**Pre-print:** accepted for publication in *Psychology of consciousness: Theory, research and practice.*

**Schizotypy and awareness of intention: variability of W judgements predicts schizotypy scores**

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**Running head:** Intention monitoring and schizotypy

**Abstract**

Patients with schizophrenia often have unusual experiences of action. For example, patients suffering from delusions of control feel that their voluntary actions are under the control of an external force. It has been argued that deficits in self-monitoring are responsible for these symptoms. However, to-date the self-monitoring of intention has been overlooked in studies on schizophrenia. Here we aim to address this oversight. We carried out a preliminary investigation of possible intention monitoring issues in schizophrenia by examining the relation between the awareness of intention and schizotypy in a healthy population. Using the Libet clock task we found that the variability of intention (or W) judgments was uniquely predictive of schizotypy: the more variable these judgments the higher the schizotypy score. We discuss the relevance of the findings for schizophrenic illness. We also discuss the utility of this intention variability measure for examining volitional disturbances more generally.

**Key words:** Intention; Volition; Schizotypy; Schizophrenia; Libet; Agency

**Introduction**

Abnormalities in the experience of voluntary action are associated with various psychiatric and neurological disorders. One of the most striking instances of such abnormalities is found in patients with schizophrenia suffering from delusions of control. Here individuals typically experience their voluntary actions as being under the control of an external force, which is exemplified in a patient with schizophrenia reported by Mellor (1970): ‘It is my hand and arm which move, and my fingers pick up the pen, but I don’t control them. What they do is nothing to do with me.’ (p. 18)

 It has been argued that these aberrant experiences of control are linked to deficits in self-monitoring. Self-monitoring (SM) is defined as the ability to monitor one’s own thoughts and actions (Farrer & Franck, 2007). In one of the earliest versions of this account, Frith and Done (1988) argued that SM deficits in patients with schizophrenia result in an unawareness of their intentions prior to movement. According to Frith and Done, patients are able to formulate intentions but these intentions fail to reach conscious awareness, the consequence of which is that patients are surprised by their actions and come to feel that they are not in control of them.

 More recently this account has been updated to accommodate advances in our understanding of the computational principles underlying motor control (Frith, 2005). On this view, the normal experience of control is based on a comparison between the predicted and actual sensory consequences of movement – where there is a match the action is experienced as self-caused. These predictions are generated by an internal forward model, which uses a copy of the motor command to predict the likely sensory consequence of movement (Blakemore, Wolpert, & Frith, 2002). In patients with schizophrenia, their SM deficits produce a lack of awareness of these sensory predictions. Accordingly, self-generated actions are not recognized as such.

 Researchers have accrued significant evidence that supports the idea that patients are unaware of predictive sensorimotor information generated by the internal forward model (e.g Delevoye-Turrell, Giersch, & Danion, 2003; Malenka, Angel, Hampton, & Berger, 1982; Stirling, Hellewell, & Quraishi, 1998; Turken, Vuilleumier, Mathalon, Swick, & Ford, 2003). An example of this lack of awareness can be seen in tasks that rely on access to information generated by the forward model. For example, Frith and Done (1989) showed that patients with delusion of control symptoms were unable to correct their movements in the absence of visual feedback regarding the movement. Given that this correction of movement relies on self-monitoring of centrally generated motor commands, this finding confirms the existence of self-monitoring impairments in patients.

 Although self-monitoring of action has been studied extensively in schizophrenia, researchers have overlooked self-monitoring of intention. This neglect is particularly surprising given the importance of intention monitoring in establishing the feeling that our actions are our own. For example, in Wegner and Wheatley's (1999) ‘Theory of Apparent Mental Causation,’ the feeling of agency is determined by the ability to monitor intentions and their relationship to actions. According to Wegner and Wheatley, our actions only feel like our own if our intentions occur before we act, are consistent with those actions, and are the only plausible cause of those actions. This assessment is only possible through the ability to monitor intentions and their (apparent) causal relationship with actions. In this way, any deficit in intention monitoring would be expected to impact the person’s sense of agency. Indeed, Frith and Done (1989) made this argument in their earlier work on self-monitoring, which emphasized intention representations (see above). In this paper we aim to remedy this oversight by providing a preliminary investigation of possible intention monitoring issues in schizophrenia by examining the relationship between the awareness of intention and schizotypy in a healthy population.

 Researchers have suggested that psychotic experiences may lie on a continuum, with such experiences occurring in psychologically healthy individuals to a greater or lesser extent (Van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009). Furthermore, previous studies have shown that cognitive performance in highly schizotypal individuals closely resembles performance of patients with a diagnosis of schizophrenia (e.g. Cochrane, Petch, & Pickering, 2012). Given this apparent link between schizotypy and schizophrenia, the schizotypy dimension offers an invaluable research tool, allowing us to explore patterns of perception, experience, and cognition redolent of schizophrenia, in a sample that is free of medication and hospitalization, both of which can be deeply problematic confounds in patient samples (Moore, Dickinson, & Fletcher, 2011).

 In the present study we used the Libet clock task (Libet, Gleason, Wright, & Pearl, 1983) to measure the temporal awareness of intention (so-called ‘W judgments’). In this task, participants watch a hand rotate rapidly around a clock face. To measure the awareness of intention, participants make a simple movement (e.g. a key press) and report the position of the hand on the clock face when they became aware of their intention to make the movement.

 The Libet clock task has been used widely in studies of the perceived onset of intention. Intention awareness is likely to be supported by both the pre-supplementary motor area (Fried et al., 1991; Lau, Rogers, Haggard, & Passingham, 2004) and inferior parietal cortices (Desmurget et al., 2009; Sirigu et al., 2003). Research also suggests that awareness of intention is (at least in part) inferential. For example, Banks and Isham (2009) showed that intention timing judgments could be influenced by post-action events. Similarly, Lau, Rogers, and Passingham (2007) showed that intention timing judgments could be altered by transcranial magnetic stimulation delivered over the pre-supplementary motor area *after* an action. More recently, studies have also used the Libet clock task to investigate volitional disturbances in psychiatric and neurological disorders (Edwards et al., 2011; Moretto, Schwingenschuh, Katschnig, Bhatia, & Haggard, 2011).

 In the present study, we use the Libet clock task to assess the putative relationship between volitional disturbances and schizotypy. Deficits in the monitoring of intention could be manifested in two ways on this task. There could be systematic changes in the average perceived onset of intention. For example, a difficulty monitoring intentions may result in awareness of intentions arising late in the action stream (perhaps the awareness of intention is captured by a more salient event like the action itself). Another manifestation of this deficit could be changes in the *variability* of intention timing judgments. If one experiences difficulty monitoring intentions, then the perception of their onset may be more uncertain resulting in greater variability (but, perhaps, no effect on the mean).

 In the present experiment, participants made simple key press movements and reported the time of their intention to act. In two separate control conditions participants were also asked to report the time of their actual key press or the time of a computer generated beep. For all three judgment types we calculated the average judgment error[[1]](#footnote-1) and also the standard deviation of these judgment errors. We investigated the relationship between these timing measures and scores on two schizotypy scales, the Cardiff Anomalous Perception Scale (CAPS; Bell, Halligan, & Ellis, 2006) and the 21 item Peters Delusion Inventory (PDI; Peters, Joseph, Day, & Garety, 2004). We hypothesized that individual differences in intention judgments would uniquely predict schizotypy scores (we also predicted there would be no significant relationship between the other control judgments and schizotypy). We made no specific prediction regarding which property of the intention timing measure (mean or standard deviation) would predict schizotypy.

**Methods**

*Participants*

Forty-four participants (volunteers for credit) took part in this experiment (mean age 24 years; age range 18-39; 11 male). All were right handed and had normal or corrected-to-normal vision. The experiment was approved by the Goldsmiths Psychology Department Research Ethics Committee.

*Stimuli*

Libet clock task

 Participants watched a computer screen on which a hand rotated around a clock-face (marked at conventional “5-minute” intervals; see Figure 1). Each full rotation lasted 2560ms. There were three separate conditions: *Intention Judgment*; *Action Judgment*; *Tone Judgment*. Judgment errors in the action and tone conditions were calculated by subtracting actual event onset from perceived event onset. Judgment errors in the intention condition were calculated by subtracting actual action onset from perceived intention onset.

*[Figure 1 about here}*

Schizotypy scales

 The *Peters Delusion Inventory* (PDI: Peters, Joseph, Day, & Garety, 2004) is a 21-item scale designed to measure delusional ideation in the normal population (e.g. “Do your thoughts ever feel alien to you in some way?”). When an item is endorsed, three five-point scales exploring distress, preoccupation, and conviction are then completed. The *Cardiff Anomalous Perceptions Scale* (CAPS: Bell, Halligan, & Ellis, 2006) is a 32-item scale designed to measure unusual perceptual experiences in the normal population (e.g. “Do you ever see things that other people cannot?”). When an item is endorsed, three five-point scales exploring distress, intrusiveness, and frequency are then completed. The validity and reliability of both measures has been previously demonstrated (Peter et al., 2004; Bell, Halligan, & Ellis, 2006). According to dimensional perspectives, higher scores on these scales position an individual closer to the psychopathological end of the putative “normal”-“psychopathological” continuum (e.g. Peters et al., 2004).

*Procedure*

Testing was carried out by a final year undergraduate project student. Participants were told beforehand that in this experiment they would be asked to report the time of certain events using a clock on the screen in front of them (further details were provided before each condition). They were also told that they would be asked to complete two questionnaires at the end of the session, and that these questionnaires are designed to evaluate beliefs and experiences in a variety of situations

 At the start of the session, participants were seated in a computer cubicle testing room. Participants were tested individually in the presence of an experimenter. All participants completed the Libet clock task first. This task consisted of three separate conditions. In the *Intention Judgment* condition participants had to press a marked key on a keyboard whenever they felt like it. They were asked to report the time at which they first became aware of their intention to make that movement. In the *Action Judgment* condition participants also had to press a marked key whenever they felt like it, but this time they reported the time they actually made the movement. In the *Tone Judgment* condition, participants remained passive throughout each trial and waited for a computer-generated beep to sound over computer speakers at a random time. They were asked to report the time they heard this beep. To make the timing judgments in each of these conditions, participants had to verbally report the position of the clock hand on the clock face when the to-be-judged event happened. The experimenter recorded this time judgment. Each condition was 20 trials long. The order of conditions was randomized across participations.

Following the intention attribution task participants completed the two schizotypy questionnaires. The order of their completion was counterbalanced across participants (22 participants completed the PDI first).

**Results**

*Descriptive statistics: Libet clock task & Schizotypy scores*

Table 1 below shows mean judgment errors and standard deviations for the three Libet clock conditions. These judgments are in line with previous work (e.g. Libet et al., 1983). Mean judgment errors were earliest for the intention condition, with participants aware of their intentions 130.5ms before moving. The mean judgment error for action was -30.7ms, suggesting that people feel they have moved slightly before they have done. The mean judgment error for the tone condition was +17.4ms, suggesting a slight delay in their awareness of this event. With respect to the standard deviation of judgment errors, these were highest for the intention condition (123.7ms), followed by the tone condition (108.6ms) and lowest in the action condition (70.8ms). Table 2 below shows the mean scores on the PDI and CAPS.

*[Table 1 about here]*

*[Table 2 about here]*

*Regression analyses*

To investigate the relationship between the performance on the Libet clock task and schizotypy we carried out a series of regression analyses (presented below).

PDI total and Judgment error

Table 3 shows the regression output for PDI total scores (dependent variable) and mean judgment errors in the three Libet clock task conditions (predictor variables). This analysis shows no significant relationship between mean judgment errors in each of the conditions and PDI scores.

*[Table 3 about here]*

PDI total and Standard deviation

Table 4 shows the regression output for PDI total scores (dependent variable) and mean standard deviations in the three Libet clock task conditions (predictor variables). This analysis shows only a significant relationship between standard deviation of intention judgment errors and the PDI total scores: the more variable the intention judgment the higher the PDI total score. This supports, at least in part, our initial hypothesis that individual differences in intention judgments (reflecting differences in the ability to monitor intentions) would predict schizotypy scores.

*[Table 4 about here]*

CAPS total and Judgment error

Table 5 shows the regression output for CAPS total scores (dependent variable) and mean judgment errors in the three Libet clock task conditions (predictor variables). This analysis shows no significant relationship between mean judgment errors and CAPS scores.

*[Table 5 about here]*

CAPS total and Standard deviation

Table 6 shows the regression output for CAPS total scores (dependent variable) and mean standard deviations in the three Libet clock task conditions (predictor variables). This analysis shows no significant relationship between mean standard deviations and CAPS scores.

*[Table 6 about here]*

**Discussion**

In this experiment we investigated the relationship between intention monitoring and schizotypy. We found that variability in the perceived onset of intention (measured by the standard deviation of timing judgments) predicted scores on the Peters Delusion Inventory (PDI). We found no other significant relationships between measures of intention awareness and schizotypy (PDI or CAPS). We also found no other significant relationships between our control judgments (actions and tones) and schizotypy. These findings partially support our initial hypothesis that deficits in intention monitoring would be predictive of schizotypy – we obtained a significant relationship between variability of perceived intention onset and PDI scores, but no significant relationship between any of the timing judgments and CAPS scores. Given the putative link between schizotypy and schizophrenia, these results suggest that intention monitoring may be impaired in schizophrenia.

 The specificity of this finding is important as it suggests that individual differences in schizotypy are not linked to general timing deficits. Rather, there seems to be a specific issue with the temporal awareness of intention. This finding lends further support to the idea that self-monitoring problems are central to the expression of certain core schizophrenic symptoms (e.g. Farrer & Franck, 2007). It is important to note here, however, that we did not examine the influence of other potentially comorbid manifestations of psychopathology, such as depression or anxiety, independent of schizotypy. It would be useful to do this in future work.

 In light of our findings, we suggest that the range of self-monitoring issues in schizophrenic illness should be extended to include awareness of intention. Problems with intention monitoring were a central theme of early theorizing on self-monitoring issues in schizophrenia (see, for example, Frith & Done, 1988), but have since been overlooked. This neglect is surprising given the importance of intention monitoring for establishing our own sense of agency (Wegner & Wheatley, 1999). Our results suggest that investigating these deficits in schizophrenia will be a fruitful line of inquiry for future research, possibly shedding light on an important cognitive deficit underpinning the disorder. This work should also explore whether these putative deficits are specific to patients experiencing delusions of control or whether they represent a more fundamental cognitive deficit across all patients suffering from delusions.

 Moreover, our results suggest that deficits in self-monitoring (at least of intentions) are not linked to all schizophrenia-like symptoms. That is, we found that the deficit in intention monitoring was only predictive of scores on the PDI, which measures unusual beliefs (akin to delusions). We found no significant relationship with the CAPS, which measures unusual perceptions (akin to hallucinations). This finding speaks to the issue, discussed by Farrer and Franck (2007), of whether self-monitoring deficits are only related to delusions or whether they are associated with positive symptoms more broadly (i.e. delusions and hallucinations). Disentangling these relationships in patient research is difficult because delusions and hallucinations often co-occur. Our findings are potentially informative here as they suggest that the link is specific to delusions. Indeed, the lack of a relationship between self-monitoring of intention and CAPS suggests that although hallucinations and delusions often co-occur in patients they may be underpinned by different information processing disturbances.

 Our study also speaks to the issue of whether or not deficits in self-monitoring represent state or trait markers of schizophrenia. If self-monitoring deficits represent a state marker, then their expression should be tied to the appearance of symptoms. On the other hand, if self-monitoring deficits represent a trait marker, then they should be present with and without symptoms and also in at risk individuals (Farrer & Franck, 2007). Although the link between schizotypy and schizophrenia is still unclear, some have argued that those who score high on schizotypy scales are at a greater risk of developing schizophrenia (e.g. Barrantes-Vidal et al., 2013). If this is the case, then our findings suggest that self-monitoring deficits, at least for intentions, represent a trait marker. This could be further explored. For example, one could examine whether or not intention-monitoring problems are present in those in the prodromal stages of schizophrenia and whether or not the severity of these problems predicts the transition to schizophrenia.

 Given previous research on the brain regions supporting intention awareness, we can speculate briefly about the neural basis of increases in the variability of perceived intention onset. Two main brain areas have been identified in this regard: the pre-supplementary motor area (e.g. Lau et al., 2004) and the inferior parietal lobe (e.g. Desmurget et al., 2009). One possible explanation for increases in the variability in perceived onset of intention could be a corruption of neuronal signalling within either (or both) of these regions. Interestingly, symptoms of passivity in schizophrenia have been associated with aberrant activity within inferior parietal regions (e.g. Schnell et al., 2008; Spence et al., 1997), making this a particularly strong candidate for the neuronal source of changes in the variability of intention awareness. Future research should directly investigate this possibility.

 Our results also have implications for measures of intention. Most, if not all, studies on intention awareness have focused on the mean perceived onset of intention, which has been a useful measure in both clinical and non-clinical studies. For example, researchers have shown that patients with Tourette’s syndrome exhibit a delayed awareness of intention relative to neurotypical controls (Moretto et al., 2011). However, our findings also suggest that the variability in perceived onset of intention is relevant, and that it might usefully capture certain volitional disturbances, for example in Anarchic Hand Syndrome (AnHS) and Utilization Behavior (UB). AnHS is characterized by the loss of sense of control for an affected limb, with the limb having its own will and responding to external cues. In UB, on the other hand, the patient’s movements are similarly triggered by external cues, but there is no sense in which they violate the patient’s own intentions. As we have written elsewhere (Moore & Fletcher, 2012), AnHS and UB are overtly similar, especially with respect to behavior in patients being driven by external triggers rather than internal goals. Nevertheless, they differ greatly in the accompanying subjective experience of the environmentally-triggered behaviors. Patients with AnHS recognize that their actions are incompatible with their intentions, whereas patients with UB fail to recognize this discrepancy and instead confabulate reasons for their actions. Blakemore, Wolpert and Frith (2002) suggest that these two groups of patients differ in terms of their ability to represent (or access representations of) intentions: AnHS patients maintain this capacity whereas UB patients do not. This hypothesis could be tested using our measure of intention monitoring – we would predict increased variability in perceived intention onset in UB patients relative to AnHS patients, reflecting this putative difficulty representing (or accessing representations of) intentions.

 In summary, we have explored the relationship between intention monitoring and schizotypy. Our findings suggest that intention monitoring, as measured by the variability in timing judgments, is related to delusion-like thinking in the healthy population. Future research should further explore the relevance of this cognitive deficit for schizophrenic illness. Furthermore, we suggest that this variability measure of intention awareness could be used as a tool to explore volitional disturbances in other neurological and psychiatric disorders.

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**Figure 1. The Libet clock stimulus used in the current experiment (following Libet et al., 1983)**

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**Table 1. Mean judgment errors and standard deviations for the three Libet clock task conditions. Standard deviation of the mean in parentheses.**

|  |  |
| --- | --- |
|  | **Mean (SD)** |
| **Judgment error** |  |
| Intention | -130.5ms (96.8) |
| Action | -30.7ms (48.0) |
| Tone | 17.4ms (49.5) |
| **Standard deviation** |  |
| Intention | 123.7ms (72.5) |
| Action | 70.8ms (25.6) |
| Tone | 108.6ms (50.6) |

**Table 2. Mean scores on the 21 Item Peters Delusion Inventory (PDI) and Cardiff Anomalous Perceptions Scale (CAPS). Standard deviation of the mean in parentheses.**

|  |  |
| --- | --- |
|  | **Mean (SD)** |
| **PDI** |  |
| Total |  43.7 (31.3) |
| Distress | 12.8 (10.1) |
| Preoccupation |  11.6 (8.8) |
| Conviction | 14.2 (10.0) |
| **CAPS** |  |
| Total | 58.5 (47.2) |
| Distress | 16.7 (15.3) |
| Distraction | 19.5 (16.5) |
| Occurrence | 14.8 (12.0) |

**Table 3. Output of regression analyses for PDI total scores (dependent variable) and mean judgment errors in the three Libet clock task conditions (predictor variables)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Beta* | *Standard error of beta* | *Standardised beta* |
| Constant | 26.57 | 8.27 |  |
| Intention judgment | -.09 | 0.05 | -0.28 |
| Action judgment | -.11 | 0.10 | -0.17 |
| Tone judgment | .12 | 0.10 | 0.19 |

Note: R2 = .14

**Table 4. Output of regression analyses for PDI total scores (dependent variable) and mean standard deviations in the three Libet clock task conditions (predictor variables)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Beta* | *Standard error of beta* | *Standardised beta* |
| Constant | 3.14 | 17.22 |  |
| Intention judgment | 0.23 | 0.06 | 0.52\* |
| Action judgment | 0.06 | 0.16 | 0.05 |
| Tone judgment | 0.08 | 0.08 | 0.13 |

Note: R2 = .28 \* <.001

**Table 5. Output of regression analyses for CAPS total scores (dependent variable) and mean judgment errors in the three Libet clock task conditions (predictor variables)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Beta* | *Standard error of beta* | *Standardised beta* |
| Constant | 50.71 | 12.99 |  |
| Intention judgment | 0.02 | 0.08 | 0.03 |
| Action judgment | -0.24 | 0.16 | -0.24 |
| Tone judgment | 0.15 | 0.15 | 0.26 |

Note: R2 = .07

**Table 6. Output of regression analyses for CAPS total scores (dependent variable) and mean standard deviations in the three Libet clock task conditions (predictor variables)**

|  |  |  |  |
| --- | --- | --- | --- |
|  | *Beta* | *Standard error of beta* | *Standardised beta* |
| Constant | 31.41 | 29.68 |  |
| Intention judgment | 0.16 | 0.10 | 0.25 |
| Action judgment | 0.04 | 0.28 | 0.02 |
| Tone judgment | 0.04 | 0.14 | 0.04 |

Note: R2 = .06

1. We use the term ‘judgment error’ in keeping with convention. For intentions, however, this is somewhat of a misnomer as there is no objective event onset against which to calculate a judgment error. [↑](#footnote-ref-1)