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Title: Schizotypy and the vicarious experience of agency

Running Head: Schizotypy and the sense of agency

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Abstract

Sense of agency is the experience of initiating and controlling an action in order to influence one's environment. It is widely accepted that various different sources of information contribute to sense of agency, including sensorimotor signals and external situational information. Moreover, it has been suggested that atypical experiences in sense of agency in schizophrenia are linked to changes in the relative influence of these agency cues, with external cues being more dominant. This study tests this hypothesis in a non-clinical population by investigating the relationship between schizotypy and performance on the vicarious agency task (a classic demonstration of the effect of external cues on sense of agency). We found that increased susceptibility to the vicarious agency illusion (i.e. an increased feeling of controlling someone else's action) was linked to higher schizotypy scores. This supports the idea that aberrant experiences of agency in schizophrenia are linked to an increased sensitivity to external agency cues.

Key words: Sense of agency; volition; schizotypy; schizophrenia; disorders; consciousness

Word count: 3958 words

Introduction

Sense of agency (SoAg) refers to the experience of initiating and controlling action in order to influence events in one's environment. It is inextricably linked to everyday notions of freedom and responsibility (Haggard & Tsakiris, 2009) and therefore forms an integral part of our cognitive and social lives (Moore & Fletcher, 2012).

In the past years, two competing views that have been used to explain the neurocognitive origins of SoAg. Some have proposed that SoAg arises principally from *internal* processes serving motor control (Haggard, 2005) while others have placed more emphasis on *external* situational cues (Wegner, 2002, 2003). More recently, a consensus has grown that these mechanisms each contribute to an individual's SoAg (Kranick & Hallett, 2013; Moore & Fletcher, 2012; Moore, Wegner, & Haggard, 2009; Wegner & Sparrow, 2004; Wegner, Sparrow, & Winerman, 2004). These cues include internal sensorimotor signals and external situational information (Moore & Fletcher, 2012). We have suggested that altered experiences of agency can be explained by differences in the relative influence of these agency cues (Moore & Fletcher, 2012; Moore et al., 2009).

Altered experiences of agency are associated with numerous psychiatric and neurological disorders. Some of the clearest examples of this are delusions of control reported by some patients with schizophrenia. Symptoms of schizophrenia can be classified into 'positive' and 'negative' symptoms. Positive symptoms are characterised by the presence of perceptions (e.g. visual hallucinations) or delusional beliefs. Negative symptoms consist in the absence, or reduction, of adaptive functions such as emotional understanding, speech or abstract thinking (Kay, Fiszbein, & Opler, 1987). Within the positive symptoms category are included abnormal experiences of agency. Patients with schizophrenia may feel that they are not in

control of their own actions. Instead they feel as though another agent or force is causing them to move. Mellor (1970) provides an example of this, presenting the words of a patient describing their experience: 'It is my hand and arm that move, and my fingers pick up the pen, but I don't control them. What they do is nothing to do with me.' Interestingly, while patients with schizophrenia have reported a lack of agency towards their actions, various experimental studies show that these patients tend to show an exaggerated sense of agency, that is an over-attribution of agency to themselves (Daprati et al., 1997; Franck et al., 2001; Synofzik, Thier, Leube, Schlotterbeck, & Lindner, 2010).

In previous experimental and theoretical work, we have suggested that these disordered experiences of control are linked to specific agency-processing changes (Voss et al., 2010). Voss and colleagues (2010) showed that in patients with schizophrenia the contribution of internal sensorimotor cues to sense of agency is reduced, while the contribution of external cues is increased. We have argued that these agency-processing changes can be explained by an optimal cue integration model of SoAg, in which the dominance of individual agency cues is linked to their reliability (Moore & Fletcher, 2012). In this way, owing to unreliable sensorimotor cues in schizophrenia there is a greater reliance on external cues.

In the present study we offer a further test of this hypothesis by exploring how schizotypy in a healthy population relates to their performance on the so-called 'Vicarious agency' paradigm (Wegner et al., 2004). The vicarious agency paradigm provides a classic demonstration of the effects of external cues on agency processing. In this paradigm participants sit facing a mirror with an experimental assistant standing behind them, hidden from view by a curtain. The assistant puts their hand forward in such a way that they look like the participant's hands (see Figure 1 for the paradigm's set-up). While looking towards

the mirror, participants also listen to action instructions through a pair of headphones. These action instructions are either a match or a mismatch with the actions the assistant was making. Wegner et al. found that participants felt an increased sense of control over the actions performed by the experimenter when there was congruency between the instructions and the actions performed by the assistant. This paradigm demonstrates how external situational agency cues, in this case action instructions and movements made by the experimenter, can have an influence on the SoAg. The influence of these external agency cues is so strong that participants can feel a SoAg over movements that they have not performed, despite them not having any related internal sensorimotor cues. Importantly, the manipulation of the participants sense of ownership towards the experimenter's arms, which is achieved by placing the experimenter's hands in a body congruent position so as they look like the participant's own hands, is essential to this paradigm's ability to elicit the experience of vicarious agency. Theoretical accounts of agency have argued that the positive experience of agency is predicated on the feeling that the body part that is moving is one's own (Gallagher, 2000). Furthermore, a large number of experimental studies have demonstrated how ownership manipulation alters the sense of agency (Pyasik, Furlanetto, & Pia, 2019 for a review), suggesting that these two components of self-awareness are, at least partially, related. In the present experiment we examined the relationship between performance on the vicarious agency paradigm and schizotypy. It has been suggested that for non-clinical populations, psychotic experiences can occur with differing degrees (Van Os, Linscott, Delespaul, & Krabbendam, 2009). Investigating the schizotypy personality in a non clinical population provides a good opportunity to explore the cognitive and biological mechanisms that may be associated with schizophrenia, without the confounding effects associated with

a clinical population, such as medications, hospitalisation and severe symptoms (Asai, 2016; Raine, Lencz, & Benishay, 1995). Similarly to how previous studies have shown a link between altered sense of agency and body ownership in patients with schizophrenia (Daprati et al., 1997; Franck et al., 2001; Peled, Ritsner, Hirschmann, Geva, & Modai, 2000; Synofzik et al., 2010), studies in the general population have found that people who are highly schizotypal showed an altered sense of agency and ownership (Asai, Mao, Sugimori, & Tanno, 2011; Asai & Tanno, 2007).

In light of the relationship between schizotypy and schizophrenia, we expected that changes in the experience of control on the vicarious agency task will be uniquely predictive of schizotypy (separate measures of anticipation and ownership during this task should show no relationship with schizotypy). More specifically, we expect that the difference in the experience of control on match and mismatch trials will be greater in participants that show higher scores on our schizotypy measures, as a consequence of a greater reliance on external agency cues.

Materials and Methods

Participants

For this experiment, 53 participants took part in exchange for course credit, of which 7 were males, all aged between 17 and 35 years and mean age of 20 years. The participants were included if their vision was normal or corrected-to-normal and they had no history of mental illness. The study was approved by the local ethical committee.

Procedure

Vicarious agency task

All participants began by performing the vicarious agency task. The experimental procedure was modified from Wegner et al. (2004), and the same as in Cioffi et al. (2016; 2017).

Participants sat facing a mirror placed one meter away. Action previews were played to the participant using over-ear headphones. We used a cloth sheet to fully cover the participant's body below the neck. The participant put on a pair of white gloves and their arms were hidden from view below the sheet. An experimenter stood behind the participant, hidden by a curtain with two armholes for the experimenter. The experimenter also wore headphones in order to be able to listen to the instructions heard by the participant. The experimenter wore a blouse along with a pair of gloves such that there was no exposed skin and the parts visible to the participant were the same colour as both the sheet and gloves worn by the participant. The experimenter positioned their left or right arm forward such that it appeared where the participant's own arm would have been, were it to be above the sheet covering the participant's body. During the experiment, the participants were asked to remain still and look at the reflection in the mirror in front of them while actions were performed by the experimenter using one of their hands (see Figure 1).



Figure 1. Left: side view of the experimental setup. Right: participant's view of the experimental setup. Note that the arm and fist in picture belong to the experimenter that is sitting behind the participant, hidden by the curtain. This picture is taken from Cioffi et al. (2016).

Sixteen instructions for unimanual actions were played through the headphones (e.g., “raise your hand,” “point at the mirror”, “point at yourself with the thumb”). The experimenter performed the gesture immediately after each action instruction played. Each trial, lasting between eight and ten seconds, consisted of one action instruction plus a gesture. A three second break was given between trials to prevent carryover effects. In order to increase the effects of this manipulation, the 16 instruction-action trials were repeated 3 times in the same order without interruption. This was performed for each condition (match/mismatch; see below) and for each hand (left/right).

Importantly, while the list of instructions played was the same for both match and mismatch conditions, the congruency of the action performed by the experimenter was manipulated.

In the *match condition*, the action performed by the experimenter corresponded to the

instruction heard by the participant over the headphones. Instead, in the *mismatch condition*, each action instruction was randomly paired with another action. For example, after the instruction “point to the mirror” the experimenter waved their hand. For the mismatch condition, the gesture paired with the instruction was changed for each repetition. For example, for the second repetition of the instruction “point to the mirror”, the experimenter snapped their fingers. The match and mismatch conditions were completed for both the left and right hands, resulting in a total of four conditions (match right, match left, mismatch right, mismatch left). The order in which these four conditions were tested was counterbalanced across participants.

Following each condition, the participants were asked to rate three aspects of their experiences on a seven-point Likert scale, based on questions presented in Wegner et al.’s (2004) study, and identical to the ones used in Cioffi (2016, 2017). The ratings were collected after each condition, and for each hand, with the lowest value, 1, being ‘not at all’ and the highest value, 7, being ‘very much’. In total, four sets of ratings were collected for each participant. Participants were asked to answer the following three questions:

1- *“To what degree did you feel you could anticipate the movements of the arm?”*

This question served as check question, as it aimed to assess whether the stimuli were overall attended to. This was included to rule out that any potential performance differences could be ascribed to a failure in attending the primes. If most primes were attended to then the anticipation judgements should be higher in the match conditions compared to the mismatch conditions.

2- *“How much control did you feel you had over the arm’s movements?”*

This question assessed the sense of control experienced by the participants.

3- *“To what degree did the arm feel like it belonged to you?”*

This question assessed the sense of ownership experience by the participants.

Each participant went through a practice session at the start of the experiment. The practice session consisted of three match and three mismatch trials.

Previous studies using this paradigm showed how the congruency between action and instruction elicits a vicarious experience of agency towards the experimenter’s movements (Wegner et al., 2004; Cioffi et al., 2016). Therefore, we expect participants to report higher control ratings following the match conditions compared to the mismatch conditions.

Schizotypy scales

Following the vicarious agency task, participants were asked to fill in two schizotypy scales.

The Peters Delusion Inventory (PDI: Peters, Joseph, Day, & Garety, 2004) is designed to measure delusional ideation in the normal population (e.g. “Do your thoughts ever feel alien to you in some way?”). It contains 21 items, and when an item is recognised by the participant then they are asked to complete three 5-point scales exploring distress, preoccupation, and conviction. The Cardiff Anomalous Perceptions Scale (CAPS: Bell, Halligan, & Ellis, 2006) aims to measure unusual perceptual experiences in non-clinical population (e.g. “Do you ever see things that other people cannot?”). The scale contains 32 items, when an item is recognised by the participant, they are asked to complete three 5-point scales exploring distress, intrusiveness, and frequency. Previous studies have

demonstrated the validity and reliability of both scales (Peters et al., 2004; Bell, Halligan, & Ellis, 2006).

Higher scores on these scales place an individual closer to the psychopathological end of the schizotypy continuum between 'normal' and 'pathological' (e.g. Peters et al., 2004).

Results

Vicarious agency task

A preliminary analysis on left and right hands was carried out for each condition using a paired sample test to see if their results could be distinguished. As no significant differences emerged, the mean judgements for left and right hands were collapsed into a single score (for example: (Anticipation match condition Left hand + Anticipation match condition Right hand)/2). These were entered into a two-way repeated measures ANOVA with one factor being *Congruence* (Match/Mismatch) and one factor being *Judgement type* (Anticipation/Control/Ownership).

We replicated the vicarious agency effect (see Figure 2). There was a significant main effect of *Congruence*; the average anticipation, control and ownership judgements were higher in the match vs. mismatch conditions ($F(1,52) = 131.99, p < .001, \eta^2_{\text{partial}} = .72$). There was also a main effect of *Judgement type*: the overall levels of anticipation were higher than control or ownership ($F(2,104) = 39.79, p < .01, \eta^2_{\text{partial}} = .44$). Finally, there was a significant interaction between *Congruence* and *Judgement type* ($F(2,104) = 46.16, p < .001, \eta^2_{\text{partial}} = .47$): the effect of our manipulation was strongest for anticipation (see Figure 2).

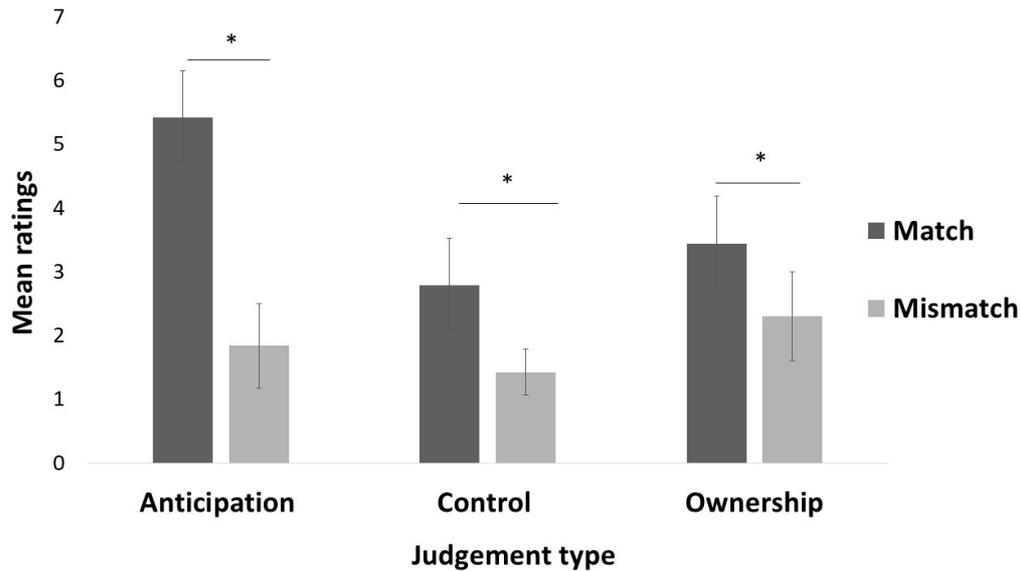


Figure 2. Mean ratings plotted as a function of judgement type and congruence (match vs. mismatch).

Schizotypy

The two schizotypy scales (CAPS and PDI) are scored in the same way. Participants answer “yes” or “no” for each item. If they answer “yes”, they then provide ratings on three additional 5-point scales. To calculate total PDI and CAPS scores, the number of “yes” responses is added to the sum of all additional ratings on the 5-point scales. Summary statistics for total scores and sub-scale scores are presented in Table 1.

Table 1. Mean scores on the 21 Item Peters Delusion Inventory (PDI) and Cardiff Anomalous Perceptions Scale (CAPS). Standard deviation of the mean is reported in parentheses.

	Mean (SD)
PDI	
Total	53.6 (38.0)

Distress	16.6 (13.0)
Preoccupation	16.1 (12.7)
Conviction	16.9 (12.8)
<hr/>	
CAPS	
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Total	64.4 (48.0)
Distress	19.0 (15.2)
Distraction	20.1 (15.3)
Occurrence	16.8 (14.3)
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Relationship between vicarious agency and schizotypy

Our key hypothesis concerned the relationship between the vicarious agency effect and schizotypy. In particular, we predicted that the stronger this effect, the higher the schizotypy score. This would be consistent with the theory that agency processing in schizophrenia is biased towards external agency cues. To test this, we ran two separate hierarchical linear regression analyses for the CAPS and PDI respectively. The predictor variables were differences in mean judgements (match – mismatch) for control, anticipation and ownership experiences respectively (see Table 2 for a matrix of simple correlations between all variables). Based on our initial hypothesis that individual differences in the feeling of control would predict schizotypy scores, ‘control’ was entered into the model first followed by the anticipation and ownership judgements. These were entered into the linear regression model simultaneously. Table 3 presents the results for both CAPS and PDI. Control was a significant predictor of CAPS total scores. This relationship is plotted in Figure

3. No other judgement types were predictive of CAPS. For the PDI no judgement types were significant predictors of PDI total scores. These results show that control did predict schizotypy but only for CAPS measure, partially supporting our hypothesis.

Table 2. Matrix of Pearson’s correlations (r).

	‘Control’	‘Ownership’	‘Anticipation’	PDI	CAPS
‘Control’	—				
‘Ownership’	0.59***	—			
‘Anticipation’	0.20	0.21	—		
PDI	0.24	0.05	0.06	—	
CAPS	0.31*	0.09	0.14	0.57***	—

Note: * p < .05, ** p < .01, *** p < .001

Table 3. Output for separate hierarchical linear regression analyses assessing the relationship between CAPS and PDI total scores (dependent variables) and mean judgement differences (match – mismatch) for the three judgement types (predictors).

	<i>Beta</i>	<i>Standard error of beta</i>	<i>Standardised beta</i>
CAPS			
Step 1			
Constant	52.16	8.30	
‘Control’	9.03	3.95	.31*
Step 2			
Constant	46.07	13.75	
‘Control’	11.19	4.96	.38*
‘Anticipation’	2.34	3.38	.10
‘Ownership’	-4.57	4.97	-.16
PDI			
Step 1			
Constant	46.06	6.71	
‘Control’	5.54	3.19	.24
Step 2			
Constant	45.74	11.17	
‘Control’	7.47	4.03	.32
‘Anticipation’	.45	2.74	.02
‘Ownership’	-3.43	4.03	-.15

Note: CAPS: $R^2 = .09$ for Step 1, $\Delta R^2 = .02$ for Step 2 / PDI: $R^2 = .06$ for Step 1, $\Delta R^2 = .01$ for Step 2. * < 0.05

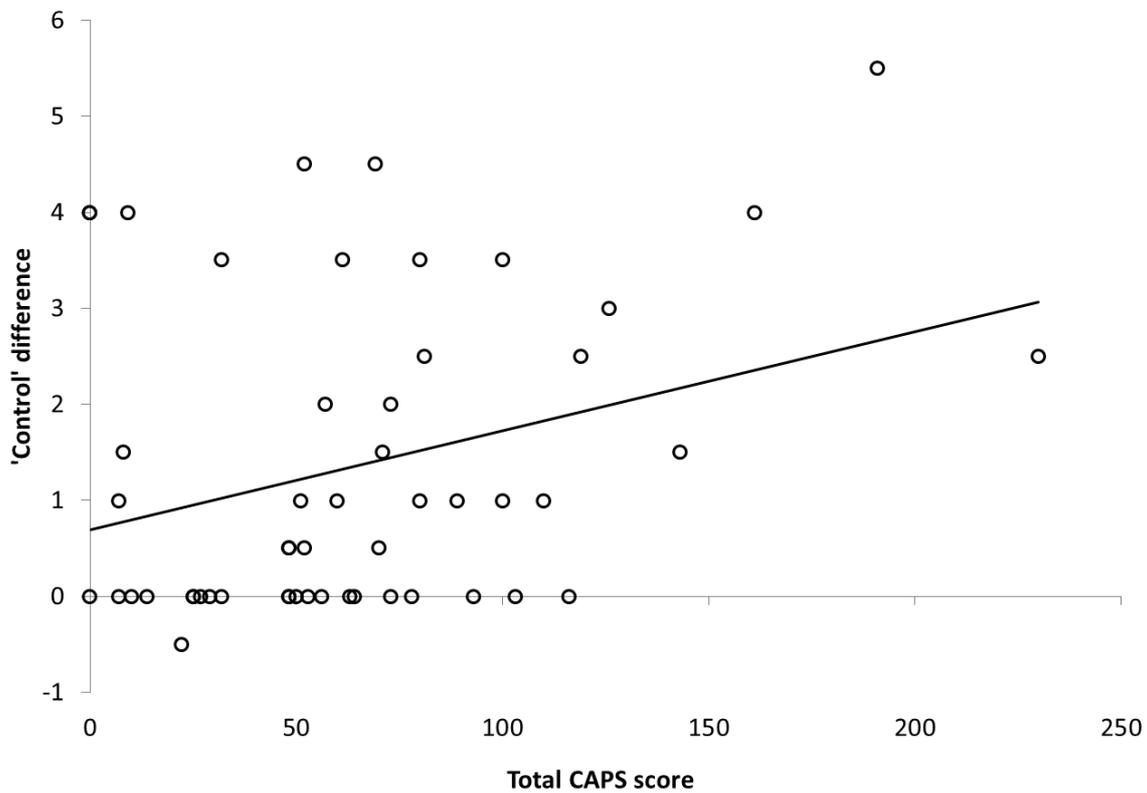


Figure 3. Scatterplot depicting the relationship between CAPS total scores and mean control judgement differences (match – mismatch).

Discussion

We investigated the relationship between the experience of vicarious agency and schizotypy. First, we replicated the basic vicarious agency effect reported by Wegner et al. (2004). That is, people experienced more control over movements made by someone else when the action instruction matched with the gesture performed. Second, we showed that individual differences in the experience of vicarious agency on this task predicted CAPS scores. These findings partially support our initial hypothesis that the experience of control on this task would predict individual differences in schizotypy.

Recent theoretical accounts of sense of agency (e.g. Moore & Fletcher, 2012) have emphasised the contribution of various agency cues, both internal (i.e. sensorimotor) and external (i.e. situational). In replicating the vicarious agency effect, we have confirmed the influence of external situational cues on sense of agency. This effect shows that in the absence of internal sensorimotor signals, external cues exert a stronger influence on sense of agency. This finding also supports the suggestion that the relative influence of agency cues is dependent on their reliability. That is, these agency cues are *optimally* integrated (Moore, Wegner & Haggard, 2009; Moore & Fletcher, 2012).

Previously we have suggested that this principle of optimal cue integration can be used to explain aberrant experiences of agency in certain clinical and neurological disorders. For example, the experience of agency in individuals with schizophrenia seems to be dominated by external cues to agency (e.g. Voss et al., 2010) and this, in turn, may be linked to unreliable sensorimotor prediction also observed in these patients. A strong prediction from this recent agency processing research in schizophrenia is that individuals with schizophrenia should be more susceptible to manipulations of external agency cues. Here we carried out a test of this in a group of healthy individuals by assessing the relationship between schizotypy and performance in Wegner's vicarious agency task. Our results provide support for this prediction: individual differences in the susceptibility to this agency illusion predicted schizotypy scores. This finding adds further weight to the idea that agency processing in patients with schizophrenia is more heavily influenced by external agency signals. It is worth underlining that our study focused on investigating the relationship between agency and the *positive* dimension of schizotypy. This was motivated by an

extensive literature showing this relationship in patients with schizophrenia (e.g. Daprati et al., 1997; Voss et al., 2010). In light of this we did not consider relationships between vicarious agency experiences and the negative or disorganised dimensions of schizotypy. Moreover, our check question 'anticipation' which was asked at the end of each condition as a marker of attention to the primes-outcome relationship, cannot guarantee that participants attended to all the trials equally. This would be particularly relevant when testing a clinical population whose level of attention may tend to fluctuate more. These are certainly limitations of this study, and they should be considered in future work looking at the relationship between agency and schizotypy.

To flesh out the *clinical significance* of this finding, future work should attempt to replicate this effect in a group of individuals with schizophrenia. Here it will be important to try to understand how this putative agency processing abnormality can explain the specific symptoms reported by patients. For example, how can this agency processing abnormality explain the occurrence and the content of passivity symptoms? Linked to this it will also be important to examine the relationship between this behavioural effect and delusional vs. hallucinatory symptoms. Our findings suggest that agentic vulnerability, at least in the context of this task, may be associated more strongly with hallucinatory symptoms - we only found a significant relationship with CAPS scores. This is an intriguing finding given that aberrant experiences of agency are typically classed as delusions. One possible explanation for this finding is that the vicarious agency task has a very strong perceptual component: both auditory and perceptual cues have to be processed in order for the vicarious agency illusion to emerge. Moreover, internal sensorimotor information is absent as the participant remains passive throughout the experiment. Given the perceptual demands of the task it

may not be surprising that behaviour on the task is predictive of perceptual aberrations as measured by CAPS.

One possible methodological issue should be noted. All participants completed the schizotypy scales at the *end* of the testing session. It is therefore possible, that the vicarious agency task influenced responses to items on these scales, potentially making it more likely that participants would endorse anomalous experiences. However, we feel that this feature of our methodology is unlikely to have unduly influenced our data and results. First, it looks like the mean CAPS and PDI scores were comparable to previous studies. Second, even if it did encourage the endorsement of CAPS statements, one would likely assume a similar shift across participants. Third, our key finding concerns the link between variability in vicarious agency and variability in schizotypy responses, which if there is a general shift in responses on the questionnaires, is unlikely to negate that result.

In summary we have shown that external situational cues can exert a powerful influence on the sense of agency. Moreover, we have shown that the magnitude of this effect is linked to schizotypy, with a stronger influence of external cues being predictive of higher schizotypy scores in a healthy adult population. This is consistent with the idea that agency processing in schizophrenia is characterised by an increased reliance external cues. Future work should aim to shed further light on this agency processing abnormality and its link with specific schizophrenia symptoms.

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