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

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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.

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 ± s.d.).

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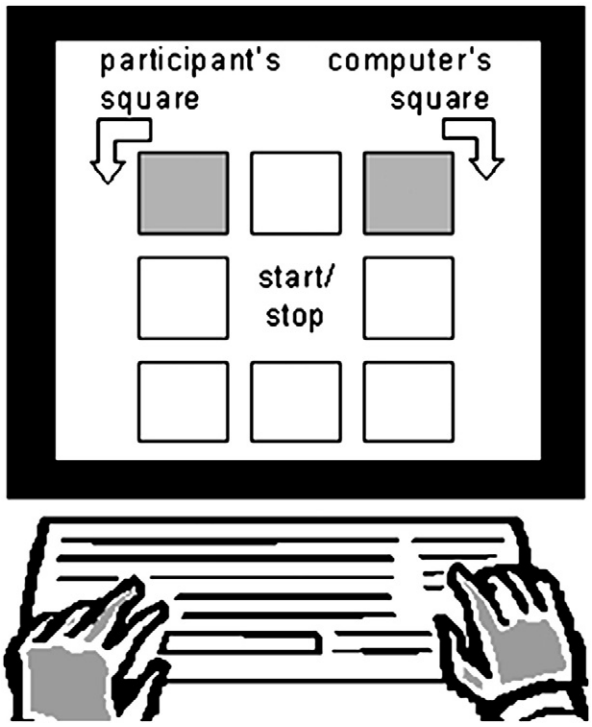

Fig. 1. Illustration of the experimental task showing how the square of the subject and the square of the computer move in opposite direction before participants stop them. Participants are shown where one of the squares stopped (i.e. the location is the outcome of their action (or not)).

2.2.2. Task motivation and performance

Because schizophrenia is associated with decreases in motivation (Konstantakopoulos et al., 2011), we administered a self-report measure of task motivation for both conditions separately. Specifically, participants indicated the level of importance to perform well and how much they tried to focus their attention on the task [9-point scale: *not at all* (1)–*strongly* (9)].

Additionally, we assessed two measures to investigate attentional processes. First, participants indicated the extent to which they were able to follow their own rotating square in both tasks [9-point scale: *not at all* (1)–*strongly* (9)]. This can be considered as a measure of visual attention maintenance. Second, response times to the stop cue were recorded and provide an objective measure of the ease of shifting attention from the rotating squares to the execution of the stopping behavior.

2.3. Statistical analyses

The averaged self-agency experiences on matching and mismatching trials were subjected to a repeated measures ANOVA with Group (patient/control) as a between-subjects measure and Type (implicit (prime)/explicit (intention)) and Matching (matching/mismatching outcome) as within-subjects measures.

To examine the role of task motivation and attention for both the implicit and explicit condition separately, ANOVAs were performed to test differences between groups, and ANCOVAs were used to control the main analyses for these measures.

3. Results

3.1. Self-agency experiences

A Group effect was found, implicating that patients experienced less self-agency compared to controls. Furthermore, main effects were found for Type and Matching. Agency experiences were lower in the implicit compared to the explicit condition, and agency experiences were stronger in matching relative to mismatching trials. In addition, the significant Type-by-Matching interaction indicated that the effect of matching was smaller in the implicit than in the explicit condition. Importantly, all these effects were qualified by a significant Type-by-Matching-by-Group interaction. The mean self-agency experiences of each cell in the design are displayed in Fig. 2 and Table 2.

To gain insight in the nature of the 3-way interaction we used ANOVAs to test effects of Matching and Group in the explicit and implicit condition separately. In the explicit condition main effects of Group and Matching were found. Controls reported stronger self-agency experiences than patients. Furthermore, matches between the actual outcome and the intended outcome led to stronger experiences of self-agency than mismatches. Importantly, the Matching-by-Group interaction was not significant, indicating that the explicit route to the feeling of self-agency operated equally well in both groups.

In the implicit condition, a main effect of Matching indicated stronger self-agency experiences when actual outcomes matched with primed outcomes compared to mismatches. Furthermore, a significant Matching-by-Group interaction emerged. Simple main effects showed that the Matching effect was significant only in the control group, not in patients. This indicates that implicit (primed) pre-activation of outcome information did not increase self-agency experiences in patients only.

3.2. Task attention

No significant differences were found between the groups on the self-reported measure of task attention during both conditions (see **supplementary tables**), implicating that patients and controls were equally able to maintain visual attention to the rotating squares.

The response time to the stop-cue provides an index for speed of shifting attention from the rotating squares to the execution of the actual stopping behavior. As expected, there was a significant main effect of Type, indicating that participants took longer to respond to the stop-cue in the explicit than in the implicit task. This confirms that having an explicit goal to stop at a specific location takes more time to act than doing so without a conscious intention, as is typical for conscious processes (Kahneman, 2011). Importantly, there was no effect of Group nor Type-by-Group interaction, suggesting that groups performed equally well on switching attention from the rotating squares to the stopping behavior, and hence, potential differences in attention/motor execution performance do not seem to explain the pattern of findings on the self-agency experiences.

3.3. Task motivation

The two items were averaged to obtain a measure of task motivation for the implicit and explicit conditions. Correlations between this measure and the self agency rating showed that subjective measures of motivation were relevant to the task (implicit: $r(46) = 0.37$, $p = .01$; explicit: $r(46) = 0.48$, $p = .001$). In the implicit condition no significant group difference was found, but in the explicit condition patients were significantly less motivated than controls (see supplementary tables). A trend-level regression effect of the motivation measure on the matching effect was found, indicating that higher motivation was associated with a stronger matching effect. Importantly, controlling the implicit and explicit matching effects for the motivation measure produced the same pattern of results as the original findings.

4. Discussion

The present study explored the explicit and implicit routes to inferences of self-agency experiences in schizophrenia patients and healthy subjects. Our results demonstrate that the explicit route operates equally well in both groups, as both felt more self-agency when their

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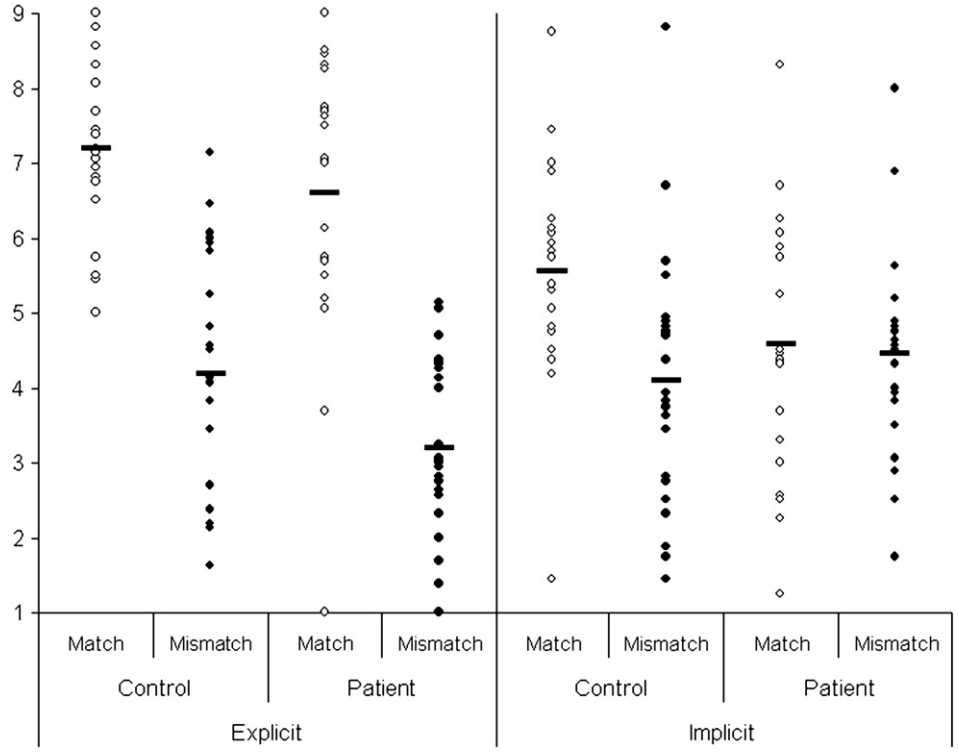

Fig. 2. Self-agency experiences as a function of Group (patient/control), Type (explicit/implicit) and Matching (match/mismatch). The black horizontal line indicates the mean.

intention to produce a specific action-outcome matched with the observed outcome compared to when the outcome did not match their intention. For patients, this finding is on par with other recent research suggesting that – in an explicit context – schizophrenia patients can use sensory evidence to form retrospective inferences of agency (Voss et al., 2010).

In line with previous research (Aarts et al., 2005), healthy subjects showed enhanced experiences of self-agency when an implicitly pre-activated outcome matched the observed outcome, suggesting that both explicit and implicit processing of action-outcome information augments agency experiences. However, patients did not show this effect, suggesting that their implicit processing route to self-agency experiences was impaired. Importantly, these group differences could not be attributed to differences in subjectively reported motivation or attention. Such disturbances are important to investigate as they might underlie poor everyday social interactions where behavior often starts and unfolds outside of conscious awareness (Waters and Badcock, 2008).

Unfortunately, no objective test was obtained to measure a potential covert attentional deficit in the patients, and therefore we cannot exclude the possibility that patients processed the primes in a different way as than controls. However, evidence suggests that patients show delayed conscious reporting of primes compared to controls, but – critical to the current study – are unimpaired in processing primes (Dehaene et al., 2003; Del Cul et al., 2006). Moreover, schizophrenia patients perform equal to healthy controls in spatial priming tasks, showing unimpaired processing of primed outcome-information even without fixating on this information (Spencer et al., 2011). It is important to note, though, that the duration of these primes was longer as compared to the primes in our task.

The observed differences in this study between patients and healthy controls raise questions about potential mechanisms that undermine the implicit (but not the explicit) nature of self-agency inferences in schizophrenia. One possible mechanism deals with the way the brain produces self-agency inferences. While the neurological basis is not yet fully delineated, it appears that experienced agency relies on frontal brain areas dealing with self-consciousness, and parietal regions representing primed goals or outcomes of movements (Frith, 1996; Jeannerod, 1999). Explicitly intended outcomes of behavior or goals are likely to enter the authorship process by gaining access to a widespread brain network broadcasting information to the frontal cortices (Baars, 1988; Dehaene and Naccache, 2001), and this process seems to effectively emerge in both health and schizophrenia. Once the outcome occurs, agency can be inferred by comparing the intention/goal and actual outcome, translating a match into experiences of self-agency. However, in implicit authorship processing (i.e. without global information broadcasting) the connection with the parietal area allows the frontal brain to establish a sense of agency by processing primed outcomes and actual outcomes. It might be that these regions are not properly connected in patients with schizophrenia (Honey et al., 2002; Burns et al., 2003). Indeed, evidence suggests disintegrated fiber integrity in the connection between frontal and temporo-parietal areas in schizophrenic patients

Table 2
Statistical analyses for self-agency experiences.

Main analyses (df = 44)	F	Sig.	η^2
Group	5.25	.03	.107
Type	6.04	.02	.121
Matching	79.2	<.001	.643
Type × group	0.91	.345	.020
Matching × group	1.08	.304	.024
Type × matching	69.7	<.001	.613
Type × matching × group	9.00	<.01	.170

Follow-up Analyses (df = 44)	Explicit			Implicit		
	F	Sig.	η^2	F	Sig.	η^2
Group	5.72	.02	.115	0.71	.40	.016
Matching	145.8	<.001	.768	8.78	<.01	.166
Matching × group	0.56	<.46	.013	6.15	<.01	.123
Simple main effects (df = 22)	Controls			Patients		
Explicit matching	88.0	<.001	.800	64.7	<.001	.746
Implicit matching	13.2	.001	.374	0.12	.72	.006

(de Weijer et al., 2011). Thus, the fronto-parietal network appears essential in the authorship ascription process, and impaired neural connectivity in this network may render implicit processes underlying inferences of self-agency less likely to occur in schizophrenia.

In conclusion, we show that schizophrenia patients are disturbed in implicit information processes underlying inferences of experienced self-agency. These abnormalities might underlie poor social interactions that often unfold implicitly and outside of awareness.

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Contributors

Author Renes aided in study design, data collection, conducted statistical analyses, interpreted results, and wrote the first draft of the manuscript. Author Vermeulen aided in data collection and editing the manuscript. Author Kahn aided in directing data collection and editing the manuscript. Author Aarts aided in designing the study, obtained grant funding, directed data collection, provided conceptualization and theory used to integrate the findings, interpreted results, and edited the manuscript. Author van Haren aided in study design, obtained grant funding, directed data collection, interpreted results, and edited the manuscript. All authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of interest

There are no conflicts of interest to report for any of the authors.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.schres.2012.10.024.

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