Self- and other-agency in people with passivity (first rank) symptoms in schizophrenia.

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1. Introduction

People who experience passivity (first-rank) symptoms (Schneider, 1946) do not feel in control of their actions, thoughts and perceptions, believing them to influenced by an external agent. Along with other domains, clinicians use passivity symptoms as a diagnostic aid for schizophrenia and related disorders. Despite this importance, these symptoms remain under-researched compared to other symptom domains such as hallucinations or delusions. One dominant explanatory framework posits that passivity symptoms are deficits in the sense of agency, which arise from a mismatch between motor predictions and actual sensory outcomes (the forward model; Frith, 1987; Frith and Done, 1989; Miall and Wolpert, 1996). There is growing recognition that the predictive components of this model are altered in people with schizophrenia and passivity symptoms (Blakemore et al., 2000; Graham-Schmidt et al., 2016b; Lindner et al., 2005). However, this framework may explain why actions are not perceived to be self-initiated, but does not explain why actions are perceived to be generated by an external agent (Gallagher, 2004; Graham and Stephens, 2000).

The sense of agency is thought to comprise multiple inter-related elements (Moore and Fletcher, 2012; Synofzik et al., 2013). One element, self-agency, is the subjective awareness that one has initiated and executed one's actions, while other-agency is the representation of events caused by another person or agent. Self- and other- agency are rarely examined independently due to the assumption that they represent opposite sides of the same phenomenon, i.e. an absence of self-agency causes the sensation of other-induced agency. However, functional imaging studies have uncovered different brain regions underlying self- and other-agency. For example, the insular cortex is activated during experiences of self-agency, while the temporoparietal junction, pre-supplementary motor area and precuneus are activated during experiences of other-agency (Sperduti et al., 2011). Additionally, the voluntary motor system is facilitated by viewing the actions of another agent, but is impeded by viewing one's own actions, again indicative of separate systems (Schütz-Bosbach et al., 2006). An examination of both agency processes in passivity symptoms has yet to be conducted and so such an examination is warranted.

Agency is often measured on motor tasks involving congruent and incongruent visual feedback, through temporal or spatial manipulations. People with schizophrenia and passivity symptoms make many errors on these tasks when reporting the agent of their actions (Daprati et al., 1997; Franck et al., 2001; Schnell et al., 2008). These agency errors are thought to be due to abnormal internal timing processes in schizophrenia (Spence, 1996; Waters and Jablensky, 2009). Normal internal timing contributes to precisely timed action elements and

correct agency attributions as the subjective experience of an action-sequence plays a key role in agency judgements (Haggard and Clark, 2003; Haggard et al., 1999). Conversely, individuals with schizophrenia and passivity symptoms have impaired timing (Martin et al., 2013) and a widened perceptual binding window for sensory events when making self-agency decisions, resulting in insensitivity to temporal incongruence (Graham et al 2014).

The question remains whether similar temporal patterns exist in schizophrenia when making other-agent decisions. This question is valuable to (i) further describe the processes underlying self- and other-agency, (ii) better understand and potentially treat problems of agency in passivity symptoms and (iii) design better tasks to assess agency.

We explored the issue with the Projected Hand Illusion (PHI), a digitised variant of the rubber hand illusion (Botvinick and Cohen, 1998). In this paradigm, participants are shown a visual image of their own hand on a screen. Participants are asked to either make simple movements or to rest their hand while it is made to move by the experimenter. A temporal delay can also be introduced in each condition, so that the visual image of the hand no longer corresponds to the felt sensation of the person's hand movement (Ijsselsteijn et al., 2006; Kammers et al., 2009).

Overall, the aim of the current study was assess the sense of agency using the PHI in a sample of people with schizophrenia classified according to their lifetime history of passivity symptoms, and age-matched controls.

According to the phenomenological continuity model of schizophrenia (Sass, 2003; Sass and Parnas, 2003), passivity symptoms are the most elaborated form of self-disturbances (Jansson, 2015). As passivity symptoms tend to re-occur in successive psychotic episodes in the same person, it is likely that there are trait-like abnormalities that engender susceptibility to these symptoms (Jablensky et al., 1992). Such trait-like disturbances in key sources of somatic information that contribute to agency processes have been demonstrated previously in people with a past or current history of passivity symptoms (Graham-Schmidt et al., 2016a; Graham et al., 2014). In line with this conceptualisation, there should be differences in the severity of agency alterations between subgroups of individuals with schizophrenia classified on their passivity symptom profile. We hypothesised the greatest errors in agency judgements would occur in the order: people currently experiencing passivity symptoms, people with a past history of passivity symptoms, those with no history of passivity symptoms and then healthy controls, and that these errors would be confined to judgements of self-agency over the other hand.

2. Methods

2.1 Participants

The clinical sample included individuals with schizophrenia or schizoaffective disorder (53 total, 36 males) from the research database of the WA Family Study of Schizophrenia (Jablensky, 2004). All patients met ICD-10 and DSM-IV criteria for a diagnosis of schizophrenia or schizoaffective disorder and were community outpatients treated with neuroleptic medication. Exclusion criteria included comorbid organic brain disease, substance-use disorder, or language difficulties. Healthy controls (48 total, 24 males) were recruited through community advertising. Exclusion criteria were a history of a psychotic disorder, or a diagnosis of schizophrenia, schizophrenia-spectrum, or bipolar affective disorder in a first-degree relative. One control and two people with schizophrenia could not complete all experimental conditions and were removed from the analysis. See Table 1 for demographic and clinical information. The study protocol was explained to all participants and written consent was obtained. The study was approved by the institutional research ethics committee and conformed to the appropriate regulatory standards.

2.2 Clinical evaluation

Clinical evaluation was conducted with the Scales for the Assessment of Positive and Negative Symptoms (SAPS and SANS; Andreasen, 1984a, 1984b). Passivity symptoms were assessed using the Passivity Symptoms Interview (Waters et al., 2009) with items from the Schedule for Clinical Assessment in Neuropsychiatry (SCAN, Version 2.1; see Wing et al., 1990). All symptoms were rated in accordance with stringent definitions and assessed for lifetime history and presence in the last 4 weeks, determined by case-note reviews and self-report respectively. The frequency of passivity symptoms in the patient groups can be seen in Table 2. Independent classification of patients into groups was conducted by two of the investigators (KGS and FW) and rated based on consensus; only presence/absence of the symptoms was used for classification. Patient groups were:

- 'Current', at least two passivity symptoms present within four weeks of testing date (n =20).
- 'Past', at least two passivity symptoms present in the past, but not within four weeks of testing date (n =10).
- 'Never', no passivity symptoms present during any period (n = 21).

2.3 Projected hand illusion

The same PHI equipment as described previously was used (Graham et al., 2014). Briefly, participants sat in front of a horizontally-oriented video monitor with their right hand hidden behind a curtain. A video camera captured an image of the right hand and transmitted it to the monitor. The hand and the image were separated by 15 cm. There were two movement conditions. In the Passive condition, the participant's right index finger was rested on a brace that was used by the experimenter to move the participant's finger (out of the participant's vision). In the Active condition, participants wore the same brace but were instructed to make random, irregular voluntary movements with their right index finger. Additionally, each movement condition was presented with synchronous (< 10 ms video feedback) and asynchronous (an additional imposed 500 ms delay) visual feedback. Participants completed each movement/delay combination once (3 minutes each). After each condition, participants completed a questionnaire assessing agency over the participant's own hand ("It seemed like I was in control of moving my finger"), agency over the other hand on the screen ("It seemed like the movements on the screen were my own"), loss of agency over the participant's own hand ("It seemed like something else was forcing my finger to move") and loss of agency over the other hand on the screen ("It seemed like something else was forcing the finger on the screen to move."). Each item was rated on a 7-point Likert scale ranging from -3 (strongly disagree) to +3 (strongly agree).

2.4 Statistical methods

All statistical analyses and figures were completed using the statistical software R (version 3.2.1; R Core Team, 2012), and the packages 'nlme' (Pinheiro et al., 2013) and 'car' (Fox and Weisberg, 2011). Analyses were performed using linear mixed-effects models with questionnaire response as the dependent variable and group (Controls, Current, Past or Never), movement condition (Active or Passive) and delay condition (Synchronous or Asynchronous) as the fixed effects. The random effects term had random participant effects with a nested movement by delay interaction. Planned comparisons comparing the delay conditions in each movement condition for each group were performed. Where Analysis of Deviance (ANODEV) on the terms of the model revealed significant differences, treatment contrasts were performed. Contrasts were corrected with the Holm-Bonferroni method. Alpha was set to 0.05.

3 Results

The results of the ANODEVs can be seen in Table 3. The parameter estimates for each mixed model are found in Supplementary Table 1.

3.1 Agency over Own Hand

A significant condition by delay interaction indicated that all participants experienced reduced agency over their own hand after asynchronous stimulation in the active, but not passive, condition. There was also a significant group by movement condition interaction; the difference in agency over the own hand between the movement conditions was significantly different between Controls and Past and Current, but not Never, decreasing with increased presence of passivity symptoms (see Figure 2). The three-way interaction was not significant. However, the planned comparisons indicated that only Controls and Past groups experienced a reduction in agency over their own hand in the asynchronous condition after active movements (see Figure 1a).

3.2 Agency over Other Hand

A significant condition by delay interaction indicated that all participants experienced reduced agency over the other hand after asynchronous stimulation in the active, but not passive, condition. The three-way interaction was not significant, however, the planned contrasts indicated that Controls and Past experienced a reduction in agency in the active condition when the visual delay was imposed, but Current and Never did not experience such a reduction in agency in the asynchronous condition (see Figure 1b).

3.3 Loss of Agency over Own Hand

There was a significant main effect of group: Current reported an overall higher loss of agency over their own hand compared to Controls ($p = 0.01$), Never ($p = 0.006$) and Past ($p = 0.04$). No other contrasts were significant (all $p > 0.05$). The three-way interaction was not significant and the planned comparisons indicated there was no difference in loss of agency between movement conditions in all groups (see Figure 1C). There was also a significant interaction between group and movement condition; the difference in the loss of agency over the own hand between the movement conditions decreased with increasing vulnerability to passivity symptoms (see Figure 3).

3.4 Loss of Agency over Other Hand

The movement by delay interaction indicated that the delay increased loss of agency over the other hand after active, but not passive, movements (see Figure 1D). This was confirmed by the planned contrasts, where all groups experienced such an effect. The main effect of group and interactions including group were not significant.

4 Discussion

The aim of the current study was to assess self- and other-agency using the PHI (with active/passive movements, and synchronous/asynchronous visual feedback) in healthy controls and people with schizophrenia and passivity symptoms. Unlike healthy participants, participants with (past & present) passivity symptoms experienced self-agency (agency over their own hand) to be more similar after active and passive movements, although this effect did not extend to agency over the other hand. The Current group continued to report self-agency in the asynchronous condition, while participants with no experience of passivity symptoms were similarly insensitive to the asynchronous feedback.

The findings will now be discussed in turn.

4.1 Active movements are experienced more akin to passive movements by people with passivity symptoms

As hypothesised, Past and Current demonstrated the most aberrant agency experiences such that they reported agency over their own hand to be more similar between movement conditions. Interestingly, this appeared to be driven by a reduction in agency over the own hand after active movements and increased agency over own hand after passive movements (although the mean responses of these groups were still negative in this condition i.e. in disagreement with the statement).

One criticism of the forward model of passivity symptoms is that a mismatch between predictions and outcomes may explain why an action is not perceived as self-generated but does not explain why someone would then perceive that action as other-generated (Gallagher, 2004; Graham and Stephens, 2000). A contemporary model of agency consists of two assertions. Firstly, that there are at least two important divisions to agency: *pre-reflective* agency (also known as prospective agency) and *reflective* agency (Moore and Fletcher, 2012; Moore et al., 2012; Synofzik et al., 2008). Pre-reflective agency is a basic low-level feeling of being an agent (“I could move that”) and is based on multiple basic sensorimotor processes, including the predictive components of the forward model. Reflective agency is a

retrospective process that involves an explicit judgement of an event ("I moved that"). This judgement takes into account the actual experience of the event, as well as information such as personal beliefs and social and contextual cues. The second assertion is that the final experience of agency is determined by numerous agency cues, that the contribution of each cue is determined by its reliability and, if one cue becomes unreliable, other cues become more important in agency judgements (Moore and Fletcher, 2012; Synofzik et al., 2013).

According to this model, impaired predictive processes and/or mismatches between predictions and sensory outcomes result in the experience of "… an action as strange, peculiar and not fully done by me" (p. 228, Synofzik et al., 2008). Tentatively, the increased similarity in perception of active and passive movements in the Past and Current groups could be a reflection of abnormal pre-reflective agency processes resulting in confusion when making explicit agency judgements, even in situations when movements are knowingly induced by an external agent.

4.2 Aberrant agency experiences are specific to self-agency

The reduction in difference scores between the active and passive conditions in people with any history of passivity symptoms was confined to agency over their own hand, confirming our hypothesis and supporting previous findings of disturbances specifically related to self-representations in Past and Current groups during the tactile PHI (Graham et al., 2014). That the Past and Current groups did not display this pattern on questions assessing agency over the other hand is explained by the two-factor model of agency. As their hand was hidden during the PHI, the participants would have been dependent upon proprioceptive cues and intentional signals in assessing agency over their own hand. Given that people with passivity symptoms have a specific deficit in proprioceptive prediction (Graham et al., 2014; Maruff et al., 2003), the Past and Current groups would have had difficulty determining agency without corresponding visual cues. When viewing the image of the hand, however, there is visual confirmation of motor outcomes, and so people with passivity symptoms could rely on external visual cues when making an agency judgement. Altogether, the findings are indicative of an overreliance on external visual cues in these symptoms.

4.3 Timing issues that impact agency are not limited to passivity symptoms

In line with our hypothesis, we found the Current group continued to report agency over the other hand and their own hand in the asynchronous condition, confirming previous studies

that found people with passivity symptoms were affected less by visuomotor (Schnell et al., 2008) or visuotactile (Graham et al., 2014) discrepancies. We previously hypothesised that altered internal timing processes cause an increase in the size of the perceptual binding window, the period in which two events may be perceptually bound and experienced as occurring together. Because of this widened binding window, people with schizophrenia are more likely to experience events, particularly external events that would normally occur too late to be considered causal to interval events, as occurring simultaneously and this then could lead to the incorrect association of external- with internal-events (Graham et al., 2014).

However, contrary to our hypothesis, the Never group also reported increased agency over the other hand in the asynchronous condition. A previous study found people with schizophrenia (undifferentiated) were insensitive to temporal incongruence on an agency attribution task (Franck et al., 2001). We have also demonstrated timing alterations in both people with, and without, passivity symptoms (Graham-Schmidt et al., 2016b). As such, it would appear an altered perceptual binding window is not unique to passivity symptoms. However, these findings demonstrate that a specific deficit in one domain, i.e. of the perceptual binding window, is not sufficient to induce passivity symptoms. Such findings emphasise the multifactorial nature of agency (Moore and Fletcher, 2012; Synofzik et al., 2013) and the necessary of multiple deficits for the development of passivity symptoms.

4.4 Limitations

Although the self-report questionnaire was developed from previously used questionnaires (e.g. Germine et al., 2013; Kalckert and Ehrsson, 2012; Longo et al., 2008), no test/retest reliability data exists for the questions chosen for the current study. A further limitation is that no objective measure of agency was recorded during the illusion to further support the findings of the self-report questionnaire.

4.5 Conclusions

This study found that an increased presence of passivity symptoms was associated with a decrease in the difference in agency between active and passive movements, but only on questionnaire items assessing agency over the own hand. These results may be due to impaired pre-reflective agency processes in people with passivity symptoms causing a reduction in agency after active movements and a greater dependence on external agency cues,. Finally, both people with a current or no history of passivity symptoms continued to experience agency over the other hand during the asynchronous condition. This suggests that

impaired internal timing processes may be important to the development of passivity symptoms, but are not unique to these symptoms.

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Fig. 1. Questionnaire responses assessing (A) agency over own hand, (B) agency over other hand, (C) loss of agency over own hand, and (D) loss of agency over other hand during the projected hand illusion in healthy controls (Controls), people with schizophrenia with no history of passivity symptoms (Never), people with a past history of passivity symptoms (Past) and people with current experiences of passivity symptoms (Current). Participants made either active movements of their hand (Active; shaded columns) or had their hand passively moved for them (Passive; unshaded columns). Visual feedback was either with a 500 ms delay (asynchronous; dark grey) or instantaneous (synchronous; light grey). Questions were answered on a 7-point Likert scale. Data are mean ± SEM. ^ $0.1 < p < 0.05$, * $p < 0.05$, ** $p < 0.01$, **** $p < 0.0001$.

Fig. 2. Group by condition interaction of responses to questions assessing agency over own hand during the projected hand illusion in Controls, Never, Past and Current groups. Participants made either active movements of their hand (Active) or had their hand passively moved for them (Passive); data shown are difference scores (Active – Passive; collapsed across synchrony conditions). Questions were answered on a 7-point Likert scale. Data are mean ± SEM, * $p < 0.05$.

Fig. 3. Group by condition interaction of responses to questions assessing loss of agency over own hand during the projected hand illusion in Controls, Never, Past and Current groups. Participants made either active movements of their hand (Active) or had their hand passively moved for them (Passive); data shown are difference scores (Passive – Active; collapsed across synchrony conditions). Questions were answered on a 7-point Likert scale. Data are mean ± SEM, ** $p < 0.01$.

Table 1.
Demographic and neuropsychological information of participants

	Controls (n = 47)	Never (n = 21)	Past (n = 10)	Current (n = 20)
Sex (M/F) [a]	24/23	14/7	9/1	12/8
Age (years) [b]	45.9 ± 1.7	42.5 ± 1.6	42.6 ± 3.2	44.0 ± 2.1
Years Education [b]	13.8 ± 0.3	12.9 ± 0.4	13.2 ± 0.6	13.8 ± 0.6
SAPS Composite [b]	-	12.0 ± 2.3 ^^^	20.3 ± 4.1	29.2 ± 3.2
SANS Composite [b]	-	21.8 ± 3.6	27.8 ± 3.9	24.7 ± 2.5
Chlorpromazine equivalents (mg) [b]	-	677 ± 121	932 ± 142	754 ± 106

Mean ± SEM of demographic and neuropsychological information.
[a] Fisher's Exact Test. [b] One-way ANOVA with Tukey's HSD post-hoc comparisons (Bonferroni corrected).
Different from Current: ^^^$p<0.001$
Antipsychotic doses converted into chlorpromazine equivalents using the formulae given in Woods (2003), Maudsley Prescribing Guidlines (Taylor et al., 2009) and Psychotropic Drug Guide (Bazire, 2009).

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Table 2.
Frequency distribution of passivity symptoms in Past and Current* groups as assessed by clinical interview and case note review. % frequency (observed number of each symptom divided by total number of observed symptoms for each group) is given in brackets.

SCAN Item	Symptom	Past (n = 10)	Current (n = 20)
17.008	Voices commenting or discussing	3 (9%)	13 (20%)
18.005	Thought echo	3 (9%)	6 (9%)
18.006	Thought insertion	7 (22%)	11 (17%)
18.007	Thought broadcast (thought sharing)	4 (13%)	6 (9%)
18.008	Thought commentary	0 (0%)	2 (3%)
18.009	Thought block	1 (3%)	8 (13%)
18.010	Thought withdrawal	4 (13%)	2 (3%)
18.012	Replacement of will by external force	3 (9%)	4 (6%)
18.013	Replaced control of voice	2 (6%)	3 (5%)
18.014	Replaced control of hand writing	0 (0%)	2 (3%)
18.015	Replaced control of actions	2 (6%)	4 (6%)
18.016	Replaced control of affect	1 (3%)	3 (5%)
18.017	Other experience of replaced control	2 (6%)	0 (0%)
	Average no. symptoms per participant (mean ± SEM)	3.2 (± 0.5)	3.2 (± 0.4)

* Occurrences of passivity symptoms in the past were also observed in some participants in the Current group. However, only symptoms within the four weeks prior to testing were used for the purposes of participant classification and so only those symptoms are included in this table.

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Table 3.
ANODEV tables of the linear mixed-effects models for questionnaire responses assessing (A) agency over own hand, (B) agency over other hand, (C) loss of agency over own hand, and (D) loss of agency over other hand, during the projected hand illusion. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.0001$.

(A) Agency over Own Hand

	χ^2	*dfn*	*dfd*	*p*
Group	0.45	3	94	0.92
Movement	539	1	279	< 0.0001 ***
Delay	16.7	1	279	< 0.0001 ***
Group x Movement	15.8	3	279	0.001 **
Group x Delay	2.66	3	279	0.45
Movement x Delay	4.41	1	279	0.04 *
Group x Movement x Delay	0.82	3	279	0.84

(B) Agency over Other Hand

	χ^2	*dfn*	*dfd*	*p*
Group	1.03	3	94	0.79
Movement	340	1	279	< 0.0001 ***
Delay	17.3	1	279	< 0.0001 ***
Group x Movement	2.24	3	279	0.52
Group x Delay	0.65	3	279	0.88
Movement x Delay	4.85	1	279	0.03 *
Group x Movement x Delay	4.48	3	279	0.21

(C) Loss of Agency over Own Hand

	χ^2	*dfn*	*dfd*	*p*
Group	10.1	3	94	0.02 *
Movement	711	1	279	< 0.0001 ***
Delay	7.29	1	279	0.007 **
Group x Movement	21.1	3	279	< 0.0001 ***
Group x Delay	0.04	3	279	0.99
Movement x Delay	1.92	1	279	0.17
Group x Movement x Delay	5.69	3	279	0.13

(D) Loss of Agency over Other Hand

	χ^2	*dfn*	*dfd*	*p*
Group	5.67	3	94	0.13
Movement	334	1	276	< 0.0001***
Delay	23.5	1	276	< 0.0001***
Group x Movement	4.21	3	276	0.24
Group x Delay	0.56	3	276	0.91
Movement x Delay	16.3	1	276	< 0.0001***
Group x Movement x Delay	1.92	3	276	0.59

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