Available online at www.sciencedirect.com
SCIENCE DIRECT®
Consciousness and Cognition 15 (2006) 295–309
Consciousness and Cognition
www.elsevier.com/locate/concog

Mental rotation in schizophrenia

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Received 17 September 2004
Available online 22 September 2005

Abstract

Motor imagery provides a direct insight into action representations. The aim of the present study was to investigate the level of impairment of action monitoring in schizophrenia by evaluating the performance of schizophrenic patients on mental rotation tasks. We raised the following questions: (1) Are schizophrenic patients impaired in motor imagery both at the explicit and at the implicit level? (2) Are body parts more difficult for them to mentally rotate than objects? (3) Is there any link between the performance and the hallucinating symptom profile? The schizophrenic patients ($n = 13$) displayed the same pattern of performance as the control subjects ($n = 13$). More particularly, schizophrenic patients' reaction time varied as a function of the angular disparity of the stimuli. On the other hand, they were significantly slower and less accurate. Interestingly, patients suffering from hallucinations made significantly more errors than non-hallucinatory patients. We discussed these latter results in terms of deficit of the forward model. We emphasized the necessity to distinguish different levels of action, more or less impaired in schizophrenia.

Keywords: Motor imagery; Schizophrenia; Action monitoring; Hallucination; Forward model; Intention

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doi:10.1016/j.concog.2005.08.001

1. Introduction

Several authors have suggested that the main underlying cognitive deficit in schizophrenia lies in their inability to monitor their own actions (Frith, 1992; Georgieff & Jeannerod, 1998), and to distinguish between imagination and reality (Bentall, Baker, & Havers, 1991; Brebion et al., 2000). Given the similarities between motor imagery and physical actions (Jeannerod, 1994; Jeannerod & Decety, 1995), one could suggest that this deficit of action monitoring is also found in schizophrenic patients when required to imagine performing a movement. Indeed, when one imagines oneself moving, one appeals to the same motor representations that one uses when one actually executes the movement. Motor imagery thus shares many properties with physical actions at the physiological level (muscle activity), at the kinematic level (similar physical constraints and laws) and at the neural level (shared patterns of brain activation, Grezes & Decety, 2001). Furthermore, patients with motor impairments such as parietal damage (Sirigu et al., 1995; Sirigu & Duhamel, 2001), Parkinson's disease (Dominey, Decety, Broussolle, Chazot, & Jeannerod, 1995; Lee, Harris, & Calvert, 1998) or lesion of the right basal ganglia (Harris, Harris, & Caine, 2002) also suffer from difficulties in motor imagery. Motor imagery provides thus a direct insight into action representations (Jeannerod, 1994) and is particularly relevant for the study of action in schizophrenia.

Several studies show a general impairment of action monitoring in schizophrenic patients (Daprati et al., 1997; Franck et al., 2001; Frith, 1992; Georgieff & Jeannerod, 1998). Patients appear to be unable to anticipate the sensory consequences of their own movements, that is, to produce a "forward model" of their actions (Wolpert, Ghahramani, & Jordan, 1995). The disruption of the forward model would lead to xenopathic experiences: patients can no longer compare the performed movement with the anticipated outcome of these movements and thus feel alienated from their own actions (Frith, Blakemore, & Wolpert, 2000). Positive symptoms such as hallucinations may thus be interpreted as a deficit of self-monitoring associated with a kind of overactivity of mental imagery: patients' inner life is particularly intense and vivid and the patients are unable to realize that their mental images come from themselves rather from the external world (Bentall & Slade, 1985; Horowitz, 1975).

The forward model involves the ability to mentally manipulate motor representations independently of action execution. Rather than inferring from the incorrect motor performance to the disruption of the forward model, we could directly evaluate the forward model by investigating motor imagery in schizophrenic patients. Two recent studies about schizophrenia investigated whether explicit imagined movements were constrained by the speed–accuracy trade-off given by Fitts' law. Patients were required to complete actual and imagined pointing task. In Danckert, Rossetti, d'Amato, Dalery, and Saoud (2002b), all schizophrenic patients showed poor relationship between imagined movement duration and target size. The authors concluded that they were unable to generate accurate internal images of their own actions independently of their symptom profile. However, their sample size was small. In contrast, in Maruff, Wilson, and Currie (2003), only the patients suffering from passivity symptoms were impaired in a similar task using different stimuli.

In our study, action representations were tested using mental rotation tasks involved in perceptual judgements. Both mirror recognition and handedness recognition automatically require motor imagery: subjects mentally rotate the stimulus to match the most common position (0°).