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**Deficits in reality and internal source monitoring of actions are associated with the
positive dimension of schizotypy**

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Abstract

People with schizophrenia have deficits in retrieving the source of memory information. Research has focused on two types of judgements: reality monitoring (discriminating internally-generated stimuli from external information) and internal source monitoring (distinguishing two different internal sources). The aim of the current study was to assess the relation between schizotypy and both types of source memory in healthy volunteers. One hundred and two participants completed two source memory tasks: one involved the completion of well-known word pairs (e.g. Fish and ?) and the other was an action based task (e.g. nod your head). At test participants needed to indicate whether the act had been performed or imagined by themselves, performed by the experimenter, or was new. The positive dimension of schizotypy was positively correlated with errors in internal source monitoring i.e. confusing participant performed and imagined acts. Furthermore, the same dimension of schizotypy was also positively associated with reality monitoring errors i.e. confusing participant performed/imagined with experimenter performed items. However, these relationships were not found in the word pair task. Our findings suggest that there might be overlap in the processes required to retrieve source information from memory, particularly for actions, and the occurrence of unusual experiences in healthy volunteers.

Keywords: Schizophrenia, schizotypy, reality monitoring, internal source monitoring, memory

1. Introduction

Occasional problems with retrieving the origin, or source, of information from our personal past can be seen in everyday life, from when we forget or confuse who told us a certain piece of information to wondering whether we just thought about replying to an email or whether we actually did it. However, in certain psychiatric disorders such as schizophrenia, these difficulties in episodic memory are far more prevalent. Indeed, they reflect a core cognitive impairment (Elvevag and Goldberg, 2000; Ragland et al., 2009), which is observed in young medication-naïve patients (MacDonald III et al., 2005) and healthy first-degree relatives of those with schizophrenia (Snitz et al., 2006; Touloupoulou et al., 2003). These memory impairments are largely unaffected by antipsychotic medication (Vinogradov et al., 1997). Research which elucidates the nature of the memory impairment is of vital importance because memory performance is one of the strongest predictors of functional outcome (Green, 1996; Milev et al., 2005).

Within episodic memory there is an important distinction between knowing whether something has been encountered before or not and being able to recover the specific details surrounding an event. The former task can be based upon familiarity, whereas the latter task requires the recollection of contextual details (Yonelinas, 2001). For example, recognising that you have met someone before but not being able to remember anything else would be consistent with the process of familiarity, whereas remembering their name or where you know them from would require recollection. Many experiments have been conducted to determine whether the deficit that individuals with schizophrenia exhibit in memory performance is a result of impairments in recollection and/or familiarity. Across a number of different paradigms a fairly consistent finding has been that individuals with schizophrenia have impairments in

recollection, but it is less clear whether they are impaired on familiarity judgements (Anselmetti et al., 2007; Moritz et al., 2003; but also see Weiss et al., 2008). A recent paper conducted a quantitative review of studies on this issue, accounting for methodological differences between tasks (Libby et al., 2013). They found deficits in both processes in this groups, but those in familiarity were more variable and smaller in size.

Recollection of contextual information can be delineated further into three different judgement types (Source-Monitoring Framework; Johnson et al., 1993): i) reality monitoring, which is the discrimination between internal and external sources of information, e.g. did I lock the door or did someone else do it?; ii) internal source monitoring, which involves distinguishing memories from two internal sources, e.g. did I send that email or just think about it?; and iii) external source monitoring which requires differentiating between different external sources, such as whether Jane or Grace told you an important fact.

A great deal of research has focussed on reality monitoring because it has been proposed that it may play a role in the pathogenesis of some of the positive symptoms of schizophrenia, such as hallucinations and delusions (Bentall et al., 1991; Frith, 1992; Frith and Done, 1988; Rankin and O'Carroll, 1995). Studies which have examined this capacity have typically involved presenting participants with either a complete sentence or one where they need to fill in the blank. In the test phase participants need to indicate whether they generated the word, it was given to them or is new (Vinogradov et al., 1997). There is now substantial evidence to suggest that people with schizophrenia have deficits in reality monitoring and, in particular, that they misattribute self-generated events to an external source (Johns et al., 2001; Keefe et al., 2002; Vinogradov et al., 2008). As anticipated, many of these studies found the deficit to be linked

to the positive symptoms (Brébion et al., 2000, 2002). However other researchers have found poor reality monitoring to be associated with negative symptoms (Brébion et al., 2002; Moritz et al., 2003), thought disorder (Nienow and Docherty, 2004), and a lack of association with clinical symptoms has also been reported (Henquet et al., 2005).

Moreover, more recently internal source monitoring has also been examined because the distinction between imagination and reality is often blurred in schizophrenia (Brébion et al., 2008; Mintz and Alpert, 1972). A wide variety of source monitoring tasks have been utilised to study the performance of patients with schizophrenia. For example, Gawęda et al. (2012) asked patients to either imagine or actually perform an action and found that they confused the source of these actions in a subsequent test phase.

A complementary strategy which other researchers have taken is to adopt a 'continuum approach' to psychosis (Claridge, 1997; Johns and Van Os, 2001; Van Os, et al., 2000, 2009). According to this view many of the symptoms seen in schizophrenia, such as paranoid ideation and hearing voices, can also be found in the general population; albeit to a milder or attenuated degree which would normally cause much less distress to the experiencing individual (Freeman et al., 2008; Johns et al., 2014). This continuum of personality characteristics and experiences is known as schizotypy. Action tasks have also been used in healthy volunteers and performance on them related to schizotypal traits. Consistent with the findings in patients with schizophrenia, deficits have been found in an internal source monitoring action task in individuals who have high proneness to hallucinations (Collignon et al., 2005) and those high in schizotypy (Peters et al., 2007).

The aim of the current study was to provide a more detailed and integrated understanding of source memory and its relationship to schizotypy in a large sample of healthy volunteers. The first issue we wished to examine was whether individuals high in schizotypy would display deficits in familiarity. On the basis of the review by Libby et al. (2013) it would be anticipated that a deficit in discriminating old from new items would be seen in those high in schizotypal traits. However, research findings on this issue have been mixed: Peters et al. (2007) found evidence for a deficit, whereas Collignon et al. (2005) did not. Next, we investigated source memory by assessing in the same participants reality monitoring and internal source monitoring. Previous work reported only deficits in internal source monitoring but not in reality monitoring (Collignon et al., 2005). This is surprising given the wealth of work highlighting problems in reality monitoring in schizophrenia (Johns et al., 2001; Keefe et al., 2002; Vinogradov et al., 2008). Therefore, we wished to examine whether individuals scoring high on schizotypy would have a deficit in both of these types of memory.

It has been argued by some researchers that the generalisability of word based paradigms to real-world situations is limited (Henquet et al., 2005; Parks, 1997) and that action based tasks might be a more naturalistic method of examining source memory. However no study has given participants these two types of tasks and assessed whether they both lead to the same findings. Therefore in this study participants completed two source memory tasks: one where a word needed to be generated (e.g. Fish and ?) and an action based task (e.g. nod your head). In both of these tasks participants needed to indicate at test whether the action was i) performed, ii) imagined, iii) performed by the experimenter, or iv) was new. We hypothesised that source memory deficits would be related to the positive dimension of schizotypy and so focussed primarily on this dimension, due to the findings of previous studies in this area (e.g. Brébion et al., 2000, 2002; Collignon et al., 2005; Peters et al., 2007).

2. Methods

2.1. Participants

One hundred and ten individuals took part in this study for payment or course credit. All participants were aged between 18-35 years, reported no diagnosis of any psychiatric disorder, were not currently taking psychotropic medication or illicit substances and possessed a high level of fluency in English. Eight participants were excluded from the study because their performance on the memory task(s) failed to exceed a threshold of 0.1 above chance i.e. less than 0.1 for corrected recognition and source accuracy of less than 0.43. Thus 102 participants (mean age 22.30 years, 80 females) were included in the study. Ethical approval was received for the study from institutional review, and all participants provided informed consent to take part.

2.2 Materials and procedure

Participants completed two memory tasks as part of a larger battery (there were no other memory tasks). The order of completion of the tasks was fixed across participants. The whole testing session took a maximum of two hours and participants were all tested individually.

2.2.1. Memory tasks

The action task involved one study-test block separated by 100 minutes. At study participants were asked to sit in a neutral position (arms and legs uncrossed) at a table opposite the experimenter. On the table were objects needed to complete some of the actions and a stack of cards with an action printed on it and above this who should complete it (Participant Perform, Participant Imagine, Experimenter Perform). Each card was turned over by the experimenter

one at a time and the participant/experimenter was encouraged to complete the action in a timely manner (usually a maximum of 6 seconds). There were 75 actions with an equal number in each action condition. Approximately half required everyday objects (e.g. stretch the rubber band, staple pieces of paper together, draw a line with the ruler) and the others were actions without using objects (e.g. nod your head, stand up and sit down, look backwards). The majority of these actions were taken from Collignon et al. (2005). An additional 12 actions were used as practice trials at the start of the study and test phases. All objects were removed prior to the test phase. Here all actions presented in the study phase were randomly intermixed with 25 new actions. The action was presented on a computer screen for 2000ms. Participants were asked to recall whether they performed the action in the study phase (Participant Perform, PP), did they imagine completing the action (Participant Imagine, PI), whether they watched the experimenter perform the action (Experimenter Perform, EP) or whether the action was New.

The word task also had one study-test block but with an interval of 45 minutes. It was completed on a computer. In the study phase 72 widely known but incomplete word pairs were presented in the centre of the display one at a time, e.g. Mum and ?, Bread and ? (most were taken from Simons et al., 2008) with the condition displayed directly above the incomplete word pairs. In the Participant Perform condition the participant generated the second word and said it out loud, or they imagined the second word (Participant Imagine condition) or listened to the experimenter complete the word pair (Experimenter Perform condition). After the act had been performed the participant needed to press a key to indicate which condition had just been completed. This terminated the trial and the next one commenced. An additional 12 word pairs were used as practice trials at the start of the study and test phases. Participants were asked to complete the word pairs to create a rich encoding context and to produce comparable

levels of performance between the two source tasks. In the test phase all actions presented in the study phase were randomly intermixed with 24 new actions. The first word of the pair was presented until the participant made a response. Only the first word of the pair was presented because occasionally participants generate a different second word to what would normally be expected. The discrimination at test was the same as in the action task test phase. For both memory tests participants were encouraged to respond as quickly but as accurately as they could and actions/word pairs were counterbalanced across conditions.

2.2.2. Measurement of schizotypy

The Oxford-Liverpool Inventory of Feelings and Experiences (O-LIFE; Mason et al., 1995) has four dimensions: unusual experiences, which indexes experiences akin to hallucinations and delusions; introvertive anhedonia, which describes a lack of pleasure in social or physical activities; cognitive disorganisation, which taps distractibility and disorganisation; and impulsive nonconformity which describes reckless and antisocial behaviour. There has been evidence which questions whether impulsive nonconformity is a meaningful schizotypy construct, so this dimension will not be considered further (Cochrane et al., 2010). The mean schizotypy scores obtained were as follows (standard deviations in parentheses): unusual experiences, 7.31 (5.83); introvertive anhedonia, 5.05 (4.52); and cognitive disorganisation, 12.31 (5.83)¹.

3. Results

¹ The 8 participants who were excluded had mean schizotypy scores as follows (standard deviations in parentheses): unusual experiences, 4.57 (3.99); introvertive anhedonia, 10.71 (5.44); and cognitive disorganisation, 6.29 (7.99). Including these participants in the main analysis did not alter the patterns of correlations.

As most of the data from the memory tasks and the unusual experiences dimension were not normally distributed (Kolmogorov-Smirnov, $ps < 0.01$) non-parametric tests were used in analyses i.e. Spearman's rho correlations (ρ). Alpha was set at 0.05 and all analyses were two-tailed. The descriptive data from the memory tasks can be seen in Table 1.

	Action Task	Word Pair Task
Hits	0.79 (0.10)	0.75 (0.11)
False Alarms	0.20 (0.17)	0.22 (0.18)
Corrected Recognition	0.59 (0.18)	0.54 (0.17)
Source Accuracy	0.81 (0.10)	0.75 (0.10)

Table 1. Mean proportions with standard deviations in parentheses for each of the memory tasks.

3.1. Action memory task

Initially data were examined in terms of the proportion of actions correctly recognised as old (Hits) and the new items falsely identified as old (False Alarms). From these data a corrected recognition score can be calculated (Hits – False Alarms; Snodgrass and Corwin, 1988) which gives an index of a participant's ability to discriminate old from new items, see Table 1. A significant negative correlation was found between the corrected recognition score and the unusual experiences dimension of schizotypy [$\rho(100) = -0.28, p = 0.004$].

A measure of overall source accuracy was calculated as the total number of items correctly assigned to Participant Perform, Participant Imagine and Experimenter Perform sources

divided by the number of Participant Perform, Participant Imagine and Experimenter Perform items correctly identified as old (regardless of whether the source judgment was correct). There was a negative correlation between source accuracy and scores on the unusual experiences dimension, $\rho(100) = -0.21, p = 0.034$. Given that source errors on this task could be due to internal source monitoring i.e. confusing Participant Imagine with Participant Perform and vice versa; or reality monitoring i.e. confusing Participant Perform/Imagine with Experimenter Perform and vice versa, these were assessed separately. Figure 1 displays the number of internal source monitoring and reality monitoring errors, which correspond to the black and white bars, respectively. The notation used in the figure and below is that the first abbreviation corresponds to the actual source and the one after is the participant's memory judgement e.g. PP/PI would be an item that the participant performed but which they thought they had imagined. A significant relationship was found between unusual experiences and total number of internal source memory errors (the sum of errors in PP/PI and PI/PP conditions, see Figure 1), $\rho(100) = 0.22, p = 0.03$.

Moreover, there was also a significant positive correlation between unusual experiences and the overall number of reality monitoring errors (the sum of errors in PP/EP, PI/EP, EP/PP, and ER/PI conditions, see Figure 1), $\rho(100) = 0.24, p = 0.014$. There is a wealth of evidence demonstrating that reality monitoring problems in schizophrenia are in the direction of misattributing self-generated events to an external source i.e. externalising (e.g. Vinogradov et al., 1997, 2008). Therefore two additional correlations were conducted separately for two components of the reality monitoring score. There was a significant relationship between unusual experiences and errors in attributing an action that the participant performed to the experimenter (PP/EP), $\rho(100) = 0.27, p = 0.005$; but we did not find the same relationship for imagined actions (PI/EP), $\rho(100) = 0.13, p = 0.19$.

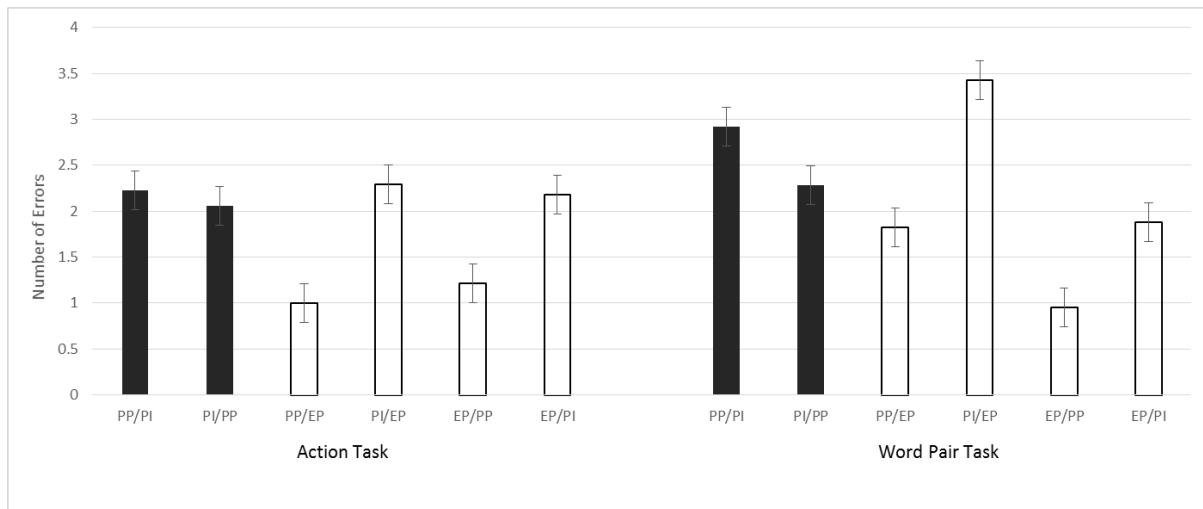


Figure 1. The mean number of errors produced in each memory task (action on the left, word pairs on the right) with error bars (\pm SEM). Internal source monitoring errors are in the black bars and reality monitoring errors in the white bars. Abbreviations are as follows: PP (Participant Perform), PI (Participant Imagine), and EP (Experimenter Perform). The first abbreviation is the actual source of the event and the second one is what the participant stated.

3.2. Word pair task

We analysed this task within the same framework as described above for the action task. There were no significant correlations between unusual experiences and corrected recognition score [$\rho(100) = -0.02, p = 0.81$] or overall source memory accuracy [$\rho(100) = -0.07, p = 0.48$]. There were also no significant associations with number of internal source memory errors [$\rho(100) = 0.15, p = 0.14$] or reality monitoring errors [$\rho(100) = 0.19, p = 0.06$]. No significant relationships were found between unusual experiences and externalising errors ($ps > 0.88$).

3.3. Other schizotypy dimensions

Although the focus of this study was on the unusual experiences dimension correlations were also conducted with the introvertive anhedonia and cognitive disorganisation dimensions of schizotypy to determine the specificity of the relationship. As can be seen from Table 2 there were no relationships with the introvertive anhedonia dimension but some with cognitive disorganisation. This might have resulted from the high degree of correlation between unusual experiences and cognitive disorganisation ($\rho(100) = 0.65, p < 0.001$).

	Action Task		Word Pair Task	
	RM	ISM	RM	ISM
Unusual Experiences	0.24*	0.22*	0.19	0.15
Introvertive Anhedonia	0.06	0.07	-0.05	-0.01
Cognitive Disorganisation	0.14	0.22*	0.24*	0.13

Table 2. Spearman’s rho correlation matrix showing coefficients between reality monitoring (RM) and internal source monitoring errors (ISM) and dimensions of the O-LIFE.

4. Discussion

The aim of this study was to provide a more detailed understanding of the nature of the memory deficits associated with the schizotypy continuum. A significant negative correlation was found between the positive dimension of schizotypy (unusual experiences) and the corrected recognition score, indicating that participants high in unusual experiences exhibited poorer old-

new discrimination. Furthermore, they were also more inclined to make errors in determining the source of the memory, even in those items correctly recalled as old. In particular, there was a positive correlation between unusual experiences and internal source monitoring errors; those participants with high scores on this dimension confused whether they had performed an act or just imagined doing it. There was also a positive relationship between the same schizotypy dimension and reality monitoring errors i.e. in determining whether the act originated from the participant (performed or imagined) or the experimenter. Consistent with previous research there was an externalising bias, such that those high in unusual experiences tended to attribute actions they had physically performed themselves to the experimenter (PP/EP errors). However we did not find the same pattern of results for those acts the participant had just imagined (PI/EP errors). All of these relationships were only found in the action based task.

It is widely acknowledged that individuals with schizophrenia have deficits in recollection but findings on familiarity have been less consistent (Achim and Lepage, 2003; Libby et al., 2013; Ranganath et al., 2008). This is also true in schizotypy work, for example Peters et al. (2007) found evidence for deficits in old-new recognition, whereas Collignon et al. (2005) did not. It is possible that the particular measure of schizotypy used may be important. Collignon et al. (2005) used a measure that specifically assessed hallucinatory proneness (Launay and Slade Hallucinations Scale; Launay and Slade, 1981), whereas Peters et al. (2007) used the Schizotypal Personality Questionnaire (Claridge and Broks, 1984) and the current study used the unusual experiences dimension of the O-LIFE (Mason et al., 1995). These latter questionnaires index positive symptoms more widely and, for example, also encompass distortions in sensory experiences and psychotic-like delusional ideation. Thus it would appear to be the case that difficulties in making old-new discriminations are related to positive symptom-like experiences more broadly, or a specific aspect of these, but not hallucinations.

The finding of more internal source errors being related to high unusual experiences is consistent with the work of Collignon et al. (2005) and Peters et al. (2007). However, we have extended this finding to include reality monitoring errors being associated with the positive dimension of schizotypy as well, which was not found by Collignon et al. (2005). There are methodological differences between the current study and that by Collignon et al. (2005) which might explain this. Firstly, in the latter study there were more conditions for participants to differentiate between; they had the added conditions of the participant imagining the experimenter performing the action and the experimenter verbalising the action (but not performing it). Secondly, the way the test response was made was quite different with Collignon et al. (2005) requiring participants to make a four-stage response at test compared to just one-stage in this study. Finally, their participants made very few errors (mean of < 1) in some of the conditions, particularly those relevant to reality monitoring, such as participant performed and experimenter performed. These floor effects might have precluded relationships being found with hallucinatory proneness by Collignon et al. (2005).

The Source-Monitoring Framework (Johnson et al., 1993) offers a useful way of understanding the errors that people make when trying to retrieve the source of a piece of information. According to this framework there are no specific memory ‘tags’ or markers on events indicating where they originated. Instead, various attributes of the memory encoded at the time it happened later serve as the basis for making the decision as to its origin. These attributes include qualities like perceptual, semantic, spatial, temporal, sensorimotor and affective details and records of cognitive operations that created them (Johnson et al., 1993; Johnson and Raye, 1981). For example, a memory that is rich in perceptual detail, with substantial contextual information but a lack of consciously remembered details of the cognitive operations which

might have generated it would likely be judged as having been perceived, whereas the opposite profile would be associated with imagined experiences. Therefore, anything which increases the similarity of these memory attributes from different sources will decrease source accuracy. For example, if imagination was particularly vivid and detailed this could be confused with an event that was actually experienced. This is pertinent because there has been a wealth of research demonstrating that people with schizophrenia (Mintz and Alpert, 1972; Rasmussen and Parnas, 2015) and those high in schizotypy (Currie, 2000; Winfield and Kamboj, 2010) tend to have more active and vibrant imaginations (Oertel et al., 2009; Sack et al., 2005). In future research it might be useful to include a measure of how well participants feel they are able to imagine completing acts as this could mediate the relationship between schizotypy/schizophrenia and memory performance.

The novel finding from this study is that significant relationships were found between memory measures and unusual experiences in the action task but not the word pair one. The same direction of result was found in the word pair task, between schizotypy and internal and reality monitoring errors, but these did not reach statistical significance. This suggests that the action task might have greater utility in examining relationships with symptoms or experiences. Due to the well-known enactment effect (Cohen, 1989; Madan and Singhal, 2012) the study-test interval for the action task was longer (100 minutes) than for the word pair task (45 minutes). This was done to ensure that performance was not at ceiling in the action task and both tasks were broadly comparable in terms of participant performance. As can be seen from Figure 1 the profile of errors between tasks is similar. Moreover, the errors also exhibit a similar profile as to what might be anticipated. For example, there is less overall confusion between Participant Perform and Experimenter Perform than between Participant Imagine and Experimenter Perform. This is likely due to the fact that when the participant performs the act

there is movement as well as afferent feedback but this is not present when they imagine the act or watch the experimenter perform it, which makes the former two conditions more distinctive than the latter two.

The action memory task has been used in a number of studies both in schizophrenia and schizotypy (Collignon et al., 2005; Gawęda et al., 2012; Peters et al., 2007) and there is substantial evidence that people with schizophrenia have abnormalities in the awareness of motor actions (Blakemore et al., 2002; Frith et al., 2000). Computational models of motor control have been developed and these have been applied to schizophrenia, particularly the forward model (Wolpert, 1997). According to this account, whenever a motor command is initiated a parallel efference copy is also generated (Von Holst, 1954). This can be used to make predictions about the sensory consequences of an action, which can be compared with the actual sensory feedback of a movement. If the predicted action and the sensory input match then the action would be considered to be self-generated.

In schizophrenia it is thought that there may be deficits in the generation of the efference copy and/or in the comparison between predicted and actual action which results in certain positive symptoms (Frith, 2005, 2012; Synofzik et al., 2010). Importantly, this would produce externalising errors, which have been found in a number of studies (for a review, see Brookwell et al., 2013), because a lack of efference copy or a mismatch between prediction and reality would suggest an external source of a change in the state of one's body (e.g. position of a limb). In the current study we only found a relationship between schizotypy and one type of externalising error: an act physically performed by the participant being attributed to the experimenter and not when the act had only been imagined by the participant. One potential explanation for this is that perhaps the forward model, and the hypothesised deficits that

individuals within the schizophrenia spectrum have with aspects of this, can only be applied to overt actions and not internal mental events such as thinking and imagining. Indeed, this model was adapted and used by Frith and colleagues to explain such phenomena as delusions of control and anarchic hand (e.g. Blakemore and Frith, 2003; Frith et al., 2000). A number of arguments have been raised about the possibility of extending this model to covert forms of behaviour, such as thinking. Gallagher (2004) argues that using the forward model makes sense for overt actions because we need to know if our actions are internally or externally caused (i.e. did I move my arm or did someone else?) and if our action is not going to achieve its goal this needs to be known in advance so that adjustments can be made. However, these reasons do not make sense when applied to thoughts. All our thoughts are internally generated, so there is never any possibility of having to work out whether it was you who thought something or someone else, in normal circumstances. Thus there is currently a great deal of debate around whether Frith's forward model can be applied to internal mental states (for other work on this issue see Seal et al., 2004; Stephens and Graham, 2000; Vicente, 2014).

To conclude, our results demonstrate that there is a negative relationship between scores on the positive dimension of schizotypy, unusual experiences, and the ability to correctly identify the source of memory information. Furthermore, our correlational analyses indicated that individuals with high scores on unusual experiences have deficits in distinguishing between actions they performed versus i) imagined and ii) those the experimenter performed. These relationships were only found in the action based task and further research is now needed to determine if a similar set of results would be found in people with schizophrenia.

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