



Abnormalities in the establishment of feeling of self-agency in schizophrenia

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ARTICLE INFO

Article history:

Received 18 May 2012

Received in revised form 14 October 2012

Accepted 25 October 2012

Available online 22 November 2012

Keywords:

Self-agency
Authorship
Schizophrenia
Implicit
Explicit
Priming

ABSTRACT

Background: People usually feel they cause their own actions and the consequences of those actions, i.e., they attribute behavior to the proper agent. Research suggests that there are two routes to the experience of self-agency: 1) an explicit route, where one has the intention to obtain a goal (if it occurs, I must have done it) and 2) an implicit route, where information about the goal is unconsciously available and increases the feeling of self-agency. Schizophrenia patients typically experience no behavioral control and exhibit difficulties in distinguishing one's own actions from those of others. The present study investigates differences in both routes to self-agency experiences between schizophrenia patients and controls.

Methods: Twenty-three schizophrenia patients and 23 controls performed a task where they performed an action (button press) and subsequently indicated whether or not they were the agent of the consequence of this action (the outcome) on a 9-point scale. The task can be manipulated to measure both the explicit and implicit route (by using priming) to the experience of self-agency.

Results: In the explicit condition (participants intended to produce a specific outcome, and this outcome matched their goal), both groups experienced enhanced self-agency. In the implicit condition (the outcome matched the primed outcome), healthy controls showed increased self-agency over the outcome, while patients did not. Potential differences in task motivation and attention did not explain these findings.

Conclusions: These findings provide new evidence for the idea that implicit processes leading to feelings of self-agency may be disturbed in schizophrenia.

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1. Introduction

I hold my hand up and a taxi stops for a ride. I make a joke, people start laughing. Whether engaging in simple motor movements or social interactions, we feel we cause our own actions and their consequences. This feeling is usually referred to as self-agency and is essential for human self-perception and social communication.

Common sense suggests that the feeling of self-agency results from the conscious intention to engage in behavior and attain specific outcomes. That is, if I had the explicit goal of doing it and then it occurred, I must have done it. However, in everyday social life humans regularly behave without much conscious thought, and their behavior produces outcomes over which they can nevertheless experience self-agency. In other words, information in our environment that we are not consciously aware of can influence our behavior and our feelings of self-causation (Wegner, 2002).

We are not all blessed with a well-operating sense of self-agency. Schizophrenia patients often exhibit difficulties in distinguishing one's own actions and outcomes from those of others. They hear voices or feel their limbs being controlled by external sources. As a consequence

patients' autonomy and their professional and personal achievements are reduced and they experience problems in social interactions and relationships with family and peers (Walker et al., 2004).

Previous research has led to the notion that disturbed experiences of self-agency in schizophrenia may derive from disturbances in the sensory-motor system that controls voluntary action (Daprati et al., 1997; Morrison and Haddock, 1997; Franck et al., 2001; Haggard et al., 2003; Voss et al., 2010). When performing a voluntary motor action, the sensory-motor system compares the predicted and actual sensory consequences that follow from that action. To enable people to differentiate between self and other-produced sensory signals, the sensory signals of self-generated movements are attenuated. This generates a feeling of self-agency when matching the actual sensory consequences with the predicted consequences (Wolpert, 1997; Blakemore and Frith, 2003). However, patients with schizophrenia fail to differentiate between the perception of self-produced and externally produced sensory signals. Consequently, schizophrenia patients' self-produced tactile stimulation feels as tickly, as other-produced tickling because it is not perceptually attenuated as is the case in controls (Blakemore et al., 2000; Shergill et al., 2005).

Interestingly, recent work shows that people can also experience self-agency over outcomes in situations where the motor prediction processes may not inform self-agency, so outside of the context of volitional behavior (Aarts et al., 2005; Moore et al., 2009; Dogge et al.,

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2012). In these cases, the experience of causation between our actions and the resulting effects is an *inference* because one cannot directly observe causal connections between them. These cognitive inferences occur fluently and perfunctorily after action performance and, in principle, this process can operate outside of conscious awareness.

To infer that one was the agent of an action and its consequences is always retrospective. Recent research suggests two routes that model the inferential nature of authorship processing (Wegner, 2002; Aarts et al., 2005). An explicit one, in which people infer agency when an actual outcome of an action is in agreement with their intentions to produce the specific action-outcome (I do something, it happens so I must have done it); and an implicit one, in which agency inferences are based on matches between actual outcomes of action and subtly pre-activated information about the action outcome. By using short presentation times (i.e., often referred to as priming) one can decrease the likelihood of conscious processing of information that yet activates the representation of action outcomes before performing the action. Subsequently observing the actual outcomes can thus enhance the experience of self-agency.

Both routes can contribute to inferences of agency in that people use sensory evidence to establish agency in retrospect. Aarts et al. (2005) showed that both intention to cause a specific outcome and priming of the action-outcome increased the sense of being the agent of the action outcome when that outcome actually occurred. These findings have been replicated across different tasks (Linser and Goschke, 2007; van der Weiden et al., 2010), and cultures (Sato, 2009).

Things may be different for patients with schizophrenia. That the explicit route to inference of self-agency may be intact in patients with schizophrenia is suggested by a study focusing on intentional binding. This is the phenomenon that people perceive their own actions as occurring later in time when they are followed by an external effect, compared to actions not followed by such effects. As such, intentional binding is an indirect measure of self-agency and it can be predictively or retrospectively generated. A predictive sense of agency means that an action is predicted to produce a given effect, whereas retrospective sense of agency means that one infers retrospectively that one's action caused the effect. Voss et al. (2010) showed that patients are able to retrospectively infer a sense of agency over their actions using the intentional binding task within the context of voluntary action. The present study aims to conceptually replicate this finding by testing whether patients display enhanced experienced agency over behavior when the actual outcome of their action matches their explicit goal to produce the outcome in a context where motor prediction processes are ruled out.

The prediction is less clear-cut when considering the implicit route to inferences of self-agency in patients with schizophrenia. Therefore, we conducted an experiment to explore whether the implicit route to self-agency is impaired in patients. If it is impaired, then priming an outcome of an action before performing the action and observing the corresponding outcome may not alter their experiences of self-agency.

2. Methods

2.1. Subjects

Twenty-three schizophrenia patients and 23 healthy controls participated in the study. Patients were recruited from the psychiatry department of the University Medical Centre Utrecht. The study was approved by the Humans Ethics Commission of University Medical Centre Utrecht. Participants gave written consent and were financially compensated for study participation.

Psychopathology levels were established by using the *Comprehensive Assessment of Symptoms and History* (CASH; Andreasen et al., 1992). All patients met DSM-IV criteria for schizophrenia. Symptom levels were assessed with the *Positive and Negative Syndrome Scale* (PANSS; Kay et

al., 1987) by trained raters. Patients were receiving atypical antipsychotics at time of testing, except for one who was on typical antipsychotic medication.

Comparison subjects had no psychiatric history, no first-degree relatives with a psychotic illness, and did not use chronic medication. A history of closed-head injury, neurological illness or endocrinological dysfunction were criteria for exclusion. Patients and controls did not differ significantly on demographic variables. See Table 1.

2.2. Procedures and measures

2.2.1. Agency inference task and procedure

Participants learned that the study was designed to examine people's feelings of personal causation and how these feelings come and go. The agency inference task was taken from Aarts et al. (2005). See Fig. 1. In this computer-task, participants pressed the S-key on the keyboard to cause a square to rapidly traverse a rectangular path, consisting of eight white squares, in a counter-clockwise direction. The computer independently moved another square along the path at the same speed, but in the opposite direction. When "stop" appeared in the center of the screen they had to press the "Enter" key immediately, thereby stopping the movement. This action turned one of the eight white tiles black, which represented the final position of either their own square, or the computer's. The computer always determined the stops and thus actual stops occurred independently of participants' action (i.e., key-press). After each stop, participants reported their sense of self-agency by indicating the extent to which they felt they had caused the displayed square to stop at that particular position [9-point scale: *not at all* (1)–*strongly* (9)].

After participants practiced and understood the task, the experiment proceeded with two conditions to examine the implicit and explicit routes to inferences of self-agency. Specifically, in the implicit condition an outcome location was subtly primed (i.e., the location flashed up for 17 ms) before participants pressed the stop-key and saw the outcome location. Priming refers to the very short (and often incidental) exposure to a stimulus that influences a response to a later stimulus, as the prime activates the representation of the outcome during ongoing action, without requiring a predetermined intention (Aarts et al., 2005). In the explicit condition they received the explicit goal (i.e., intention) to stop on a certain location before starting the trial.

Each condition comprises 32 trials that were divided in 2 blocks of 16 trials. In each block, the black square was used as a prime or as an explicit goal twice on each of the eight tiles of the path. Crucially, half of the trials matched the outcome information (being presented as a goal/intention or as a prime), and the other half mismatched this information. The trials were randomly presented within a block. To prevent instruction carryover effects, the session started with the implicit task and was followed by the explicit condition task. There was a short break (30 s) between the blocks within a condition, and a longer break (5 min) between the two conditions (see the online supplementary material for task details).

Table 1

Characteristics of patients with schizophrenia and control subjects (means \pm s.d.).

	Schizophrenia patients (N = 23)	Normal controls (N = 23)
Age	32.7 \pm 7.1	28.5 \pm 8.6
Male/female	20/3	19/4
Years of education	13.2 \pm 2.0	14.1 \pm 1.7
Parental years of education	13.9 \pm 3.4	14.0 \pm 2.5
Illness duration (years) ^a	13.8 \pm 8.5	–
PANSS Positive score	14.7 \pm 4.4	–
PANSS negative score	16.5 \pm 7.0	–
PANSS general score	32.2 \pm 8.3	–
Medication dose ^b	7.3 \pm 4.0	–

^a Time between the onset of psychotic symptoms and inclusion in the study.

^b Mean dose in mg/day haloperidol equivalents.

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