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Creativity and positive symptoms in schizophrenia revisited: Structural connectivity analysis with diffusion tensor imaging

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ABSTRACT

Both creativity and schizotypy are suggested to be manifestations of the hyperactivation of unusual or remote concepts/words. However, the results of studies on creativity in schizophrenia are diverse, possibly due to the multifaceted aspects of creativity and difficulties of differentiating adaptive creativity from pathological schizotypy/positive symptoms. To date, there have been no detailed studies comprehensively investigating creativity, positive symptoms including delusions, and their neural bases in schizophrenia. In this study, we investigated 43 schizophrenia and 36 healthy participants using diffusion tensor imaging. We used idea, design, and verbal (semantic and phonological) fluency tests as creativity scores and Peters Delusions Inventory as delusion scores. Subsequently, we investigated group differences in every psychological score, correlations between fluency and delusions, and relationships between these scores and white matter integrity using tract-based spatial statistics (TBSS). In schizophrenia, idea and verbal fluency were significantly lower in general, and delusion score was higher than in healthy controls, whereas there were no group differences in design fluency. We also found positive correlation between phonological fluency and delusions in schizophrenia. By correlation analyses using TBSS, we found that the anterior part of corpus callosum was the substantially overlapped area, negatively correlated with both phonological fluency and delusion severity. Our results suggest that the anterior interhemispheric dysconnectivity might be associated with executive dysfunction, and disinhibited automatic spreading activation in the semantic network was manifested as uncontrollable phonological fluency or delusions. This dysconnectivity could be one possible neural basis that differentiates pathological positive symptoms from adaptive creativity.

1. Introduction

Creativity has long been thought as the ability to produce original, novel, flexible, and useful ideas that are free from established mental habit. One of the most commonly used definitions is "the production of effective novelty" (Mumford, 2003). A number of factors are thought to be related to creativity, such as divergent thinking (Guilford, 1959), openness (Dollinger et al., 2004), handedness (Shobe et al., 2009), language (Leonhard and Brugger, 1998), problem solving, adaptability, self-expression, quality of life (Runco, 2004), artistry (Bhattacharya and Petsche, 2002, 2005), magical ideation (Badzakova-Trajkov et al., 2011), and schizotypy (Fisher et al., 2004).

Both creativity and schizotypy are suggested to be manifestations of the hyperactivation of unusual or remote concepts/words (Mohr et al., 2001). Therefore, relationships between creativity and schizophrenia-spectrum disorder have been widely investigated (Sass, 2000; Nelson and Rawlings, 2010). Indeed, a study reported that schizophrenia patients tended to engage in artistic occupation (Kyaga et al., 2011). However the results of studies on creativity in schizophrenia are varied. Some studies reported enhanced mental imagery manipulation in schizophrenia using jigsaw puzzle task (Benson and Park, 2013), whereas other studies reported lower figural creativity using the Berlin Intelligence Structure Test (Jaracz et al., 2012) or lower creativity in general using design, idea, and word fluency tests (Nemoto et al., 2007) in schizophrenia. One possible reason for these inconsistencies may be found in the differences in definition and measurement methods of creativity. Furthermore, Tsakanikos et al. reported that

Abbreviations: TBSS, tract-based spatial statistics; DTI, diffusion tensor imaging; SCID, Structural Clinical Interview for DSM-IV Axis I Disorders; JART, Japanese Version of the National Adult Reading Test; PANSS, Positive and Negative Symptom Scale; TCT, Test for Creative Thinking; BACS-J, Brief Assessment of Cognition in Schizophrenia Japanese-language version 3.0; PDI, Peters Delusions Inventory; Design Td, task-dependent; Design Tm, task-modified; Design Ti, task-independent; Verbal C, category fluency test; Verbal L, letter fluency test; FA, fractional anisotropy; TFCE, threshold-free cluster enhancement; CC, corpus callosum; ATR, anterior thalamic radiation; HP, haloperidol; Hc, healthy control; Sc, schizophrenia

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increased positive schizotypy or positive symptoms had relationships with increased creativity, whereas negative schizotypy or negative symptoms could be related to reduced creativity (Tsakanikos and Claridge, 2005). Thus, the clinical background of patients should also be taken into account in respect to such inconsistencies.

In previous literature investigating the semantic priming effect, it has been suggested that enhanced automatic spreading activation in semantic networks is associated with creativity (Tsakanikos and Claridge, 2005), and might underlie some of the positive symptoms (Spitzer, 1997) such as thought disorder (Kreher et al., 2008), hallucination (Lindamer and Whitman, 1997; Kerns et al., 1999), or delusion (Debruille et al., 2007) in schizophrenia. Thus, it is reasonable to ask the following questions: what is the difference between creativity and positive symptoms, or why could hyperactivation result in innovative output in one case, but in psychotic symptoms in another? Fisher et al., in dealing with these questions, suggested that frontal lobe functions, i.e., executive functions such as monitoring, controlling, or inhibiting ability, play pivotal roles in the use of semantic information and differentiate creativity from psychopathology (Fisher et al., 2013).

Therefore, in this study, we aimed to examine creativity in schizophrenia patients with multiple creativity measures with and without semantic contents, and to investigate its impact on psychopathology, especially on positive symptoms. We predicted that overall creativity performance in schizophrenia might increase or decrease depending on the proportion of positive and negative symptoms, and that some creativity measures would positively correlate with positive symptoms. Furthermore, we hypothesized that this correlation between creativity and pathological, positive symptoms would be underpinned by the pathology of the frontal lobe structure. One of the influential hypotheses of schizophrenia, "the disconnection hypothesis" (Friston, 1998), assumes that dysconnectivity among multiple neural systems might underlie some symptoms of schizophrenia, mainly positive symptoms. We therefore utilized diffusion tensor imaging (DTI) to investigate the structural connectivity, and examined its relation with creativity and psychopathology.

2. Methods

2.1. Participants

Forty-three patients with schizophrenia (22 men and 21 women, age = 37.37 ± 8.66) were recruited. Each patient fulfilled the criteria for schizophrenia based on the Structural Clinical Interview for DSM-IV Axis I Disorders (SCID) Patients Edition, Version 2.0. None of the patients were comorbid with other mental disorders. Predicted IQ was measured using the Japanese Version of the National Adult Reading Test (JART) short form (Matsuoka et al., 2006; Matsuoka and Kim, 2007), which is thought to reflect the premorbid IQ of schizophrenia patients. Psychopathology was assessed using Positive and Negative Symptom Scale (PANSS) (Kay et al., 1987). All patients were receiving antipsychotic medication (typical [n = 3], atypical [n = 31], typical and atypical [n = 9]). Haloperidol equivalents were calculated according to the practice guideline for the treatment of schizophrenia patients (Lehman et al., 2004; Inagaki and Inada, 2008).

Thirty-six age-, gender-, handedness-, and predicted IQ-matched healthy individuals (24 men and 12 women, age = 33.86 ± 8.69) were recruited for this study as the control group. They were also evaluated using SCID Non-patient Edition, Version 2.0. They had no history of psychiatric disorders, and no first-degree relatives with psychotic episodes. Exclusion criteria for both groups were: a history of head trauma, neurological disease, severe mental disease, or substance abuse that could affect brain function. Handedness was assessed with the Edinburgh Handedness Inventory (Oldfield, 1971).

After receiving a complete description of the study, written informed consent was obtained from each participant. This study was approved by the Committee on Medical Ethics of Kyoto University, and was conducted in accordance with the Code of Ethics of the World Medical Association.

2.2. Psychological tests

We used three different fluency tests: the design fluency test and the idea fluency test from Test for Creative Thinking (TCT) Japanese version (Waseda Creativity Society, 1984; Nemoto et al., 2005), and the verbal fluency test from Brief Assessment of Cognition in Schizophrenia Japanese-language Version 3.0 (BACS-J) (Keefe et al., 2004; Kaneda et al., 2007). Two different examiners, "SS" and "MK", kept the scores of the design and idea fluency tests of each participant and blindly chose the scores of ten participants to confirm the inter-rater reliability as performed in a previous study (Nemoto et al., 2005). We used Peters Delusions Inventory (PDI) 21-item version (Peters et al., 2004) to evaluate the participants' delusions.

2.2.1. Design fluency test

In the design fluency test, the examiner asked the participants to produce as many different drawings for one set of four dots as possible within 3 min. After completing the task, the examiner classified the drawings into three categories: task-dependent (Design Td), the drawings based on a geometrical pattern; task-modified (Design Tm), the drawings based on the shape of a square; and task-independent (Design Ti), the rest of the drawings except for task-dependent and task-modified (Fig. 1) (Nemoto et al., 2005).

2.2.2. Idea fluency test

In the idea fluency test, the examiner asked the participants to think of as many usages for an empty tin can as possible within 2 min. In this test, we also classified the responses into three categories: task-dependent (Idea Td), ideas based on nature as a container, for example

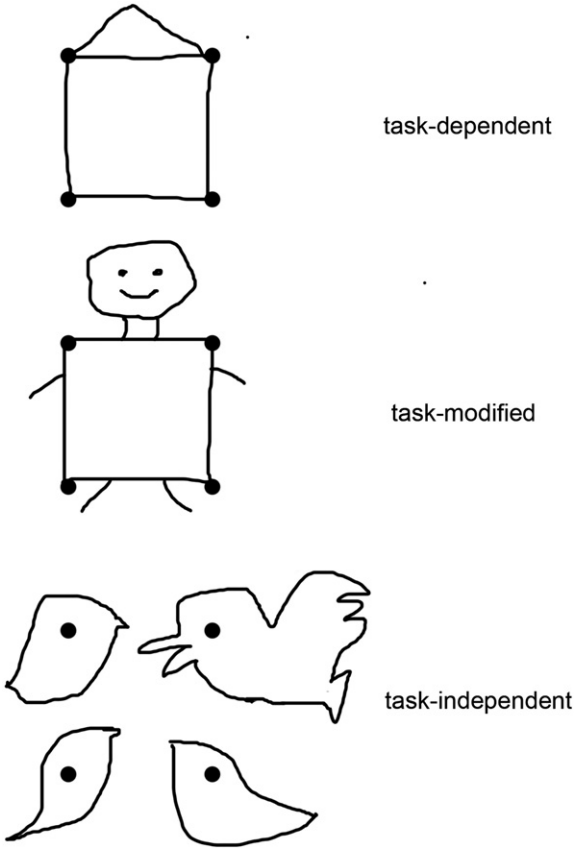

Fig. 1. Examples of responses on design fluency.