difference. Moreover, the total score distinguished the patients from normal controls with a sensitivity of 0.87 and a specificity of 0.69 and the area under the ROC curve was 0.84, which indicated high level of discrimination. Thus, the robust between-group differences in the subscales of ToM and hostility bias and the total score in the SCSQ provide support for the sensitivity and construct validity of these subscales.

We found a weak but significant between-group difference in the metacognition subscale, which was in line with the previous research[24] measuring the participants' confidence level in error responses to the "Reading the mind in the Eyes test" indicating that the patients committed more high-confidence errors than did healthy controls. In the present study, metacognitive ability was, at least in part, evaluated using confidence level to the error responses, which might have led to the similar result.

Internal consistency

Cronbach's alpha for the SCSQ total score was 0.72, which was considered acceptable. Considering that social cognition is a multifaceted concept and the scale covers different dimensions and that panelists in a recent RAND panel agreed not to consider Cronbach's alpha as a criterion for evaluation of social cognitive measures[25], the significance of the value is not necessarily clear. However, we consider that the value is acceptable to use the SCSQ total score summing up these subscale scores.

Convergent and discriminant validity

We found that the SCSQ ToM subscale scores showed a relatively strong relationship with the Hinting task scores, which supports the SCSQ's convergent validity. Both tasks require the subjects to characterize the mental states of other people and to modify their responses by projecting oneself imaginatively into the 'mental shoes' of another person in an interpersonal situation.[26] In contrast, the SCSQ schematic inference subscale scores did not significantly correlate with the Hinting task scores. Although both the SCSQ ToM and schematic inference subscales require the subjects to make inferences from uncertain and ambiguous context information, the latter does not involve mentalizing, which is associated with the SCSQ ToM subscale and the Hinting task. The lack of a significant correlation between the SCSQ schematic inference subscale and the Hinting task supports the view that the key element that links the SCSQ ToM subscale and the Hinting task may be the process of mentalizing. Moreover, we found a significant negative correlation between SCSQ ToM subscale scores and scores of AIHQ blame scores and aggression bias. Although we did not a priori expect these relationships, considering that poor ToM leads to a misunderstanding of another's intent, together with personalizing bias, it is not difficult to presume that it may cause exaggerated blame and aggression to others. An alternative explanation is that because the SCSQ ToM and hostility bias scales are based on the same response set, it is possible that, for some participants, poor ToM performance was caused by high hostility bias rather than by diminished mentalizing capacity.

We also found SCSQ hostility bias scores significantly correlated with scores of AIHQ hostility, aggression bias, and blame scores in ambiguous situations, as expected. Both tasks require subjects to judge the intention of characters in short, ambiguous vignettes, which may have contributed to the significant relationship between the scores in the two tests.

Moreover, as "blame score" and "aggression bias" are well assumed to be related to "hostility bias" in the AIHQ, it is unsurprising to find a significant correlation between SCSQ hostility bias and AIHQ blame scores and aggression bias.

There was a significant but modest correlation between SCSQ metacognition and BCIS composite scores. The SCSQ is a performance-based measure while the BCIS is a self-report measure, which may have led to the modest level of correlation. In a previous study investigating the relationship between BCIS scores and confidence level of error responses to the "Reading the mind in the Eyes test", along with a positive correlation between BCIS self-certainty scores and the confidence level to error responses, a *positive* correlation was unexpectedly demonstrated between self-reflective scores and the confidence level to error responses.[24] Although we found a significant positive correlation between SCSQ metacognition subscale scores and BCIS composite scores as expected, the level of correlation was modest. We should take care about the metacognitive dissonance between subjective and objective social cognition abilities; it may happen that the patients think they are more self-critical, although in fact they show greater overconfidence in errors.

Ecological validity

Social cognition has been identified as a contributor to functional outcome because the ability to process social stimuli is essential for social interactions and thus affects interpersonal relationships with others in the community as well as work and school behavior[3]. In several recent studies, it has been demonstrated that social cognition serves as a mediator between neurocognition and social functioning. [4-7,27,28] Therefore, we predicted that the subscale scores of the SCSQ would correlate with the scores of social functioning measured by the SFS. We found a significant positive correlation between SCSQ ToM subscale and the four domains of social functioning, including social engagement, interpersonal communication, recreation, and occupation, and also positive correlations between the SCSQ metacognition subscale and the two SFS domains such as recreation and occupation, and a negative correlation between the SCSQ hostility bias and the domain of social engagement. As for the SCSQ total score, we found only a modest correlation with the domain score of occupation, which suggests that the TOM subscale is more closely related to social functioning than the SCSQ total score. This finding may relate to evidence that social cognition is more closely linked to social functioning and the total score includes verbal memory, which is more neurocognitive and thus may dilute the association to social functioning. Although most previous studies examining the relationship between social cognition and social functioning used emotion and social perception measures of social cognition, a few studies have demonstrated a significant relationship between ToM, metacognition, attributional bias, and functional outcome.[28-31] For example, Couture et al.[28] demonstrated that ToM as indexed by the Hinting Task partially mediated the relationship between neurocognition and social competence. Our study results support the ecological validity of the SCSQ, and also the continued use of subscale scores rather than just the total score.

LIMITATIONS

There are several limitations of the present study that should be addressed. First, as we lack validated standard measures for assessing social cognition in the adult psychiatric population in Japan, we selected the measures for investigating the criterion-related validity of the SCSQ under the following conditions; a) the original version of the test had been validated, b) not so much affected by the cultural differences, c) assumed to tap similar domains of social cognition as the SCSQ. Although both the Hinting task and the AIHQ are validated in their original forms, neither of the Japanese translation versions has yet been validated. However, except for a few points in the AIHQ, we found it unnecessary to change the content of these measures to fit the Japanese culture. The few points in the AIHQ concerned settings that were rather unusual in Japan. Through discussion with Dr. Combs, who developed the AIHQ, we replaced them with settings more natural and appropriate for the Japanese culture. The fact that we obtained significant relationships between the SCSQ ToM subscale and the Hinting task, and also between hostility bias of the SCSQ and hostility bias, blame scores and aggression bias of the AIHQ in ambiguous situations, provides some initial support for the validity of the Japanese versions of both the Hinting task and the AIHQ.

Second, our sample size was small, and included participants of a wide range of age, illness duration, and symptom profiles. These demographic factors could have different effects on social cognition and a greater sample size may enable us to investigate the effect of various demographic as well as clinical factors.

Third, to apply the SCSQ in clinical trials targeting social cognition, we need to confirm its test-retest reliability, which was not evaluated in the present study. Given the current study's support for the construct validity of the SCSQ ToM and hostility bias subscales, we are now planning to investigate the test-retest reliability in the near future.

CONCLUSION

Based on these results, the SCSQ subscales appeared to be valid measures. The construct validity evidence for the SCSQ supports its use as a novel measure of ToM, metacognition and hostility bias.

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REFERENCES

1. Roberts DL, Fiszdon J, Tek C. Initial validity of the Social Cognition Screening Questionnaire (SCSQ). *Schizophr. Bull.* 2011; 37 (Suppl. 1): 280.
2. Regier DA, Narrow WE, Rae DS, Manderscheid RW, Locke BZ, Goodwin FK. The de facto US mental and addictive disorders service system. Epidemiologic Catchment Area prospective 1-year prevalence rates of disorders and services. *Arch. Gen. Psychiatry* 1993; 50: 85–94.
3. Couture SM, Penn DL, Roberts DL. The functional significance of social cognition in schizophrenia: a Review. *Schizophr. Bull.* 2006; 32 (Suppl. 1): 44-63.
4. Brekke J, Kay DD, Lee KS, Green MF. Biosocial pathways to functional outcome in schizophrenia. *Schizophr. Res.* 2005; 80: 213-225.
5. Addington J, Saeedi H, Addington D. Facial affect recognition: a mediator between cognitive and social functioning in psychosis. *Schizophr. Res.* 2006; 85: 142–150.

6. Addington J, Saeedi H, Addington D. Influence of social perception and social knowledge on cognitive and social functioning in early psychosis. *Br. J. Psychiatry* 2006; 189: 373–378.

7. Schmidt SJ, Mueller DR, Roder V. Social cognition as a mediator variable between neurocognition and functional outcome in schizophrenia: empirical review and new results by structural equation modeling. *Schizophr. Bull.* 2011; 37 (Suppl. 2): 41-54.

8. Adolphs R. The social brain: neural basis of social knowledge. *Annu. Rev. Psychol.* 2009; 60: 693-716.

9. Ochsner KN. The social-emotional processing stream: five core constructs and their translational potential for schizophrenia and beyond. *Biol. Psychiatry* 2008; 64: 48–61.

10. Green MF, Olivier B, Crawley JN, Penn DL, Silverstein S. Social cognition in schizophrenia: recommendations from the measurement and treatment research to improve cognition in schizophrenia new approaches conference. *Schizophr. Bull.* 2005; 31: 882-887.

11. Premack D, Woodruff G. Does the chimpanzee have a theory of mind? *Behav. Brain Sci.* 1978; 4: 515-526.

12. Corcoran R, Mercer G, Frith CD. Schizophrenia, symptomatology and social inference: investigating theory of mind in people with schizophrenia. *Schizophr. Res.* 1995; 17: 5-13.

13. Garety PA, Freeman D. Cognitive approaches to delusions: a critical review of theories and evidence. *Br. J. Clin. Psychol.* 1999; 38: 113-154.

14. Moritz S, Woodward TS. A generalized bias against disconfirmatory evidence in schizophrenia. *Psychiatry Res.* 2006; 142: 157-165.

15. Beck AT, Baruch E, Balter JM, Steer RA, Warman DM. A new instrument for measuring insight: the Beck Cognitive Insight Scale. *Schizophr. Res.* 2004; 68: 319–329.

16. Uchida T, Matsumoto K, Kikuchi A et al. Psychometric properties of the Japanese version of the Beck Cognitive Insight Scale: Relation of cognitive insight to clinical insight. *Psychiatry Clin. Neurosci.* 2009; 63: 291-297.

17. Martin JA, Penn DL. Attributional bias in schizophrenia: an investigation in outpatients with and without persecutory delusions. *Schizophr. Bull.* 2002; 28: 131-141.

18. Combs DR, Penn DL, Wicher M, Waldheter E. The Ambiguous Intentions

Hostility Questionnaire (AIHQ): a new measure for evaluating hostile social-cognitive biases in paranoia. *Cogn. Neuropsychiatry* 2007; 12: 128–143.

19. Birchwood M, Smith J, Cochrane R, Wetton S, Copestake S. The Social Functioning Scale. The development and validation of a new scale of social adjustment for use in family intervention programmes with schizophrenic patients. *Br. J. Psychiatry* 1990; 157: 853-859.
20. Social Cognition and Interaction Training program for schizophrenia spectrum disorders. *Psychiatr. Serv.* 2007; 58: 449-451.
21. Matsuoka K, Uno M, Kasai K, Koyama K, Kim Y. Estimation of premorbid IQ in individuals with Alzheimer's disease using Japanese Ideographic script (kanji) compound words: Japanese version of National Adult Reading Test. *Psychiatry Clin. Neusosci.* 2006; 60: 332-339.
22. Kay SR, Fiszbein A, Opler LA. The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophr. Bull.* 1987; 13: 261–276.
23. Savla GN, Vella L, Armstrong CC, Penn DL, Twamley EW. Deficits in domains of social cognition in schizophrenia: a meta-analysis of the empirical evidence. *Schizophr. Bull.* 2012. doi: 10.1093/schbul/sbs080.

24. Köther U, Veckenstedt R, Vitzthum F, et al. "Don't give me that look" — Overconfidence in false mental state perception in schizophrenia. *Psychiatry Res.* 2012; 196: 1-8.

25. Pinkham AE, Penn DL, Green MF, Buck B, Healey K, Harvey PD. The Social Cognition Psychometric Evaluation Study: Results of the Expert Survey and RAND Panel. Schizophr. Bull. 2013; doi:10.1093/schbul/sbt081.

26. Diamond MD. The ability of schizophrenics to modify responses in an interpersonal situation. *J. Consult. Psychol.* 1956; 20: 441-444.

27. Sergi MJ, Rassovsky Y, Nuechterlein KH, Green MF. Social perception as a mediator of the influence of early visual processing on functional status in schizophrenia. *Am. J. Psychiatry* 2006; 163: 448-454.

28. Couture SM, Granholm EL, Fish SC. A path model investigation of neurocognition, theory of mind, social competence, negative symptoms and real-world functioning in schizophrenia. *Schizophr. Res.* 2011; 125: 152–160.

29. Lysaker PH, Lancaster RS, Nees MA, Davis LW. Attributional bias and symptoms as predictors of social function in schizophrenia. *J. Rehabil.*

Res. Dev. 2004; 41: 225-232.

30. Roncone R, Falloon IR, Mazza M, et al. Is theory of mind in schizophrenia more strongly associated with clinical and social functioning than with neurocognitive deficits? *Psychopathology* 2002; 35: 280-288.

31. Koren D, Seidman LJ, Goldsmith M, et al. Real-world cognitive--and metacognitive--dysfunction in schizophrenia: a new approach for measuring (and remediating) more "right stuff". *Schizophr. Bull.* 2006; 32: 310-326.

A list of Supporting Information

Appendix 1: Sample item of SCSQ

Appendix 2: Sample item of AIHQ; ambiguous situation

Appendix 3: Sample item of Hinting task

Table 1. Demographic and clinical variables of patients with schizophrenia and normal controls

	schizophrenia (n = 52)	normal controls (n = 53)	between-group comparison
sex, males : females	28 : 24	25 : 28	n.s.
age	38.1 (10.8)	37.8 (10.2)	n.s.
years of education	13.7 (2.2)	16.5 (2.3)	Z = -5.46, P < 0.0001
JART	99.3 (17.5)	110 (7.5)	Z = -4.37, P < 0.0001
settings, admission : outpatients	31: 21		
duration of illness (months)	158.5 (120.6)		
PANSS total	63.4 (14.7)		
positive	14.9 (5.1)		
negative	17.1 (4.8)		
general	31.3 (7.7)		
SFS (total scores)	104.4 (31.8)		
GAF	52.9 (11.0)		
Daily dosage level (chlorpromazine equivalent)	707.0 (590.4)		

† mean (standard deviation)

Table 2. Between-group comparison of SCSQ and AIHQ subscale scores

	schizophrenia (n = 52)	normal controls (n = 53)	between-group comparison
SCSQ			
verbal memory	7.92 (1.13)	8.64 (0.86)	Z = -3.57, P < 0.001
schematic inference	7.54 (1.35)	8.60 (0.91)	Z = -4.31, P < 0.0001
theory of mind	6.56 (1.51)	8.43 (1.38)	Z = -6.08, P < 0.0001
metacognition	9.22 (0.64)	9.50 (0.53)	Z = 2.43, P < 0.05
hostility bias	1.52 (1.09)	0.89 (0.91)	Z = -3.08, P < 0.01
AIHQ			
hostility bias intentional	1.93 (0.41)	2.19 (0.40)	Z = -3.68, P < 0.001
ambiguous	1.71 (0.46)	1.59 (0.32)	n.s.
accidental	1.30 (0.33)	1.25 (0.20)	n.s.
blame score intentional	3.23 (0.75	3.54 (0.55)	Z = -2.44, P < 0.05
ambiguous	2.49 (0.71)	2.34 (0.48)	n.s.
accidental	2.13 (0.64)	2.09 (0.41)	n.s.
aggression bias intentional	1.77 (0.64)	1.82 (0.52)	n.s.
ambiguous	1.75 (0.61)	1.69 (0.32)	n.s.
accidental	1.61 (0.64)	1.51 (0.40)	n.s.
Hinting task	14.02 (3.67)	16.23 (3.07)	Z = -3.34, P < 0.001

† mean (standard deviation)

Table 3. Spearman's rho between SCSQ subscale scores and other social cognition measures

	verbal memory	schematic inference	Theory of mind	metacognition	hostility bias
Hinting task	0.35*	0.25	0.52****	0.13	-0.25
BCIS					
composite	-0.10	0.10	0.22	0.32*	0.19
AIHQ (ambiguous)					
hostility	0.12	-0.05	-0.06	0.24	0.34*
blame	-0.25	-0.28*	-0.42**	-0.17	0.47***
aggression	-0.31*	-0.26	-0.45***	-0.02	0.37**

**** $P < 0.0001$
*** $P < 0.001$
** $P < 0.01$
* $P < 0.05$

Table 4. Spearman's rho between SCSQ and SFS subscale scores

	verbal memory	schematic inference	Theory of mind	Metacognition	hostility bias
SFS Total score	0.03	0.10	0.23	0.08	-0.22
Social engagement	0.00	0.10	0.33*	0.16	-0.29*
Interpersonal communication	0.14	-0.01	0.41**	0.18	-0.18
Independence-performance	-0.09	0.02	-0.04	-0.13	-0.08
Recreation	-0.01	0.01	0.38**	0.30*	-0.13
Social activities	0.12	0.18	0.15	0.08	-0.22
Independence-competence	-0.08	0.02	0.01	-0.12	-0.11
Occupation	0.17	0.04	0.46***	0.29*	-0.22

*** $P < 0.001$
** $P < 0.01$
* $P < 0.05$

Behavioral/Cognitive

Topographic Representation of an Occluded Object and the Effects of Spatiotemporal Context in Human Early Visual Areas

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Occlusion is a primary challenge facing the visual system in perceiving object shapes in intricate natural scenes. Although behavior, neurophysiological, and modeling studies have shown that occluded portions of objects may be completed at the early stage of visual processing, we have little knowledge on how and where in the human brain the completion is realized. Here, we provide functional magnetic resonance imaging (fMRI) evidence that the occluded portion of an object is indeed represented topographically in human V1 and V2. Specifically, we find the topographic cortical responses corresponding to the invisible object rotation in V1 and V2. Furthermore, by investigating neural responses for the occluded target rotation within precisely defined cortical subregions, we could dissociate the topographic neural representation of the occluded portion from other types of neural processing such as object edge processing. We further demonstrate that the early topographic representation in V1 can be modulated by prior knowledge of a whole appearance of an object obtained before partial occlusion. These findings suggest that primary "visual" area V1 has the ability to process not only visible or virtually (illusorily) perceived objects but also "invisible" portions of objects without concurrent visual sensation such as luminance enhancement to these portions. The results also suggest that low-level image features and higher preceding cognitive context are integrated into a unified topographic representation of occluded portion in early areas.

Introduction

The contents of our visual perception are more than simple transcriptions of scenes projected on the retina: even when objects are largely occluded by neighboring objects, we can readily and effortlessly perceive each object shape by completing the occluded portion. This remarkably constructive way of visual processing of occluded objects is termed "amodal completion" (Michotte et al., 1964; Kanizsa, 1979) because the completion is mediated amodally (without any concurrent sensory representation of the completed region). The neural mechanism underlying amodal completion has been a functionally and ecologically significant topic of interest (Nakayama et al., 1990, 1995; Pessoa et al., 1998; Albright and Stoner, 2002; Kellman, 2003; Komatsu, 2006). Recent physiological and imaging studies have accumulated evidence that complete visual representations of partially occluded objects are established within visual cortex, at least in higher object-selective lateral occipital regions (Kovács et al., 1995; Kourtzi and Kanwisher, 2001; Lerner et al., 2002, 2004; Yin et al., 2002, Hulme and Zeki, 2007; Murray et al., 2004).

However, it remains unclear how and where in the brain occlusion completion is achieved. One possibility is that completion is mediated exclusively by high-level mechanisms without any influence on lower processing levels. This "higher" or "top-down" hypothesis may be supported by human fMRI studies demonstrating robust preferential activity in response even to partially occluded objects in higher object-selective regions, lateral occipital complex (LOC), but revealing little activity in earlier areas (Lerner et al., 2002, 2004). Alternatively, it is possible that an occluded portion of an object is processed or completed topographically at the early stage via bottom-up and filling-in mechanisms before reaching higher stage of object recognition

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