The Relationship Between the Sense of Self-Agency and Schizotypal Personality Traits

Tomohisa Asai
Yoshihiko Tanno
Department of Cognitive and Behavioral Science
University of Tokyo, Japan

ABSTRACT. People with schizotypal traits may possess abnormal self-awareness, particularly with regard to their sense of self-agency, that is, the sense that it is oneself who is causing or generating an action. Participants in Experiments 1A (N = 11), 1B (N = 12), and 2 (N = 20) moved a mouse device and viewed resultant feedback, which was biased either temporally or spatially. They then judged whether there was a bias or whether they felt they had moved the cursor on their own. The authors found, for the 1st time, that a sense of self-agency can be experienced even if some degree of temporal bias is perceived. Furthermore, they determined that highly schizotypal people have an abnormal (weaker) sense of self-agency.

Keywords: forward model, motor control, schizotypy, self-agency

Schizotypal traits may indicate a predisposition to schizophrenia (Cyhlarova & Claridge, 2005), and schizophrenic traits probably exist on a continuum. Relatives of schizophrenic patients score significantly higher on measures of schizotypal personality, which suggests that there is a range within the spectrum of schizophrenic disorders in which schizotypal traits may be expressed and that the degree of expression is at least partly genetic (Kremen, Faraone, Toomey, Seidman, & Tsuang, 1998; Platek & Gallup, 2002).

It has been suggested that people with schizotypal traits have abnormalities relating to their self-consciousness or self-awareness. Platek and Gallup showed that schizophrenic spectrum disorder in a nonclinical population may compromise individuals’ ability to recognize their faces. Moreover, Barnacz, Johnson, Constantino, and Keenan (2004) examined the relationship between schizotypal personality traits and deception, both of which are correlated with the theory of mind and self-awareness. Although the results of those studies suggested that people with schizotypal traits have abnormal self-consciousness, that characteristic was not clearly defined or directly measured in those investigations.

Gallagher (2000) proposed that self-consciousness can be divided into two important aspects: (a) the minimal self, that is, a self devoid of temporal extension, and (b) the narrative self, which involves personal identity and continuity across time. The minimal self includes the sense of self-agency and the sense of self-ownership. When one acts physically or mentally, one always feels that “I act myself,” which is the sense of self-agency. A sense of self-agency is the feeling of causing our own actions. In contrast, the sense of self-ownership is the sense that “I am the one who is undergoing an experience.” In the normal experience of voluntary or willed action, the senses of self-agency and self-ownership coincide and are indistinguishable. In the case of involuntary action, however, it is quite possible to distinguish between the sense of agency and the sense of ownership.

It has been suggested that schizophrenic patients have abnormalities in both their sense of agency and their sense of ownership. Lindner, Their, Kircher, Haarmeier, and Leube (2005) showed that schizophrenic patients attribute the sensory consequences of their own eye movements to the environment rather than to themselves, suggesting abnormalities in the sense of self-agency. Peled, Ritsner, Hirschmann, Geva, and Modai (2000) reported that schizophrenic patients felt the rubber hand illusion (Botvinick & Cohen, 1998). That illusion is related to the person’s sense...
of stronger and quicker ownership of his or her body than others feel they own theirs, indicating abnormalities in the sense of ownership. A strong relationship between schizophrenia and the sense of self-agency has been suggested. Phenomena such as delusions of control, auditory hallucinations, and thought insertion may all be caused by abnormal self-agency (Frith, Blakemore, & Wolpert, 2000b; Gallagher, 2004; Lindner et al.). Although highly schizotypal people may have an abnormal sense of self-agency, the relationship between schizotypal personality traits and the sense of self-agency has never been examined.

The neuropsychological mechanism of actions (Frith, Blakemore, & Wolpert, 2000a; Wolpert, 1997) is explained in the computation model of the motor system (or motor control). The model comprises two types of internal models, the inverse model and the forward model (Wolpert, Ghahramani, & Jordan, 1995). In the inverse model, the motor commands necessary to achieve a certain goal on the basis of the desired state are provided. In contrast, in the forward model, predictions about the behavior of the motor system and its sensory consequences are made. Predictions can be used in several ways, including the differentiation of self-produced sensations from externally generated sensations. In other words, one can use predictions to generate a sense of self-agency. Some researchers claim that a sense of self-agency is derived from the existence of little or no discrepancy between the predicted and actual sensory consequences (forward output model; Blakemore & Frith, 2003; Blakemore, Wolpert, & Frith, 2002; Frith et al., 2000b; Wolpert; Wolpert et al.). It has also been proposed that an abnormal sense of self-agency involving delusions of control arises when no deviation of the predicted state of the motor system occurs before movement. The absence of the deviation results in an abnormal experience of the movement. Nevertheless, the movement is still correctly performed, and there is no discrepancy between the intended and achieved movements (Frith et al., 2000b). Previous investigators have suggested that will or volition is important in feeling a sense of self-agency. It has been suggested that a sense of self-agency occurs when an observed consequence is produced by willed actions (Fourneret, Franck, & Jeannerod, 2001; Franck et al., 2001; Knoblich, Stotmeister, & Kircher, 2004). In other words, a sense of self-agency is derived from the existence of little or discrepancy between the predicted and intended consequences (forward dynamic model).

Indeed, Daprati et al. (1997), Franck et al. (2001), and Van den Bos and Jeannerod (2002) reported that when there is a discrepancy in visuomotor perception, we might not feel a sense of self-agency. For example, we do not feel that an action is our own when biased (angular or temporal) feedback is given on the screen (Franck et al.). Is that because of a discrepancy between the predicted and actual sensory consequences or because of a discrepancy between the predicted and intended consequences? Using the paradigm of Spence et al. (1997), we examined whether willed actions enhance the sense of self-agency. Under a freely selected movement condition, participants moved a mouse device to a destination that they chose freely, whereas under the stereotypic movement condition, they moved a mouse device to a destination chosen by the experimenter (Spence et al.). Using positron-emission tomography (PET), we found the activation areas to be different under the two conditions. Under the freely selected movement condition, left prefrontal, bilateral premotor, left sensorimotor, and bilateral parietal cortices were activated. Under the stereotypic movement condition, left sensorimotor and parietal cortices were activated. Those findings indicate that the cognitive processes differed between the two conditions.

Another unresolved question persists. Can we feel a sense of self-agency even if we perceive a discrepancy (bias in feedback) in visuomotor perception? In other words, is judging a sense of self-agency equal to judging the existence of a discrepancy? Alternatively, is the existence of the discrepancy permitted to some extent in feeling a sense of self-agency? Miyazaki and Hiraki (2006) showed that 4-year-olds were successful at self-recognition tasks involving delayed video feedback. Their results indicated that 4-year-olds are able to identify themselves in delayed feedback when they are aware that the feedback was presented with short temporal delays. Although sensing self-agency may be different from detecting visuomotor incongruency, those two cognitive mechanisms are not completely distinct from one another. Applying the paradigm of Franck et al. (2001), we examined that question by using a mouse device and biased cursor feedback.

In Experiments 1A and 1B of the present study, we examined the relationship between the sense of self-agency and the discrepancy in visuomotor perception and the effect of free selection of movement on each factor. In Experiment 2, we investigated the relationship between the sense of self-agency and schizotypal personality traits.

Participants moved the mouse device, and the cursor correspondingly moved on the screen with either a temporal (Experiment 1A) or a spatial (Experiment 1B) bias. We examined whether participants felt they had moved the cursor on their own even when they perceived the bias. We also examined whether they felt more of a sense of self-agency when they moved the mouse device to a destination that they chose freely. We first discuss Methods and Results in Experiments 1A and 1B; in the Discussion, we address both Experiments together.

**EXPERIMENT 1A**

**Method**

**Participants, Apparatus, and Stimuli**

Participants were 11 right-handed university students. We conducted Experiment 1A in a silent, dark room. We used MATLAB (The MathWorks, Natick, MA) and Psychophysics Toolbox (Brainard, 1997; Pelli, 1997) to create the visual stimuli and conduct the experiment.
The stimulus was a cursor on the screen (768 × 1,024 pixels) that moved in response to movement of the mouse device. The cursor moved with a time delay (0, 250, 500, 750, or 1,000 ms) from the center of the screen in every trial. It stopped when it had moved over 350 pixels or when 3 s had elapsed from the start of the mouse’s movement.

**Procedure**

Participants in Experiment 1A were required to move the mouse device in a straight line to one of the four corners of the screen. Under the freely selected movement condition, the participants chose the destination in every trial. Under the stereotypic movement condition, the experimenter chose the destination randomly. After participants finished moving the mouse device, they judged whether a delay had occurred (perception of bias task) or whether they felt that they had moved the cursor on their own (sense of self-agency task). We gave the following instructions: “There are two cases. In one case, you might see the movement as a result of your mouse moving. But in another case, the experimenter (PC) might make movements. All you have to do is to judge whether the movement you saw on the screen exactly corresponded to [the one] that you have made with your hand without concern for its agent (perception of the bias task) or whether you were the one who made movements you saw on the screen without concern for its correspondence (the sense of self-agency task).” The students participated in four blocks (2 movement conditions × 2 judgmental tasks). The order was counterbalanced among participants. In each block, we conducted 40 trials.

**Results**

Using the average scores for each block, we compared the sense of self-agency with the perception of bias and examined the effect of the free selection of movement on each factor (Figure 1A). We performed a within-participant multivariate analysis of variance (MANOVA) design on the results of two judgment tasks, one with temporal delay and one with the free selection of movement. The analysis revealed a significant main effect of delay for the perception of delay task as well as for the sense of self-agency task, $F_{s}(4, 100) = 96.238$ and $34.888$, respectively, both $p < .01$. To clarify the difference between those two tasks, we applied a three-way within-participants analysis of variance (ANOVA). The analysis revealed a significant main effect between the two tasks, $F(1, 10) = 48.85$, $p < .01$. We found no significant difference between the freely selected condition and the stereotypic movement condition. However, participants scored higher on the sense of self-agency than they did on the perception of temporal bias.

**EXPERIMENT 1B**

**Method**

**Participants, Apparatus, and Stimuli**

Participants in Experiment 1B were 12 right-handed university students, none of whom had taken part in Experiment 1A.

We used the same materials in both Experiments 1A and 1B. In Experiment 1B, we replaced the temporal bias stimuli used in Experiment 1A with angular bias stimuli. The cursor on the screen moved in response to the movement of

![Figure 1](image_url)
the mouse device. The cursor moved with an angular bias (0°, 15°, 30°, 45°, 60°, + or −, assigned randomly in each trial) from the center of the screen for each trial.

Procedure

Participants completed four blocks (2 movement conditions × 2 judgmental tasks) as in Experiment 1A.

Results

We compared averaged scores for each block for the sense of self-agency and the perception of bias, and we examined the effect of the free selection of movement on each factor (Figure 1B). We performed a within-participants design MANOVA on the results of two judgmental tasks, one with angular bias and one with the free selection of movement. The perception of angular bias task revealed a significant main effect of only angular bias, $F(4, 110) = 170.524, p < .01$. The sense of self-agency task also revealed a significant main effect of only angular bias, $F(4, 110) = 57.502, p < .01$. To clarify the difference between the sense of self-agency task and the perception of delay task, we performed a three-way within-participants ANOVA; we found no significant main effect between the two tasks. We did not observe any significant difference between the sense of self-agency and the perception of angular bias; nor did we identify any effect of the free selection of movement.

Experiments 1A and 1B: Discussion

In Experiments 1A and 1B, we examined the effect of delays in visuomotor perception on the sense of self-agency and also the effect of the free selection of movement on each of those factors. We found that the more distinguished the temporal or angular bias became, the more accurately participants could perceive it. The more distinguished the bias became, however, the less the participants felt a sense of self-agency. The finding that the sense of self-agency becomes weaker as bias becomes more distinguishable is similar to the results of Franck et al. (2001) and Sato and Yasuda (2005). The weakening appears to occur because the discrepancy between the predicted and observed consequences is too large to generate a sense of self-agency.

We also found that the sense of self-agency is felt even when a perceptible visuomotor temporal bias occurs, but that it is not felt when a perceptible angular bias is presented. That finding may mean that in judging the origin of actions, we permit a temporal discrepancy to some extent, but a spatial discrepancy is unacceptable. To feel that oneself is the origin of an action, spatial synchronization may be more important than simultaneity between the action and the feedback. The sense of self-agency may be brought about by the detection of a contingent relationship between several modalities (Botvinick & Cohen, 1998; Miyazaki & Hiraki, 2006; Van den Bos & Jeannerod, 2002). The amount of contingency in visuomotor information in the temporally delayed condition may be sufficient to enable one to feel a sense of self-agency. On the other hand, the amount of contingency in the spatially biased condition may be insufficient; that is, we would not identify as ourselves things that move simultaneously.

Third, we did not identify any effect of the free selection of movement, which may be a part of volition or willingness, on the sense of self-agency and the perception of bias. Selecting the destination oneself, rather than moving to a predetermined destination, did not influence the sense of self-agency. Sato and Yasuda (2005) also examined the effect of volition on the sense of self-agency, and they, too, found no effect. They assumed that key pressings for correct answers were willed actions whereas key pressings for answers known to be incorrect were unwilled actions. The finding that volition does not affect the sense of self-agency may reflect the fact that we use the same motor commands to move our bodies, regardless of the presence of volition. Those results suggest that the forward output model may generate the sense of self-agency.

EXPERIMENT 2

High-schizotypal and low-schizotypal students participated in Experiment 2, which was otherwise identical to the stereotypic movement condition in Experiment 1B. In Experiments 1A and 1B, we found no difference between the stereotypic and freely selected movements in the sense of self-agency and perception in visuomotor incongruency. In Experiment 2, we accordingly decided to use only the stereotypic movement because of its procedural simplicity. Therefore, we did not have to worry that highly schizotypic students would be confused in selecting movements. We compared the perception of bias and the sense of self-agency between the high- and low-schizotypal students.

Method

Participants, Apparatus, and Stimuli

We rated 224 students on the basis of the Schizotypy Traits Questionnaire (STA; Claridge & Broks, 1984; Gregory, Claridge, Clark, & Taylor, 2003). STA is a 37-item true or false self-report questionnaire based on the Diagnostic and Statistical Manual of Mental Disorders-III (DSM-III) diagnostic criteria for schizotypal personality disorder.

Participants in Experiment 2 were 10 students from the top 25% (with a score of 18 or above, the high-schizotypal group) and 10 students from the bottom 25% (with a score of 9 or below, the low-schizotypal group). They were all right-handed.

We used the same apparatus and the same stimuli in both Experiments 1 and 2.

Procedure

Participants were required to move the mouse device in a straight line to one of the four corners of the screen. The experimenters randomly chose the destination. After participants had finished moving the mouse device, they judged whether an angular bias (perception of bias task) had
occurred or whether they felt that they had moved the cursor on their own (sense of self-agency task). They participated in two blocks (perception of bias task and sense of self-agency task). We counterbalanced the order among participants. In each block, we conducted 40 trials.

Results

We compared the averaged scores for each block between the high- and the low-schizotypal groups (Figure 2). We performed a mixed design MANOVA on the results of the two judgmental tasks, with angular bias as the within-participant factor and the two schizotypal groups as the between-participants factor. For the perception of angular bias task, the analysis revealed a significant main effect of only delay, \( F(4, 90) = 230.350, p < .01 \). For the sense of self-agency task, it revealed a significant main effect of angular bias, \( F(4, 90) = 143.177, p < .01 \), and group, \( F(1, 90) = 4.617, p < .05 \). We observed no difference between the high- and the low-schizotypal groups in the perception of angular bias, although the high-schizotypal group may have possessed a weaker sense of self-agency.

Discussion

In Experiment 2, we compared the sense of self-agency and the perception of bias between the high- and low-schizotypal groups. No significant difference was detected between the two groups’ perception of bias. In other words, both groups could perceive bias equally well; and from that perspective, the high-schizotypal students showed normal perception. However, the high-schizotypal students had a weaker sense of self-agency than did the low-schizotypal students.

Platek and Gallup (2002) showed that schizotypal people may have compromised self-face recognition, which may be correlated with a weaker sense of self-agency. People with schizotypal traits possibly have a lower degree of self-consciousness or self-awareness. In the present study, we focused on the sense of self-agency, which is a part of self-consciousness (Gallagher, 2000).

The finding that high-schizotypal students have a weaker sense of self-agency is consistent with the idea that schizophrenic experiences, including auditory hallucination, thought insertion, and delusions of control, could occur because of the feeling that one is not at the origin of one’s own acts (Frith et al., 2000a, 2000b; Gallagher, 2004). STA measures schizotypal traits, particularly perceptual aberration, which is analogous to positive symptoms, including auditory hallucination, thought insertion, and delusions of control.

The data presented here in Experiment 2 are the first to show that highly schizotypal people possess an abnormal sense of self-agency.

GENERAL DISCUSSION

The present study produced some interesting results. However, because of the small number of participants, we must regard the findings as preliminary. We investigated three issues. First, we showed for the first time that a temporal bias is tolerated to some extent when participants feel a sense of self-agency. Second, we observed no identifiable effect of the free selection of movement—which may be a part of volition as defined by Spence et al. (1997)—on the participants’ sense of self-agency. Third, we demonstrated for the first time that highly schizotypal people have normal perception of bias but a weaker than normal sense of self-agency.

Many people with schizophrenia describe a sense of passivity to their experiences, such that their actions, thoughts,
or emotions are created for them by some external agent rather than by their own will. In most cases, the actions carried out when people feel that they are being controlled by alien forces are not discrepant with their intentions (Frith et al., 2000a, 2000b). In other words, people with schizophrenia have an abnormal sense of self-agency. Daprati et al. (1997) and Franck et al. (2001) reported that when required to make judgments about the origin of actions on the basis of biased feedback, people with schizophrenia were more likely than normal controls to judge that they were at the origin. That suggests that people with schizophrenia feel a stronger sense of self-agency.

The just-mentioned finding contradicts the idea that people with schizophrenia have a weaker than normal sense of self-agency. Schizophrenic experiences, including auditory hallucinations, thought insertion, and delusions of control, could occur because of the individuals' feelings that they are not at the origin of their own acts. Sufferers misattribute auditory hallucinations, which typically consist of hearing spoken voices, to external forces, although, in fact, they were the ones who spoke. Delusions of control happen when people experience a sense that their will has been replaced by that of some other agency or force. In other words, the sufferers feel that they are not at the origin of their own acts (Frith et al., 2000a, 2000b; Gallagher, 2004).

It is possible that the results of Daprati et al. (1997) and Franck et al. (2001) simply reflected the abnormal perception of people with schizophrenia; they may have perceived the bias less. In particular, in Franck et al., the instruction was, “Did the movement you saw on the screen exactly correspond to [the one] that you have made with your hand?” In the present study, we focused on schizotypal people, that is, individuals who may be seen as having a predisposition to schizophrenia (Cyhlarova & Claridge, 2005). It is highly likely, however, that the participants have normal perception because schizotypal traits are part of their personality, and they do not take medication that could disturb their perception. In the present study, we actually showed no difference in visuomotor incongruency perception between the high- and low-schizotypal groups. Focusing on schizotypal people can be an effective way of studying the process of schizophrenia while avoiding the problems that can arise when conducting experiments with schizophrenic patients (Williams & Beech, 1997). We found that highly schizotypal people do not have a stronger than normal sense of agency; instead, they have a weaker one. Further research examining in more detail differences in disorders of the self, including schizotypal affective disorder and schizophrenia, is needed.

There may be limitations in the sense of agency paradigm used by Daprati et al. (1997), Franck et al. (2001), and ourselves. In that paradigm, participants receive feedback consisting of analogs to their movements on the PC screen, and they judge whether they were the agent of the movements they observed on the screen. However, that feedback is actually unrelated to their movements. Because of that issue, it is unclear whether it is possible for the participants to experience that they made movements that did not correspond to their actual movements. In another study, Brindley and Merton (1960) reduced the sensitivity of participants’ eye muscles to deprive them of their sense of position, meaning that participants were unable to move their eyes intentionally. It would be beneficial to develop a paradigm capable of measuring a so-called real sense of agency without using the kind of feedback used in this study.

Frith et al. (2000a, 2000b) and Blakemore et al. (2002) suggested that the abnormal sense of self-agency experienced by people with schizophrenia might be caused by an abnormal prediction system in their motor control. They are aware that the action matches the intention but have no awareness of initiating the action or of its predicted consequence. That is, actual sensory feedback may still produce a sense of self-ownership (“I am moving”) but the sense of self-agency will be compromised (“I am not causing the movement”), even if the actual movement matches the intended movement (Gallagher, 2000).

It is also claimed that schizophrenia may be a disorder of the corollary discharge systems (Feinberg & Guazzelli, 1999; Ford & Mathalon, 2004, 2005; Ford et al., 2001), which are the parts of the prediction system. It is suggested that motor actions are accompanied by a corollary discharge to the sensory cortex, signaling that impending sensations are self-initiated or self-generated. In the visual system, a corollary discharge may serve to stabilize the visual image during eye movements, maintaining visuospatial constancy. In the somatosensory system, a corollary discharge could work as a sensory attenuation, which may explain why we cannot tickle ourselves (Blakemore, Rees, & Frith, 1998). Shergill, Samson, Bays, Frith, and Wolpert (2005) provided evidence for sensory prediction deficits in schizophrenia. Their schizophrenic participants demonstrated significantly less sensory attenuation than did healthy subjects. Researchers must investigate further how abnormal corollary discharge systems could lead to an abnormal sense of self-agency in people with schizophrenia or schizotypal traits.

Biographical Note

Tomohisa Asai is a candidate for the doctoral degree. His research interests include schizophrenia, forward model, and self-consciousness. Yoshihiko Tanno teaches psychopathology. His research interests include schizophrenia and cognitive behavioral therapy (CBT).

REFERENCES

T. Asai & Y. Tanno

ences, 6, 237–242.
Gregory, A. M., Claridge, G., Clark, K., & Taylor, P. D. (2003). Handedness and schizotypy in a Japanese sample: An associa-

Journal of Motor Behavior