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Spatial compatibility and affordance compatibility in patients with chronic schizophrenia

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ABSTRACT

A deterioration in information-processing performance is commonly recognized in patients with chronic schizophrenia. Although the enhancement of cognitive skills in patients with schizophrenia is important, the types of external stimuli that influence performance have not received much attention. The aim of present study was to clarify the effects of spatial and affordance compatibility in patients with schizophrenia, compared with those in healthy people. The subjects (25 patients with schizophrenia and 25 healthy controls) participated in two experiment examining the effects of the spatial location of stimuli and the action-relevance of objects. The results showed that the effect of spatial compatibility was similar in both the patients and the controls, whereas the influence of action-relevant objects was not highlighted in either patients with chronic schizophrenia or healthy controls. These findings provide important evidence of a normal spatial compatibility effect in patients with chronic schizophrenia. However, further research examining the affordance compatibility effect is needed, taking into consideration the symptomatology and the severity of the social functioning level in patients with schizophrenia.

1. Introduction

Slow information processing has been implicated in the abnormal visual processing of objects in patients with schizophrenia (Delerue and Boucart, 2012; Place and Gilmore, 1980; Silverstein et al., 1996) and in deficits in the recognition of social cues (Gastaldo et al., 2002; Huang et al., 2009; Lalanne et al., 2012; Monkul et al., 2007; Roder et al., 2015). An abnormal contextual-coordination between visual-spatial perception and actions is currently considered to be a core symptom of patients with schizophrenia that affects their social functioning skills (Barch et al., 2003; Bazin et al., 2000; MacDonald et al., 2003; Penn et al., 2002). For example, performance on information-processing tasks was reportedly associated with several social skills (e.g., paralinguistic skill) in female patients with chronic schizophrenia (Penn et al., 1996) and with the processing of social information (Corrigan et al., 1992). Establishing a relationship between cognition and action is a critical step in the development of cognitive rehabilitation programs (Liberman and Green, 1992). Given the therapeutic importance of cognitive skills related to social functioning in patients with schizophrenia, it is critical to establish how patients with schizophrenia perceive external stimuli that influence the contextual coordination of the motor system.

In healthy people, it is commonly recognized that spatial correspondence between stimulus and response leads to faster reaction times, even if the stimulus location is irrelevant to the task. Thus, healthy people can make faster responses when the stimulus is presented in the right location congruent with the response required by the task, such as pressing a right button (Wang et al., 2014). This is known as the “Simon effect” or spatial-compatibility effect (Simon, 1969, 2011). The Simon effect has been shown to occur as soon as a visual-spatial coding of the response is made possible (Hommel, 1994, 2011). A previous study addressed spatial compatibility in patients with schizophrenia and showed an apparently normal stimulus-response compatibility effect similar to that observed in control subjects (Sevos et al., 2013).

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On the other hand, the motor system can also be affected by the action-relevant features of an object (Creem-Regehr and Lee, 2005; Thill et al., 2013). For healthy subjects, viewing action-relevant objects that prime an observer to act, such as a cup with a handle, can activate sensorimotor brain areas (Grezes and Decety, 2002) and affect the response time for the task (Tucker and Ellis, 1998). For example, healthy subjects can respond faster when the graspable handle location of the object is on the same side as the button that needs to be pressed, compared with when the correct button is on the opposite side of the handle's location (Ellis and Tucker, 2000). This is known as the "affordance effect" or affordance compatibility (Tucker and Ellis, 1998; Ellis and Tucker, 2000). Affordance compatibility lends credibility to the original notion of "affordance", in which the features of an action-relevant object are directly perceived and automatically activate the motor system (Becchio et al., 2008; Ferri et al., 2011; Gibson, 1979). Sevos et al. (2013) previously demonstrated that affordance compatibility was not highlighted in patients with schizophrenia.

Some studies have postulated that affordance compatibility might arise from the spatial-compatibility effect (Anderson et al., 2002; Fischer and Dahl, 2007). In their studies, the visual asymmetry of stimuli would tend to capture visual attention and evoke a spatial compatibility effect between the spatial location of the stimulus and the motor response side. However, Borghi et al. (2012) and Symes et al. (2005) provided evidence suggesting that the affordance compatibility effect can be clearly distinguished from the spatial compatibility effect. They suggested that automatic responses are triggered by the features of action-relevant objects, and not by the object's spatial location. Interestingly, Symes et al. (2005) proposed that the two effects (spatial location and handle orientation of a graspable object) might be additive and that they could also be dissociable in healthy people.

A recent study also examined both spatial and affordance compatibility, suggesting that patients with schizophrenia showed an equivalent effect of spatial compatibility, whereas action-relevant graspable handles did not exert an affordance compatibility effect (Sevos et al., 2013). So far, the available information has been insufficient to support the characteristics of spatial and affordance compatibility. Because patients with chronic schizophrenia, in particular, exhibit perceptual disorganization and abnormal context-processing (Silverstein et al., 2000), the potential issues for perception in patients with schizophrenia cannot be estimated without further study examining the influence of spatial location and action-relevant stimuli on the motor system. Thus, we hypothesized that patients with schizophrenia might exhibit a similar effect of spatial compatibility but might not exhibit the additional influence of action-relevant object features.

The present study was performed to examine the effects of spatial and affordance compatibility in patients with schizophrenia, compared with those in healthy controls. This paper follows up on previous research (Sevos et al., 2013) comparing the effects of spatial-compatibility and the features of action-relevant objects between patients with schizophrenia and healthy controls. Importantly, this approach allowed us to examine qualitative and quantitative differences between spatial and affordance compatibility in patients with schizophrenia.

2. Materials and methods

2.1. Experiment 1

2.1.1. Subjects

Twenty-five patients with chronic schizophrenia were recruited at three psychiatric day-care facilities in Akita prefecture, Japan (a day-care center at Yokote Kohsei Hospital, a day-care center at Akita Kaiseikai Hospital and a day-care center at Sugiyama Hospital). The patients were living in their own accommodation and were undergoing various psychosocial or psychiatric rehabilitation practices as part of occupational therapy. The diagnosis of schizophrenia was assessed using the residents' medical records and the Structured Clinical Interview for Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (Dilip et al., 2013). Criteria for the recruitment of the patients were a stable clinical status for at least 4 weeks prior to the study and stable doses of antipsychotic medications, with a mean (standard deviation [SD]) chlorpromazine equivalent of 533.3 (312.8) mg. The Global Assessment of Functioning (GAF) scale (Luborsky, 1962) was used to measure the clinical status of symptom severity and social capacity in each of the patients. The mean (SD) of the GAF scores in the patients was 62.1(12.7), and the mean length of illness was 18.8 (11.4) years.

The control subjects consisted of 25 healthy people living in Akita prefecture. The control subjects were matched to the patients in terms of age, gender and dominant hand. All the subjects were right-handed (to assess handedness, all the subjects were asked which hand [right or left] they dominantly used when manipulating household items such as a cup, knife, etc.) (Table 1). Subjects with an organic central nervous system disorder, substance-related disorder, or mental retardation were excluded.

The present study was approved by the ethics committee of the Department of Health Sciences, Akita University (approval No. 1109) and was performed in accordance with the Declaration of Helsinki II. Informed consent was obtained from all the subjects who participated in the present study.

2.1.2. Apparatus

Each trial was performed using a PC running presentation software version 16.2 (Neurobehavioral Systems, Inc., http://www.neurobs.com/) (McBride et al., 2013). Stimuli were displayed on a 13.3-inch-wide monitor (1920 × 1080) that the subjects viewed from a distance of 40 cm. Subjects were asked to keep his or her left finger on the "Ctrl" key on the left side of a keyboard and his or her right finger on the "Right" key on the right side of the same keyboard throughout the experiment. The response keys were located 25 cm apart and 12 cm from the screen.

2.1.3. Stimuli and procedure

A left- or right-pointing arrow (i.e. "←" or "→") was displayed on the screen using a font size of 500 points and was used as the targeted stimulus (Fig. 1). The subject was instructed to press the response key as fast and as accurately as possible using their left or right index finger according to the direction of the arrow (i.e. "←" or "→"), without considering the spatial side of its appearance. The arrows were displayed, pointing either to the same side of their appearance (compatibility) or to the opposite side (incompatibility). The arrows were displayed in a random order.

The trial was started with the presentation of a fixed cross on a background on the monitor. This cross was displayed with a font size of 12 points and was presented in the center of the screen for 1000 ms. After a 1000-ms blank interval, the targeted arrow was

Table 1
The characteristic of subjects (Mean ± Standard deviation) in both experiments.

	Controls	Patients	t	p value
N	25	25	–	–
Age (years)	44.0(12.3)	45.5(12.5)	0.45	0.66
Gender (male/female)	11/14	13/12	–	0.39

Age showed t statistic and p value of the unpaired *t*-test between groups.
Gender showed p value of the χ^2 test.