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Research Paper

Effect of cognitive function on jumping to conclusion in patients with schizophrenia

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ABSTRACT

The “jumping to conclusion” (JTC) bias is related to the formation and maintenance of delusions. Higher JTC bias can be based on both neurocognitive dysfunction and social cognitive dysfunction in patients with schizophrenia. The aim of this study was to assess the relationship between JTC bias, neurocognition, and social cognition in patients with schizophrenia.

A total of 22 patients with schizophrenia and 21 controls participated in this study. Neurocognition and social cognition were assessed using the Brief Assessment of Cognition in Schizophrenia (BACS) and Social Cognition Screening Questionnaire (SCSQ), respectively. The JTC bias and the decision confidence were assessed using the beads task.

The patients were classified into the JTC group (with higher JTC bias; n = 10) and JTC-non group (n = 12). The JTC group scored significantly lower on verbal memory, working memory, and motor speed sub-scores of BACS than the JTC-non group. No difference in social cognition was observed between the two groups. The decision confidence was predicted by metacognition, which is an SCSQ sub-score. Similarly to the patients, the controls were classified into the JTC group (higher JTC bias; n = 9) and the JTC-non group (n = 12). There were no significant differences in neurocognition and social cognition between the control JTC and JTC-non groups.

The present results indicated that JTC bias is related to neurocognition and decision confidence is related to social cognition in patients with schizophrenia. These findings may bridge the gaps between psychotic symptom and cognitive dysfunction in schizophrenia.

1. Introduction

Previous studies have argued that people with delusion show a “jumping to conclusion” (JTC) bias whereby they are willing to accept hypotheses on the basis of less evidence than non-delusional people and with greater confidence in their judgment than controls (Lincoln et al., 2010; Warman et al., 2007; Moritz and Woodward, 2002, 2004, 2005). The JTC bias is typically assessed using a probabilistic reasoning task known as the beads task. During the test, the participants are initially presented with two jars of beads, which are later hidden from them. The experimenter would choose of the two jars and draws as many beads as the participants choose to. The participants are subsequently requested to decide about the jar of origin. After each draw, the participants would be asked if they would like to draw more beads or if they could say, with decision confidence made on a 0–100 scale, from which of the two jars were the beads drawn. The JTC bias has been operationally defined based on the number of draws before making a decision. In particular, it has been recently suggested that JTC bias is defined when a decision is made after viewing less than three beads being drawn (Freeman et al., 2008; Ward et al., 2018).

Recent studies have reported JTC bias in persons with schizophrenia regardless of the clinical characteristics (Garety et al., 2013; Ochoa et al., 2014). The relationship between JTC bias, neurocognition, and social cognition were also investigated (Ochoa et al., 2014; Woodward et al., 2009; Buck et al., 2012), but the results were inconsistent. For example, in patients with schizophrenia, JTC bias was reported to be correlated (Ochoa et al., 2014; Woodward et al., 2009) or not correlated (Buck et al., 2012) with neurocognition. Similarly, different studies reported different results on the relationship between JTC bias and social cognition in patients with schizophrenia. Social cognition, including the theory of mind (ToM) and metacognition, refers to psychological processes related to perception, encoding, storage, retrieval,

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and regulation of information about ourselves and other people (Green et al., 2008, 2015). Woodward et al. (2009) reported a correlation between JTC bias and neurocognition, but not ToM. Buck et al. (2012) reported a correlation between JTC bias and metacognition in patients with schizophrenia. These inconsistencies might derive from methodological differences. For example, the studies assessed social cognition using only one psychological test (Woodward et al., 2009; Buck et al., 2012). Therefore, more comprehensive assessment of social cognition is needed to investigate the relationship between social cognition and JTC bias in patients with schizophrenia. Roberts et al. (2011) developed the Social Cognition Screening Questionnaire (SCSQ) to measure multiple domains of social cognition and differentiate performance in these domains from non-social cognition. The SCSQ includes subscales measuring the non-social domain of verbal memory and schematic inference, as well as social cognitive domains including ToM, metacognition, and hostile attribution bias. It is still not clear which of these social cognition domains are crucial for predicting JTC bias.

To the best of our knowledge, only few studies have assessed the relationship between JTC bias and both neurocognition and social cognition in patients with schizophrenia. Thus, the aim of this study was to assess the relationship between JTC, decision confidence, neurocognition, and social cognition in patients with schizophrenia using relevant measuring scales.

2. Methods

2.1. Participants

Twenty-two patients with schizophrenia were selected, including 12 men and 10 women with a mean age (± standard deviation [SD]) of 42.64 ± 10.11 years. All patients were diagnosed with schizophrenia based on the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition criteria. At the time of study admission, the patients were clinically stable, as judged by the therapeutic psychiatrist after drug adjustment was completed. There was no remarkable change in their psychopathology during this study. The exclusion criteria were: (1) past history or presence of any serious medical and neurological disorders that affect the brain or cognitive functioning, such as epilepsy, serious head injury, or brain tumor; (2) drug or alcohol abuse; (3) active drug use in the past year.

Moreover, 21 demographically matched healthy controls were selected, including 11 men and 10 women. They were college students, hospital employees, or their acquaintances, with a mean age of 42.76 ± 10.67 years. All participants provided written informed consent and the study was approved by the institutional ethics committee of Tokushima University.

We originally recruited 23 patients and controls. However, one patient and two controls withdrew their consents before starting experiment.

2.2. Measures

2.2.1. Japanese adult reading test

To estimate the intellectual ability, we used a 25-item short version of the Japanese adult reading test (Nelson and Willison, 1991; Matsuoka et al., 2006).

2.2.2. Positive and negative symptoms

To assess the positive and negative symptoms, we used the Positive and Negative Syndrome Scale (PANSS). Higher scores indicated a greater level of symptom severity (Kay et al., 1987, 1991).

2.2.3. Depression

To assess depression, we used the Calgary Depression Scale for Schizophrenia (CDSS). The CDSS was specifically developed to distinguish depressive symptoms from positive and negative symptoms or antipsychotic-induced adverse effects. Higher scores indicated a greater level of depression (Addington et al., 1993; Kaneda et al., 2000).

2.2.4. Side effects

To assess drug-induced extra-pyramidal symptoms, we used the Drug Induced Extra-Pyramidal Symptoms Scale. Higher scores indicated a greater level of extrapyramidal adverse effects (Inada, 1996).

2.2.5. Neurocognition

To assess neurocognition, we used the Brief Assessment of Cognition in Schizophrenia (BACS). The domains of neurocognition that were evaluated by the BACS included verbal memory, working memory, motor speed, verbal fluency, attention and speed of information processing, and executive function (Keefe et al., 2004; Kaneda et al., 2007).

2.2.6. Social cognition

To assess social cognition, we used the Social Cognition Screening Questionnaire (SCSQ). The SCSQ has five domains including were verbal memory, schematic inference, ToM, metacognition, and hostility bias. The task comprised 10 short vignettes. Higher scores represented a better level in each domain, except for hostility bias, where higher scores reflected larger bias (Roberts et al., 2011; Kanie et al., 2014). We used the ToM, metacognition, and hostility bias as social cognition.

2.2.7. Decision confidence and JTC

To assess JTC and decision confidence, we used a probabilistic reasoning task known as the "beads task." The task consisted of two neutral versions, including a ratio of beads at 85:15 (easy) and another at 60:40 (difficult). We used the difficult version because of its stronger association with neurocognition (Garety et al., 2013; Ochoa et al., 2014). Briefly, the participants were presented physical two jars, one containing 60 red beads and 40 blue beads and another containing 60 blue beads and 40 red beads. The two jars were then hidden and the participants were told that one of the jars would be selected at random by the experimenter who would then draw beads from it upon their request. The sequences of beads shown to the subjects were decided with reference to Huq et al. (1988) before starting experiment, while Ochoa et al.'s (2014) bead task is drawn beads by random. We employed Huq's way to control the order of the color of the presented beads. After each bead draw, the participants were asked if they would like to draw more beads or if they would like to make a decision about which of the two jars were the draws made form, with decision confidence on a 0–100 scale. The key variables were the number of beads indicated by the participants before making a decision and the decision confidence. High JTC bias was indicated when requesting two or fewer beads, while the JTC-non groups were indicated when requesting three or more beads (Freeman et al., 2008; Ward et al., 2018).

2.3. Statistical analysis

Data analysis was conducted using PASW Statistics 18 software (SPSS Inc., 2009). The comparison of the demographic indices between patients with schizophrenia and controls and between the JTC and JTC-non groups was carried out using unpaired Chi-squared test and Welch's t-test. In addition, Pearson's correlation coefficients were calculated to evaluate the relationship between decision confidence and cognitive function both in patients with schizophrenia and in controls. Finally, simultaneous multiple regression analysis was performed with decision confidence as the objective variable and clinical variables that have significant correlation with decision confidence as explanatory variables.

3. Results

The demographic indices and cognitive performances of patients with schizophrenia and controls are summarized in Table 1. The results

Table 1
Demographic data of patients with schizophrenia and healthy controls.

		Schizophrenia	Control	Statistical value	*p*-Value	Effect-size
N (men/women)		22 (12/10)	21 (11/10)	$x^2 = 0.03$	$p = 0.89$	$\varphi = 0.03$
Age (years)		42.64 (10.11)	42.76 (10.67)	$t = -0.04$	$p = 0.97$	$d = 0.01$
Education (years)		14.23 (1.85)	15.00 (2.37)	$t = -1.19$	$p = 0.24$	$d = 0.36$
IQ (JART)		97.18 (10.38)	109.33 (5.98)	$t = -4.73$	$p < 0.01$**	$d = 1.43$
Duration of illness		16.50 (8.53)				
Dose of antipsychotics (mg/day)		436.05 (366.25)				
PANSS	Positive syndorome	12.14 (3.59)				
	Negative syndrome	15.68 (4.03)				
CDSS		3.27 (3.31)				
DIEPSS		1.73 (2.33)				
BACS	Verbal memory	31.59 (14.04)	44.43 (9.10)	$t = -3.54$	$p < 0.01$**	$d = 1.08$
	Working memory	16.18 (3.75)	20.76 (4.45)	$t = -3.64$	$p < 0.01$**	$d = 1.12$
	Motor speed	66.64 (16.68)	78.95 (10.23)	$t = -2.93$	$p < 0.01$**	$d = 0.88$
	Attention and speed of information processing	49.00 (10.62)	65.62 (7.71)	$t = -5.89$	$p < 0.01$**	$d = 1.78$
	Verbal fluency (total)	36.55 (11.95)	45.86 (10.56)	$t = -2.71$	$p = 0.01$*	$d = 0.82$
	Executive function	16.95 (2.19)	18.91 (2.17)	$t = -2.93$	$p = 0.01$*	$d = 0.90$
SCSQ	Theory of mind	7.00 (1.75)	8.71 (1.01)	$t = -3.97$	$p < 0.01$**	$d = 1.19$
	Hostility bias	1.09 (1.06)	0.67 (0.73)	$t = 1.53$	$p = 0.14$	$d = 0.46$
	Metacognition	9.23 (0.62)	9.68 (0.44)	$t = -2.79$	$p < 0.01$**	$d = 0.83$
JTC	Number of draws	3.27 (2.21)	3.29 (2.28)			
	Number of JTC	10	9			
	Decision confidence	51.50 (26.58)	52.62 (18.55)			

*$p < 0.05$; **$p < 0.01$; Welch's *t*-test.
BACS, Brief Assessment of Cognition in Schizophrenia; CDSS, Calgary Depression Scale for Schizophrenia; DIEPSS, Drug Induced Extra-Pyramidal Symptoms Scale; IQ, intelligence quotient; JART, Japanese adult reading test; JTC, jumping to conclusion; PANSS, Positive and Negative Syndrome Scale; SCSQ, Social Cognition Screening Questionnaire.

indicated significant differences between the two groups in the following variables: intelligence quotient ($t_{33.84} = -4.73$, $p < 0.01$), verbal memory ($t_{41} = -3.54$, $p < 0.01$), working memory ($t_{41} = -3.66$, $p < 0.01$), motor speed ($t_{41} = -2.90$, $p < 0.01$), attention and speed of information processing ($t_{41} = -5.85$, $p < 0.01$), total verbal fluency ($t_{41} = -2.70$, $p < 0.05$), executive function ($t_{41} = -2.93$, $p < 0.05$), ToM ($t_{41} = -3.92$, $p < 0.01$), and metacognition ($t_{41} = -2.77$, $p < 0.01$).

Moreover, patients with schizophrenia and controls were subdivided into JTC or JTC-non based on the results of the beads task. In patients with schizophrenia, JTC bias consisted of 10 patients (3 men, 7 women; age, 48.70 ± 9.31), and JTC-non consisted of 12 patients (9 men, 3 female; age, 35.78 ± 7.93). Significant differences we observed between the two groups in the following variables: sex ($x^2 = 4.46$, $df = 1$, $p < 0.05$), age ($t_{20} = 3.03$, $p < 0.01$), verbal memory ($t_{12.39} = -2.51$, $p < 0.05$), working memory ($t_{20} = -2.54$, $p < 0.05$), and motor speed ($t_{20} = -2.12$, $p < 0.05$). In addition, the decision confidence was significantly correlated with ToM (Pearson's $r = -0.60$, $p < 0.01$), hostility bias (Pearson's $r = 0.46$, $p < 0.05$), and metacognition (Pearson's $r = -0.72$, $p < 0.01$; Table 3). Multiple regression analysis was calculated to predict the decision confidence based on their metacognition, ToM and hostility bias. A significant regression equation was found (F (2, 19) = 10.61, $p < 0.01$), with an R^2 of 0.53. Metacognition was only significant predictor of the decision confidence ($\beta = -0.72$, $p < 0.01$; Fig. 1).

In the control group, JTC consisted of nine controls (4 men, 5 women; age, 37.67 ± 7.07 years) and JTC-non consisted of 12 controls (7 men, 5 women; age, 46.58 ± 11.56 years). There were no significant differences in neurocognition and social cognition between the two groups (Table 2).

4. Discussion

We showed that JTC bias is related to neurocognition and decision confidence is related to social cognition in patients with schizophrenia. The results of this study indicated significant differences in neurocognition between the JTC and JTC-non groups in patients with schizophrenia. Moreover, decision confidence was significantly correlated with social cognition. Therefore, we suggested that JTC bias and decision confidence might be related to different modalities of cognitive function.

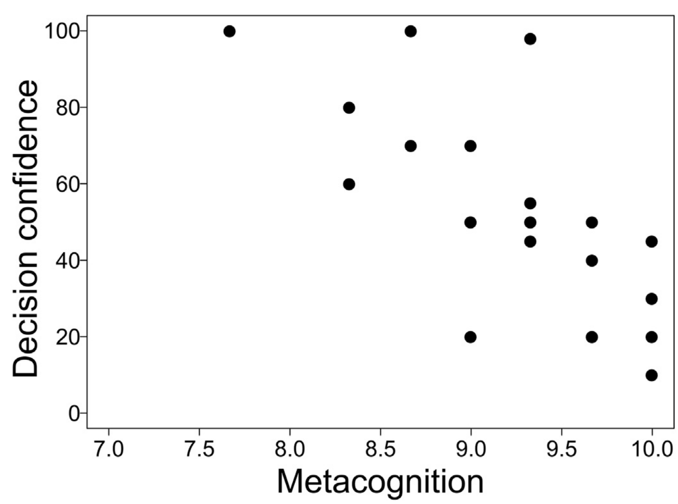

Fig. 1. Relationship between decision confidence and metacognition scores. There is a significant negative correlation ($R^2 = 0.52$, $p < 0.01$; simple linear regression analysis).

Our patients with schizophrenia showed lower cognitive function than that of control. As for social cognition, Kanie et al. (2014) demonstrated that patients with schizophrenia had lower scores in ToM, metacognition, and hostility bias than controls. However, contrary to the expectation, our study found no significant difference in hostility bias of SCSQ. The effect size of hostility bias in our results (95% confidence interval [CI] = 0.46 [−0.16, 1.09]) was comparable to that of the previous study (Kanie et al., 2014) (95% CI = 0.63 [0.23, 1.02]). Thus, the discrepancies may be explained by the low statistical power due to the small number of participants. Moreover, there were no significant differences between the two groups in the number of draws and the decision confidence. These results were consistent with those from Menon et al. (2006) and Langdon et al. (2010), but not with other

Table 2
Demographic data of JTC and JTC-non groups of patients with schizophrenia and controls.

	Schizophrenia					Control				
	JTC	JTC-non	Statistical value	p-Value	Effect-size	JTC	JTC-non	Statistical value	p-Value	Effect-size
N (men/women)	10 (3/7)	12 (9/3)	$x^2 = 4.46$	$p = 0.04$*	$\varphi = 0.45$	9 (4/5)	12 (7/5)	$x^2 = 4.00$	$p = 0.53$	$\varphi = 0.44$
Age (years)	48.70 (9.31)	37.58 (7.93)	$t = 3.03$	$p < 0.01$**	$d = 1.30$	37.67 (7.07)	46.58 (11.56)	$t = -2.04$	$p = 0.06$	$d = 0.90$
Education (years)	14.10 (1.66)	14.33 (2.06)	$t = -0.29$	$p = 0.78$	$d = 0.12$	14.78 (1.56)	15.17 (2.89)	$t = -0.37$	$p = 0.72$	$d = 0.16$
IQ (JART)	94.70 (12.10)	99.25 (8.69)	$t = -1.03$	$p = 0.32$	$d = 0.44$	111.56 (4.98)	107.67 (6.31)	$t = 1.52$	$p = 0.14$	$d = 0.67$
Duration of illness	19.94 (7.19)	13.63 (8.76)	$t = 1.82$	$p = 0.08$	$d = 0.78$					
Dose of antipsychotics (mg/day	444.00 (459.39)	429.42 (288.62)	$t = 0.09$	$p = 0.93$	$d = 0.04$					
PANSS										
Positive syndrome	12.50 (4.30)	11.83 (3.04)	$t = 0.41$	$p = 0.69$	$d = 0.18$					
Negative syndrome	15.50 (3.69)	15.83 (4.45)	$t = -0.19$	$p = 0.85$	$d = 0.08$					
CDSS	3.80 (3.65)	2.83 (3.10)	$t = 0.67$	$p = 0.51$	$d = 0.29$					
DIEPSS	2.20 (2.53)	1.33 (2.19)	$t = 0.86$	$p = 0.40$	$d = 0.37$					
BACS										
Verbal memory	23.90 (16.29)	38.00 (7.79)	$t = -2.51$	$p = 0.03$*	$d = 1.14$	46.11 (7.72)	43.17 (10.15)	$t = 0.73$	$p = 0.48$	$d = 0.32$
Working memory	14.20 (4.02)	17.83 (2.66)	$t = -2.54$	$p = 0.02$*	$d = 1.09$	19.89 (5.23)	21.42 (3.87)	$t = -0.77$	$p = 0.45$	$d = 0.34$
Motor speed	59.00 (15.27)	73.00 (15.60)	$t = -2.12$	$p = 0.047$*	$d = 0.91$	77.33 (9.54)	80.17 (10.97)	$t = -0.62$	$p = 0.54$	$d = 0.27$
Attention and speed of information processing	47.20 (9.46)	50.50 (11.70)	$t = -0.72$	$p = 0.48$	$d = 0.31$	67.89 (7.01)	63.92 (8.06)	$t = 1.18$	$p = 0.25$	$d = 0.52$
Verbal fluency (total)	31.50 (10.15)	40.75 (12.08)	$t = -1.92$	$p = 0.07$	$d = 0.82$	46.11 (8.52)	45.67 (12.24)	$t = 0.09$	$p = 0.93$	$d = 0.04$
Executive function	16.60 (2.46)	17.25 (2.01)	$t = -0.68$	$p = 0.50$	$d = 0.29$	18.56 (2.65)	19.17 (1.80)	$t = -0.63$	$p = 0.54$	$d = 0.28$
SCSQ										
Theory of mind	7.30 (1.95)	6.75 (1.60)	$t = 0.73$	$p = 0.48$	$d = 0.31$	9.00 (0.87)	8.50 (1.09)	$t = 1.13$	$p = 0.27$	$d = 0.50$
Hostility bias	0.90 (1.20)	1.25 (0.97)	$t = -0.76$	$p = 0.46$	$d = 0.32$	0.33 (0.50)	0.92 (0.79)	$t = -1.93$	$p = 0.07$	$d = 0.86$
Metacognition	9.33 (0.74)	9.14 (0.52)	$t = 0.73$	$p = 0.48$	$d = 0.30$	9.70 (0.45)	9.67 (0.45)	$t = 0.19$	$p = 0.86$	$d = 0.07$
JTC										
Number of draws	1.70 (0.67)	4.58 (2.19)				1.33 (0.50)	4.75 (1.96)			
Decision confidence	50.50 (29.67)	52.33 (25.02)				45.56 (12.36)	57.92 (21.05)			

*$p < 0.05$; **$p < 0.01$; (1), Chi-squared test; (2), Welch's t-test.
BACS, Brief Assessment of Cognition in Schizophrenia; CDSS, Calgary Depression Scale for Schizophrenia; DIEPSS, Drug Induced Extra-Pyramidal Symptoms Scale; IQ, intelligence quotient; JART, Japanese adult reading test; JTC, jumping to conclusion; JTC-non, No jumping to conclusion; PANSS, Positive and Negative Syndrome Scale; SCSQ, Social Cognition Screening Questionnaire.

studies (Lincoln et al., 2010; Ochoa et al., 2014). It remains unclear whether healthy controls have JTC bias.

When comparing only the patients with schizophrenia based on JTC bias, our results were consistent with those of Ochoa et al. (2014), where significant differences in verbal memory, working memory, and motor speed between the JTC and JTC-non groups were reported. However, our results failed to find a relationship between JTC bias and cognitive processing speed, which may be the result of methodological and measurement discrepancies of the cognitive processing speed. In addition, contrary to the expectation, we did not find a relationship between JTC bias and delusion because our results indicated no significant difference in delusion (PANSS delusion item) between the JTC

Table 3
Correlation coefficients among decision confidence, neurocognition, and social cognition.

		Decision confidence					
		Schizophrenia			Control		
		r	p-Value	t-Value	r	p-Value	t-Value
BACS	Verbal memory	0.18	$p = 0.43$	$t = 0.82$	−0.24	$p = 0.29$	$t = -1.08$
	Working memory	0.14	$p = 0.52$	$t = 0.63$	0.01	$p = 0.97$	$t = 0.04$
	Motor speed	−0.28	$p = 0.20$	$t = -1.30$	0.13	$p = 0.57$	$t = 0.57$
	Attention and speed of information processing	−0.13	$p = 0.56$	$t = -0.59$	−0.33	$p = 0.14$	$t = -1.52$
	Verbal fluency (total)	0.15	$p = 0.52$	$t = 0.68$	0.08	$p = 0.74$	$t = 0.35$
	Executive function	0.36	$p = 0.10$	$t = 1.73$	0.21	$p = 0.37$	$t = 0.94$
SCSQ	Theory of mind	−0.60	$p < 0.01$**	$t = -3.35$	−0.31	$p = 0.18$	$t = -1.42$
	Hostility bias	0.46	$p = 0.03$*	$t = 2.32$	0.27	$p = 0.24$	$t = 1.22$
	Metacognition	−0.72	$p < 0.01$**	$t = -4.64$	−0.31	$p = 0.17$	$t = -1.42$

*$p < 0.05$; **$p < 0.01$; Pearson's correlation test.
BACS, Brief Assessment of Cognition in Schizophrenia; SCSQ, Social Cognition Screening Questionnaire.

and JTC-non groups ($t_{20} = 1.34$, $p = 0.20$). However, this result might be attributed to the small effect size in the association among the number of draws, decision, and delusion (Ross et al., 2015). Lunt et al. (2012) explored the link between JTC bias in patients with neurosurgical excisions to the prefrontal cortex and attention deficit hyperactivity disorder. They suggested that JTC bias was not specific to delusional states or schizophrenia and was associated with prefrontal lobe dysfunction. Taken together, these previous and current findings indicated that increased JTC bias is derived from neurocognitive dysfunction, which is itself not specific to schizophrenia. Thus, delusion would be a schizophrenia-specific manifestation of JTC bias. However, other aspects of the relationship between JTC bias and delusion still need to be clarified.

In addition to JTC bias, decision confidence has also been considered as a basis for delusion (Warman et al., 2007; Moritz et al., 2005). Our study also revealed that greater decision confidence was predicted by less metacognition. Kanie et al. (2014) reported that metacognition deficit in patients with schizophrenia includes decreased ability to evaluate the accuracy of one's own judgments, often due to overconfidence. Moritz et al. (2015) also indicated that metacognition-augmented cognitive remediation therapy reduced overconfidence in patients with schizophrenia. The present results also suggested that metacognition was an important variable for evaluating the accuracy of one's own judgment. However, Buck et al. (2012) indicated that decision confidence is lined to executive function, which was measured using the Wisconsin card sorting test. Our present findings indicated that decision confidence was not significantly related to executive function, as evidenced by the tower of London test (Pearson's $r = 0.36$, $p = 0.10$). This inconsistency might be due to differences in the measurement method of the executive function and the low statistical power due to the small number of participants.

In the control group, we observed no significant differences in neurocognition and social cognition between the JTC and JTC-non groups. Previous studies have revealed significant differences in the neurocognitive function between the JTC and JTC-non groups in healthy controls (Ochoa et al., 2014; Falcone et al., 2015). Differences in the measurement methods of the neurocognitive function might account for this discrepancy. In control group, BACS might be easy for control, because BACS was made to measure the neurocognition of patients with schizophrenia. For example, mean score of executive function measured by BACS in healthy controls showed almost full score. Such an effect, known as ceiling effect, might occur in present study and affect results of statistics because of variability reduction (Ledbetter et al., 1991). For other reasons, we think that JTC might be influenced by interaction between neurocognitive decline and delusional ideation. Previous study showed that JTC in non-clinical sample was strongly associated with delusional ideation (Freeman et al., 2008; Ross et al., 2015). Our study did not test delusional ideation. Therefore, we could not test the relationship between JTC and delusional ideation. On the other hand, we did not find the significant difference in delusion ($t_{20} = 1.34$, $p = 0.20$) between JTC and JTC-non in patients with schizophrenia. However, we showed the significant difference in neurocognition between JTC and JTC-non in patients with schizophrenia. Based on above, we just speculate that the better neurocognition they have, the more resilience for the JTC bias they show in patients with schizophrenia.

Our findings suggested that both neurocognition and social cognition might be involved in the delusion in schizophrenia through the influence of JTC bias and decision confidence. Furthermore, our findings may bridge the gap between neurocognitive dysfunction and behavioral tendency related to psychotic symptoms in patients with schizophrenia. Recently, some treatment modalities such as cognitive remediation therapy (CRT) and metacognitive therapy (MCT) have been found to be effective for neurocognitive impairment and cognitive traps or biases (e.g., JTC bias, overconfidence in errors) of patients with schizophrenia (Wykes and Reeder, 2005; Moritz et al., 2014). The present study may also provide a framework for applying CRT and MCT to manage psychotic symptoms in patients with schizophrenia.

4.1. Limitation

The current study has several limitations. First, the sample size was relatively small. Second, the participants showed relatively mild symptoms. Therefore, there is a possibility that our results do not reflect the characteristics of all patients with schizophrenia. Third, medications may have had an influence on our findings. Fourth, sex and age might have affected our results. However, we could not run the analysis of covariance (ANCOVA) model with sex and age as covariates because the independent variable and the covariate were not independent of each other, which meant a violation of the ANCOVA assumptions. Thus, future studies need further considerations of the relationship among sex, age, neurocognition, and JTC bias. Fourth, SCSQ which was measured social cognition in this study was self-report measure but not performance-based measure. Hence, future study needs further consideration of the relationship between confidence and social function which was measured by performance-based measure. Furthermore, we have not tested mental health status of control subjects. However, we carefully asked them whether they had mental illness and history of psychiatric disease or not. Our control subjects did not have mental illness and history of psychiatric disease. Future study needs more detail assessment of mental status of healthy control.

5. Conclusion

In conclusion, our findings indicated a significant correlation of JTC bias with neurocognition and of decision confidence with social cognition; social cognition may be independent of neurocognition (Van Hooren et al., 2008). The present study provided further evidence that neurocognition and social cognition are two separate areas of vulnerability in psychosis. Thus, taking into consideration both JTC bias and decision confidence will be beneficial for addressing the underlying cognitive vulnerability in patients with schizophrenia.

Conflict of interest

The authors declare no conflict of interest.

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