia symptoms are related to virtual park and virtual maze performance. Previous studies have repeatedly demonstrated relationships between clinical syndromes and various neuropsychological deficits of schizophrenia subjects (Basso et al., 1998; Cuesta and Peralta, 1995; Daban et al., 2002; Hill et al., 2001).

2. Methods

2.1. Subjects

2.1.1. Subjects with schizophrenia

The sample comprised 25 inpatients with schizophrenia consecutively admitted to the Psychiatric Hospital of the University of Göttingen. Subjects fully met the criteria of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV*) (American Psychiatric Association, 1994) for a lifetime diagnosis of schizophrenia on the basis of interviews with the *Structured Clinical Interview for DSM-IV (SCID)* (Wittchen et al., 1997). Subjects with a history of head injury, neurological diseases or substance dependence or abuse (*SCID*) were excluded. All subjects were on antipsychotic medication (Table 1). Medication dose at testing was converted to chlorpromazine equivalents according to Bezchlibnyk-Butler and Jeffries (2001).

2.1.2. Healthy controls

Subjects with schizophrenia were compared with 25 healthy control subjects matched for age, sex and years of education (Table 1). Only subjects without a history of neurological or psychiatric disorder (as assessed by the *SCID*) were studied.

After complete description of the study to the subjects informed written consent was obtained. The Ethical Committee of the Medical Faculty of the University of Göttingen had approved of the study design.

2.2. Clinical and neuropsychological assessment

Subjects were assessed within 3 weeks after admission to the hospital when they were in a clinically stable phase. Diagnosis of schizophrenia was established by two independent and trained interviewers on the basis of interviews with the *SCID* and clinical assessment. Extrapyramidal motor symptoms were evaluated during the run-in phase of antipsychotic medication and in a comprehensive and quantitative evaluation at the day of the assessment. Positive and negative symptoms were assessed by using the *Scale for the Assessment of Positive Symptoms* (*SAPS*) (Andreasen, 1984) and the *Scale for the Assessment of Negative Symptoms* (*SANS*) (Andreasen, 1983). We calculated three different summary scores from the *SAPS* and *SANS* scales, "positive symptoms" (hallucinations and delusions), "negative symptoms" (avolition, anhedonia, affective flattening and alogia), and "disorganized symptoms" (bizarre behavior, positive thought disorder and attention). We further used the *Clinical Global Impressions* (*CGI*) for the assessment of general psychopathology. Current psychosocial functioning was rated on the *SCID* (*DSM-IV*) *Global Assessment of Functioning Scale* (*GAF*).

Subjects also received a neuropsychological assessment to control for the influence of intellectual and mnemonic performance. A short form of the *Wechsler Adult Intelligence Scale-Revised* (*WAIS-R*) (Tewes, 1991)