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Source monitoring deficits in patients with schizophrenia; a multinomial modelling analysis

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ABSTRACT

Background. Schizophrenia patients, particularly those with symptoms such as thought insertion, passivity experiences and hallucinations, may share an underlying cognitive deficit in monitoring the generation of their own thoughts. This deficit, which has been referred to as 'autonoetic agnosia', may result in the conclusion that self-generated thoughts come from an external source. Previous work supports this notion, yet the statistical approaches that have been used have not enabled a distinction between specific deficits suggesting autonoetic agnosia and more general cognitive dysfunction.

Methods. Autonoetic agnosia was assessed using source-monitoring paradigms in 28 patients with schizophrenia and 19 control subjects. Multinomial model analyses, which allow the distinction between deficits in recognizing information, remembering its source, and response biases, were applied to the data.

Results. Schizophrenia patients were impaired in discriminating between words that came from two external sources, from two internal sources, and one internal and one external source. In a condition requiring subjects to distinguish between words they had heard from those they had imagined hearing, when schizophrenic patients did not remember the source of the information, they showed a stronger bias than controls to report that it had come from an external source.

Conclusions. The application of multinomial models to source monitoring data suggests that schizophrenia patients have source monitoring deficits that are not limited to the distinction between internally-generated and externally-perceived information. However, when schizophrenia patients do not remember the source of information, they may be more likely than controls to report that it came from an external source.

INTRODUCTION

Schizophrenia is characterized by a variety of symptom domains, including positive, negative, and mood symptoms as well as adaptive and cognitive dysfunction. While the cognitive deficits of schizophrenia have been clearly described as having strong relations with negative symptoms (Addington *et al*. 1991; Gold & Harvey, 1993; Davidson *et al*. 1995) and adaptive dysfunction (Green, 1996), the relations between cognitive deficits and positive, or psychotic, symptoms are poorly understood. It has been generally believed that performance on standard neuropsychological tests is not strongly correlated with severity of psychotic symptoms in patients with schizophrenia (Gold & Harvey, 1993; Goldberg *et al*. 1993). However, these studies have generally used tests designed to measure cognitive functions in individuals with brain injury following normal pre-morbid histories; these tests may not be appropriate for the study of the specific cognitive deficits associated with specific psychotic symptoms in schizophrenia.

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Several of the psychotic symptoms of schizophrenia suggest that patients with this disorder are unable to monitor the initiation of certain types of self-generated thought (Frith & Done, 1989; Frith, 1992). These symptoms include thought insertion; passivity experiences such as made actions, made impulses, and made feelings; delusions of control; and many hallucinatory experiences. Patients with these symptoms may share a common underlying cognitive deficit in monitoring the generation of their own thoughts, which then results in their conclusion that these self-generated thoughts came from an external source. This deficit has been referred to as 'autonoetic agnosia', which literally means 'the inability to identify self-generated mental events' (Keefe, 1998).

Autonoetic agnosia has been measured with various experimental cognitive tests, including tests of source monitoring (Hashtroudi *et al.* 1989), reality monitoring (Johnson & Raye, 1981), and 'generation-effect' paradigms (Slamecka & Graf, 1978; Hirshman & Bjork, 1988). Source monitoring refers to individuals' ability to remember the source of information that they have obtained. Reality monitoring is a specific kind of source monitoring in which individuals have to remember if information originated from an external source or was self-generated (internal source). For example, a reality monitoring task might test an individual's ability to remember whether an event actually occurred or whether it was only imagined (Johnson *et al.* 1993). The generation-effect refers to the tendency of normal individuals to remember self-generated information better than information that comes from external sources.

These paradigms have been used to suggest that autonoetic agnosia is present in patients with schizophrenia, and that it may be associated with specific symptoms. Performance on reality monitoring tests has been found to be impaired in patients with schizophrenia and is associated with formal thought disorder in patients with schizophrenia but not in patients with mania (Harvey, 1985). Schizophrenia patients make more errors than normal controls in remembering whether words came from a list that they have actually read aloud or from a list that they have read silently to themselves and imagined themselves saying (Harvey, 1985; Harvey *et al.* 1988; Tanenbaum & Harvey, 1988). While normal controls also make errors on this task, most of their errors are the result of the belief that they only imagined themselves saying words that they actually said (Raye & Johnson, 1980). In contrast, schizophrenia patients are more likely to make the opposite error: they believe they said words that they only imagined themselves saying (Harvey *et al.* 1988), suggesting that they mistake internal representations or images for actual events in the external world.

Schizophrenia patients' ability to monitor the source of information may be specifically related to whether they themselves are a possible source of the information. Psychotic patients with hallucinations were found to be more likely than psychotic non-hallucinators to misattribute to the experimenter items they had generated themselves (Bentall *et al.* 1991). Among a group of schizophrenia patients, those with Schneiderian experiences of alien control of their thoughts and actions are significantly less likely to make error corrections in the absence of visual feedback, suggesting that these patients may have particular difficulties monitoring their responses (Frith & Done, 1989). In addition, increased self-monitoring load may be associated with severity of source-monitoring deficits in patients with experiences of alien control (Mlakar *et al.* 1994; Stirling *et al.* 1998). These data suggest that some schizophrenic patients manifest specific deficits in distinguishing between internal and external sources of information. These deficits may be particularly severe in patients with hallucinations and specific types of Schneiderian delusions.

One of the major limitations of this area of study has been that many findings are difficult to interpret due to the broad range of cognitive deficits found in patients with schizophrenia. Recent data suggest that schizophrenia patients with hallucinations only show source monitoring deficits compared to schizophrenia patients without hallucinations if IQ and verbal memory deficits are not used as covariates (Seal *et al.* 1997). In addition, in a study of schizophrenia patients and normal controls matched for demographic variables, source monitoring performance was dependent upon IQ only in the subjects with schizophrenia; however, this relationship was not present in analyses that included only schizophrenia patients with IQs in the normal range (Vinogradov *et al.* 1997). In contrast, in a study of schizophrenia patients monitoring their own drawings, patients performed significantly worse than normal controls even when IQ, visual memory and vigilance performance were used as covariates (Stirling *et al*. 1998).

A second limitation of previous work has been the measures and statistical approaches that have been used. In the typical source-monitoring paradigms that have been employed in schizophrenia research (Harvey, 1985; Vinogradov *et al*. 1997), subjects obtain information from different sources. In a later source-monitoring test, they are presented with items of information that they had incurred during the acquisition phase of the study as well as with new items. Subjects are instructed to indicate if an item is old or new, and if they believe it is old, from which source it originated. Subjects' responses in this paradigm depend on their ability to distinguish old items from new ones (item recognition), on their memory for the source, and on different forms of response bias. For example, subjects might have a bias toward responding 'new item' when they are not sure, or they might have a bias toward attributing items to one particular source over the others. These traditional source memory measures confound source memory with item recognition (Murnane & Bayen, 1996, 1998) and do not account for response biases. Thus, they are not accurate assessments of source memory except in the unlikely case that the groups being compared are equal with regard to item recognition and response biases (Batchelder & Riefer, 1990), which is particularly unlikely in studies involving patients with schizophrenia. Fortunately, these measurement problems have been solved with the advent of multinomial processing tree models of source monitoring.

Multinomial processing tree models (Riefer & Batchelder, 1988) are a group of mathematical models that assess different aspects of cognitive functioning, such as item recognition and source memory. Specific deficits can be determined by calculating the probabilities that patient groups fail to utilize the specific cognitive functions represented in the model. These model parameters can be estimated from raw data via maximum-likelihood parameter estimation. Multinomial models have been used with increasing frequency in recent years and are available for a wide variety of cognitive tasks (Batchelder & Riefer, 1980; Bayen & Murnane, 1996; Bender *et al*. 1996; Erdfelder & Buchner, 1998). The models we used in our study are specifically designed for the analysis of data from standard source-monitoring tasks and provide separate and independent measures of item recognition, source memory, and response biases. Thus, the models used in this study can distinguish between performance deficits due to general memory impairment and those due to specific biases.

The aim of this study is to apply these multinomial models to determine whether schizophrenic patients, and, more specifically, schizophrenic patients with specific target symptoms, demonstrate autonoetic agnosia as measured by four tests of source monitoring and reality monitoring. These tests vary in the extent to which the subject must discriminate between internal and external sources of information: discriminating between words that were presented by a male or female voice on audio tape (external *v*. external); discriminating between words that the subject heard the experimenter say or imagined the experimenter saying (external *v*. internal); discriminating between words that the subject said or imagined him- or herself saying (internal-perceived *v*. internal-imagined); and discriminating between words that the subject imagined him or herself saying or imagined the experimenter saying (internal-imagined *v*. internal-imagined). The target symptoms of interest in this study are those that appear most likely to be manifestations of an underlying cognitive deficit of autonoetic agnosia: thought insertion, made impulses, made feelings, made thoughts, delusions of control, voices arguing and voices commenting.

The hypotheses of this study are: (1) schizophrenic patients, particularly patients with the 'target' symptoms listed above, will demonstrate poorer source monitoring than normal controls as evidenced by their impaired ability to remember the source of information; (2) these source monitoring deficits will be related to the extent to which the subject needs to discriminate internally-generated or imagined information from externally-generated or perceived information (thus, schizophrenic patients should perform normally when discriminating two sources of perceived information; perform worse than normal controls when discriminating events they imagine from those they execute or observe; and perform normally in discriminating events they imagine themselves performing from those they imagine being performed by an outside agency) – patients with the 'target' symptoms will perform particularly poorly when discriminating events they imagined from those they executed or observed; (3) schizophrenia patients, particularly patients with the target symptoms, will demonstrate response biases toward reporting that they executed or observed events that they actually had imagined (for example, when they do not remember whether they heard a word or imagined hearing it, they will demonstrate a bias toward reporting that they heard it).

METHOD

Subjects

Twenty-eight patients with DSM-IV (APA, 1994) schizophrenia (24 males and four females) from John Umstead Hospital of Duke University Medical Center were entered into the study. Patients were selected if they did not have an organic brain disorder, a pervasive developmental disorder, or a history of substance dependence. Each patient was required to have a minimum of 8 years of education. Seventeen patients were off medication for a mean of 21·9 days (S.D. = 16·9) and 11 were stable on medication. Patients were participants on a research ward that was specifically designed to handle acutely psychotic individuals. In many cases, patients had withdrawn medication themselves prior to entry onto the research ward. Thus, they were in the process of being evaluated to determine whether they did require medication, and were normally medicated immediately following this evaluation. Our research protocols were conducted during this drug-free evaluation period. Of the medicated group, one patient was on a benzodiazepine; one was on a benzodiazepine, a typical antipsychotic, and an anticholinergic; six were on typical antipsychotics; one was on both a typical and an atypical antipsychotic, and two were on typical antipsychotics and anticholinergics.

Nineteen control subjects (nine males and 10 females) were either hospital employees recruited through bulletin board advertisements and word-of-mouth or community residents recruited through newspaper advertisements. A clinical psychologist or a trained research assistant screened all control subjects using the Schedule for Affective Disorders and Schizophrenia-Lifetime Version (Endicott & Spitzer, 1978) and an additional screening questionnaire for assessing odd cluster and borderline personality symptoms in non-psychiatric populations (Dr Jerry M. Silverman and Dr Robert L. Trestman, unpublished questionnaire, 15 June 1991). The 19 control subjects did not have any psychopathology or history of psychiatric problems in their family. All subjects gave written, informed consent. The schizophrenia group did not differ from the normal controls in age, but the control group had significantly more years of education, $P < 0{\cdot}05$ (see Table 1).

Table 1. *Demographic profile of all schizophrenia patients and the control group*

	Schizophrenia patients	Controls
Number	28	19
Age in years	37·2 (9·2)	34·6 (8·0)
Education in years	12·7 (1·9)*	14·3 (6·7)

Means are presented followed by standard deviations in parentheses.

* The schizophrenia group had significantly fewer years of education, $P < 0{\cdot}05$.

A clinical psychologist blind to autonoetic agnosia results assessed Schneiderian first-rank schizophrenia symptoms (Schneider, 1959) in all patients. Schizophrenia patients were divided into two groups based upon the presence of any of the following symptoms: thought insertion, voices arguing, voices commenting, made feelings, made acts and made impulses. Individuals who had at least one of these symptoms (the 'target symptom group') were compared to individuals with none of these symptoms (the 'non-target symptom group'). The target and non-target symptoms groups did not differ in terms of age, education, number of hospitalizations, or number of months in the hospital over a lifetime; however, individuals who were not on medications in the target group had been off medication for a significantly fewer number of days, $P < 0{\cdot}05$ (see Table 2). Schizophrenia patients experiencing their first psychotic episode were not included in the 'number

Table 2. *Clinical and demographic information on target symptom and non-target symptom schizophrenia groups*

	Schizophrenia patients	
	Target symptoms	Non-target symptoms
Number	18	10
Age in years	36·6 (10·5)	39·1 (7·0)
Education in years	12·7 (1·7)	12·8 (2·3)
Illness duration in years	10·1 (7·7)	14·5 (8·1)
Number on medication	5	6
Number off medication	13	4
Number of days since last medication	15·0 (9·4)*	35·8 (20·9)
Number of hospitalizations	4·6 (3·3)	6·6 (2·6)
Number of months hospitalized in lifetime	6·2 (5·5)	10·1 (3·8)

Means are presented followed by standard deviations in parentheses.

* The target symptoms group had been off medication for significantly fewer days, $P < 0·05$.

of days since last medication category' since they had never received medication. Two first-episode schizophrenia patients were in the target symptom group and none were in the non-target symptom group.

Source monitoring tasks

In each one of the four source monitoring tasks, words were presented from one of two sources (Source A, or Source B). At test, words from the two sources were presented intermixed with foils (New words). The four tasks were the following: (1) Say–Imagine, subjects distinguished words they had spoken aloud from words they had imagined themselves saying; (2) Hear–Imagine, subjects distinguished words they had heard the experimenter say from words they had imagined the experimenter saying; (2) Imagine Self–Imagine Other, subjects distinguished words they had imagined themselves saying from words they had imagined the experimenter saying; and (4) Female–Male, subjects distinguished between audiotaped words that had been presented by a male or female voice.

Materials

The words used in the source monitoring tasks were randomly chosen from a list of the 500 words most commonly used in the English language (Thorndike & Lorge, 1944), and balanced across source conditions based upon imaginability and number of features (Toglia & Battig, 1978). Two parallel tests were constructed for each task.

Procedure

Subjects were administered two versions of each of the four source monitoring tasks, as well as a battery of other cognitive and neuropsychological tests. One version of the source monitoring task and half of the cognitive battery were administered on the first testing day. The other version of the source monitoring tasks and the second half of the cognitive battery were administered on a second testing day. Testing sessions were usually on consecutive days with no more than 2 days between sessions. The patients' medication status did not change during the testing period. The source monitoring tasks were given at the beginning of the testing session in the following order: Say–Imagine, Hear–Imagine, Imagine Self–Imagine Other and Female–Male.

Prior to word presentation in each task, subjects were instructed to remember the words presented and their source. The words presented from Source A and Source B were counter-balanced across subjects, except in the Female–Male task. Source-A items and Source-B items alternated. Half of the subjects received a Source-A item first, the other half received a Source-B item first. There were a total of eight words from each source.

In the Say–Imagine Task, the experimenter showed the subject the 16 words, one at a time. Each word was presented for 3 s on a flashcard in 72-point type size. The experimenter then instructed the subject to respond according to the source condition. For 'say' words, the experimenter instructed the subject to 'say the word aloud', for 'imagine' words, the instruction was to 'imagine yourself saying the word'. Immediately after the word presentation, the experimenter gave the subject a test list that consisted of the 16 presented words plus eight foils in a random order that was the same for each subject. All words were typed on the same response sheet. The experimenter used a cover sheet so the subject could only see one word at a time. The subject had three response options ('said', 'imagined', or 'new'), and was instructed to circle the correct response.

In the Hear–Imagine task, the experimenter read the 'hear' words aloud. For the 'imagine' words, the experimenter instructed the subject to 'imagine me saying this word'. Otherwise, the procedure for the Hear–Imagine task was identical to the procedure of the Say–Imagine task.

In the Imagine Self–Imagine Other task, the experimenter instructed the subject to 'imagine yourself saying this word' or 'imagine me saying this word'. All other aspects of the procedure were the same as in the previous two tasks.

In the Female–Male task, words were presented by audiotape in either a male or female voice. The female voice on the audiotape was not the same as that of the female experimenter. the same audiotape was used for all subjects. At test, the subject decided if a word had been presented by the female voice, the male voice, or was new.

Each of the four tasks was preceded by practice. During practice, one word from each of the two sources was presented. Then, a list of three words (the two presented words and a new word) was presented and the subject had to indicate successfully the source of each word.

Statistical analyses

We used the two-high threshold multinomial model of source monitoring for all our data analyses. This model is described in detail in previous work (Bayen *et al*. 1996). Several identifiable submodels of the two-high-threshold model are available (see Bayen *et al*. 1996, Fig. 4). For each one of our four experimental tasks, we chose the submodel for data analyses based upon the following criteria: (1) goodness-of-fit based as indicated by the log-likelihood ratio statistic, G^2 (Riefer & Batchelder, 1988; Batchelder & Riefer, 1990); and (2) parsimony as defined by the least number of parameters required while maintaining goodness-of-fit. Parameter values were estimated from response frequencies (raw data may be obtained from the authors) via maximum-likelihood estimation (Hu & Batchelder, 1994).

RESULTS

Target symptoms *versus* non-target symptoms

Performance of schizophrenia patients with the target symptoms was indistinguishable from that of schizophrenia patients without those symptoms on the parameters of interest with one exception (see Table 3). Patients with the target symptoms were significantly poorer at distinguishing between items they had imagined themselves saying compared to items they imagined the experimenter saying. The following results describe the differences between the normal control group and entire schizophrenia group.

Female–Male

We chose Submodel 4 of the two-high threshold multinomial model of source monitoring (see Bayen *et al*. 1996) to analyse the data from schizophrenia patients and normal controls in the external source-monitoring task. In applying Model 4 we hypothesized that item recognition was the same for items that were presented by a female voice, items that were presented by a male voice, and new items ($D_1 = D_2 = D_3$). The model further assumes equal source memory for the two voices ($d_1 = d_2$). It also assumes that the probability of guessing a particular source is equal for recognized and unrecognized items ($a = g$). Model 4 has four parameters, one for the probability of item recognition (D), one for the probability of remembering the source (d), one for the probability of guessing that an unrecognized item is old (b), and one for the probability of guessing that an item was presented by the female source (g). Model 4 fit the external source-monitoring data well ($G^2(4) = 6{\cdot}08$), indicating that the assumptions of Model 4 were valid for these data.

The estimates for the model parameters that are of interest for testing our hypotheses are presented in Table 4. Significance tests indicated that the item recognition parameter D was lower for the schizophrenia group than for the normal group, $G^2(1) = 4{\cdot}83$. That is, patients with schizophrenia were significantly worse as compared to normal controls at recognizing words. The source memory parameter d was also lower for the schizophrenia group than for the control group, $G^2(1) = 8{\cdot}96$. That is, patients with schizophrenia had, in comparison to normals, difficulties remembering whether words had been presented by the male or female voice. Thus, the schizophrenia group had difficulties in external source monitoring. The schizophrenia group was not significantly different from the control group with regard to the g response bias

Table 3. *Parameter estimates for all four conditions: target symptom* v. *non-target symptom patients*

Condition	Model	Recognition (D)		Source memory (d)	Guess (g)
Female–Male	4				Female
Target symptom		0·28 (0·22–0·33)		0·19 (0·01–0·39)	0·50 (0·46–0·54)
Non-target		0·33 (0·25–0·40)		0·52 (0·28–0·76)	0·59 (0·52–0·65)
Say–Imagine	5b	Say/New Recognition (D13)	Imagine Recognition (D2)		Say
Target symptom		0·62 (0·56–0·67)	0·29 (0·16–0·42)	0·71 (0·56–0·80)	0·32 (0·25–0·38)
Non-target		0·58 (0·50–0·65)	0·54 (0·39–0·68)	0·67 (0·52–0·83)	0·44 (0·36–0·52)
	5c	Say Recognition (D1)	Imagine/New Recognition (D23)		Say
Target symptom		0·71 (0·65–0·77)	0·46 (0·40–0·52)	0·58 (0·49–0·68)	0·35 (0·29–0·41)
Non-target		0·60 (0·48–0·72)	0·56 (0·48–0·64)	0·65 (0·51–0·79)	0·45 (0·37–0·52)
Hear–Imagine Experimenter	5b	Hear/New Recognition (D13)	Imagine Recognition (D2)		Hear
Target symptom		0·40 (0·33–0·46)	0·19 (0·05–0·33)	0·63 (0·42–0·84)	0·39 (0·33–0·44)
Non-target		0·43 (0·35–0·51)	0·37 (0·24–0·50)	0·76 (0·55–0·96)	0·42 (0·34–0·50)
	5c	Hear Recognition (D1)	Imagine/New Recognition (D23)		Hear
Target symptom		0·47 (0·38–0·56)	0·31 (0·25–0·38)	0·49 (0·34–0·63)	0·40 (0·36–0·45)
Non-target		0·46 (0·33–0·59)	0·40 (0·31–0·48)	0·71 (0·51–0·90)	0·42 (0·34–0·50)
Imagine Self–Imagine Other	5b	Imagine Self/New Recognition (D13)	Imagine Other Recognition (D2)		Imagine Self
Target symptom		0·41 (0·35–0·47)	0·22 (0·08–0·35)	0·43 (0·23–0·63)	0·45 (0·41–0·50)
Non-target		0·44 (0·36–0·53)	0·36 (0·23–0·48)	0·73 (0·53–0·93)	0·48 (0·39–0·56)
	5c	Imagine Self Recognition (D1)	Imagine Other/New Recognition (D23)		Imagine Self
Target symptom		0·49 (0·39–0·58)	0·33 (0·26–0·39)	0·33 (0·19–0·47)	0·46 (0·42–0·51)
Non-target		0·48 (0·36–0·60)	0·39 (0·31–0·47)	0·67 (0·49–0·85)	0·48 (0·40–0·55)

95% confidence intervals are given in parentheses.

parameter. That is, both groups had similar probabilities of guessing that an item was presented by the female or male source (g and $l-g$, respectively). The probability of guessing that an unrecognized item was old (b) was not different between the groups.

For the data from the three other experimental tasks (Say–Imagine, Hear–Imagine experimenter, Imagine Self–Imagine Other) the most parsimonious models with adequate fit were Models 5b and 5c (Bayen *et al.* 1996). The $G^2(2)$ of the Models 5b and 5c are also listed in Table 3.

Models 5b and 5c each have five parameters: two for time recognition (D_{13} and D_2 in Model 5b; D_1 and D_{23} in Model 5c), one for source memory (d), one for guessing that an item is old (b), and one for guessing the source of an item (g). Both models postulate that the probability of remembering the two sources is equal ($d_1 = d_2$). Further, both models assume that the probability of guessing a particular source is equal for recognized and unrecognized items ($a = g$). The difference between Model 5b and Model 5c is that Model 5b postulates that the probability of knowing that a new item is new equals the probability of recognizing an item from Source A as old ($D_3 = D_1$), whereas Model 5c postulates that the probability of knowing that a new item is new equals the probability of recognizing an item from Source B as old ($D_3 = D_2$).

Say–Imagine

Analyses with Model 5b yielded a significant difference between normal controls and schizophrenia patients in the probability of correctly recognizing items the participant had said and new items. The item recognition parameter, D_{13}, indicated that compared to normal controls, schizophrenia patients had greater difficulty recognizing words that they had said and new words, $G^2(1) = 5{\cdot}80$ (see Table 4). Model 5b did not show any other statistically significant differences between groups.

Alternatively, Model 5c which also fit the data showed a significant difference between normal controls and schizophrenia patients in the source

Table 4. *Parameter estimates for all four conditions: schizophrenia patients* v. *normal controls*

Condition	Model	Recognition (*D*)		Source memory (*d*)	Guess (*g*)
Female–Male	4				Female
Normal controls		0·58* (0·53–0·62)		0·68* (0·58–0·77)	0·49 (0·44–0·55)
Schizophrenics		0·29 (0·25–0·34)		0·32 (0·16–0·47)	0·52 (0·49–0·56)
Say–Imagine	5b	Say/New Recognition (D13)	Imagine Recognition (D2)		Say
Normal controls		0·70* (0·65–0·75)	0·43 (0·33–0·52)	0·82 (0·73–0·90)	0·33 (0·25–0·41)
Schizophrenics		0·60 (0·56–0·65)	0·37 (0·28–0·47)	0·71 (0·61–0·80)	0·36 (0·31–0·41)
	5c	Say Recognition (D1)	Imagine/New Recognition (D23)		Say
Normal controls		0·74 (0·69–0·80)	0·53 (0·47–0·58)	0·74* (0·67–0·81)	0·37 (0·29–0·44)
Schizophrenics		0·68 (0·62–0·73)	0·49 (0·45–0·54)	0·60 (0·53–0·68)	0·38 (0·34–0·43)
Hear–Imagine Experimenter	5b	Hear/New Recognition (D13)	Imagine Recognition (D2)		Hear
Normal controls		0·52* (0·46–0·58)	0·39 (0·30–0·48)	0·80 (0·69–0·91)	0·29 (0·23–0·35)
Schizophrenics		0·41 (0·34–0·46)	0·26 (0·17–0·36)	0·67 (0·52–0·82)	0·40* (0·35–0·44)
	5c	Hear Recognition (D1)	Imagine/New Recognition (D23)		Hear
Normal controls		0·58 (0·50–0·66)	0·44* (0·38–0·50)	0·72 (0·62–0·83)	0·29 (0·23–0·35)
Schizophrenics		0·47 (0·39–0·55)	0·34 (0·29–0·39)	0·56 (0·45–0·68)	0·41* (0·37–0·45)
Imagine Self–Imagine Other	5b	Imagine Self/New Recognition (D13)	Imagine Other Recognition (D2)		Imagine Self
Normal controls		0·59* (0·54–0·65)	0·52* (0·43–0·62)	0·71 (0·61–0·82)	0·42 (0·35–0·48)
Schizophrenics		0·42 (0·37–0·47)	0·27 (0·17–0·36)	0·55 (0·41–0·69)	0·45 (0·41–0·50)
	5c	Imagine Self Recognition (D1)	Imagine Other/New Recognition (D23)		Imagine Self
Normal controls		0·62* (0·54–0·69)	0·56* (0·50–0·61)	0·68* (0·58–0·77)	0·42 (0·36–0·48)
Schizophrenics		49 (0·41–0·56)	0·35 (0·30–0·40)	0·46 (0·35–0·57)	0·46 (0·42–0·50)

* $P < 0{\cdot}05$.
95% confidence intervals are given in parentheses.

memory parameter d, $G^2(1) = 4{\cdot}82$. This difference indicated that schizophrenia patients were worse than normal controls at remembering the source of words. Since both models fit the data, it was not possible to determine whether the schizophrenia patients' poor performance was due to a difficulty in recognizing 'said' words and new words, or whether they had a more general deficit in discriminating between two different sources of information.

Hear–Imagine experimenter

As in the previous condition, both Models 5b and 5c fit the data (see Table 4). For both models, analyses yielded a significant difference in guessing parameter g between the two participant groups, $G^2(1) = 5{\cdot}78$ (Model 5b), $G^2(1) = 7{\cdot}19$ (Model 5c). These results indicated that when schizophrenia patients did not remember the source of an item, they had a greater tendency than normal controls to guess that the word was from an external source – the heard source.

An interesting question is whether this tendency was for all words, recognized or unrecognized, or if it was only for recognized words for which the subject could not remember the source. As mentioned above, both models assume that the probability g of guessing that an unrecognized word was from a certain source equals the probability a of guessing that a recognized word was from a certain source. The fact that both models fit the data implies that the differences in guessing bias were not specific – schizophrenia subjects were equally likely to guess that they heard words that they did not recognize as they were to guess that they heard words they recognized but of which they did not remember the source.

Model 5b showed a significant difference, favouring the normal controls, in the item recognition parameter for 'hear' words, D_{13} (indicating the probability of recognizing new items as new and heard items as old), $G^2(1) = 5{\cdot}30$, whereas Model 5b showed a significant difference in item recognition parameter D_{23} (indicating the probability of recognizing new items and imagined items), $G^2(1) = 4{\cdot}06$. Thus,

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both models agreed that schizophrenia patients had significant difficulties knowing that an item was new and not previously presented. Model 5b indicated that schizophrenia patients also had difficulties recognizing the words that they 'heard', whereas Model 5c indicated that schizophrenia patients had difficulties recognizing words that they 'imagined the experimenter saying'.

In summary, schizophrenia patients guessed that a word was from an external source more than normal controls. Also, they showed difficulties in knowing that new items were new, as well as difficulties recognizing information that came from either an external source or an internal source.

Imagine Self–Imagine Other

The data from this subtest also fit both Model 5b and Model 5c (see Table 4). Analyses with both models yielded that all item recognition parameters were significantly lower for the schizophrenia group than the control group. Using Model 5b, for parameter D_{13}, $G^2(1) = 14{\cdot}60$; for parameter D_2, $G^2(1) = 19{\cdot}94$. Using Model 5c, for parameter D_1, $G^2(1) = 30{\cdot}82$, and for D_{23}, $G^2(1) = 19{\cdot}72$. Thus, both models indicated that schizophrenia patients had an item recognition deficit for items from both sources as well as for new items. It appears that schizophrenia patients had difficulty with recognition when both sources were internally generated.

In addition, Model 5c found that schizophrenia patients had significantly more difficulty than normal controls with source memory (parameter d, $G^2(1) = 6{\cdot}02$).

DISCUSSION

In this study, multinomial analyses enabled us to determine if schizophrenia patients had specific deficits in source monitoring that exceeded their general recognition deficits. Indeed, as predicted by our first hypothesis, schizophrenia patients had source memory deficits in a variety of conditions. However, patients with the 'target' symptoms of thought insertion, voices arguing, voices commenting, made feelings, made impulses and made acts differed from other patients with schizophrenia only on distinguishing between items they had imagined themselves saying from items they had imagined the experimenter saying.

In contrast to our second hypothesis, these source monitoring deficits were not specific to the discrimination between internally-generated or imagined and externally-perceived events. Schizophrenia patients were impaired in one of the conditions that required them to discriminate words that came from one internal and one external source – when they attempted to discriminate words that they said from words that they imagined saying. However, they also were impaired compared to normal controls when they attempted to discriminate between words that came from two external sources – a male and female voice on audiotape, and they were also impaired in discriminating words from two internal sources – words they imagined themselves saying and words they imagined the experimenter saying. These results suggest that the source monitoring deficit in patients with schizophrenia may not be specific to the discrimination between internally-generated and externally-perceived information.

Our third hypothesis was that patients with schizophrenia, particularly patients with the target symptoms, would demonstrate response biases toward believing that they heard or said words that they had only imagined hearing or saying. This hypothesis was partially confirmed. In one condition, the Hear–Imagine condition, schizophrenia patients had, in comparison to normal controls, a higher tendency to guess that information for which they did not remember the source had originated from an external source. This guessing bias leads patients to respond that the experimenter had actually said words that they had only imagined the experimenter saying. While this result is consistent with our hypothesis that schizophrenic patients have source monitoring deficits and that these deficits may explain some of their symptoms, this bias was not found in a condition in which subjects discriminated words they said from words they imagined saying. Patients with the target symptoms did not demonstrate more of this type of response bias than patients without the target symptoms.

As expected, patients with schizophrenia demonstrated recognition deficits in each of the paradigms suggesting that some aspects of performance on source monitoring tasks is dependent upon more general memory deficits. This result is consistent with numerous previous reports of memory disturbance in schizophrenia (Saykin *et al*. 1991) that extends to general recognition deficits in some (Calev, 1984; Tamlyn *et al*. 1992) but not all (Bentall *et al*. 1991; Frith *et al*. 1991) studies. It is important to note, however, that our multinomial analyses enabled us to conclude that the source monitoring deficits in patients with schizophrenia in this study were present independent of these more general recognition deficits.

These results suggest that schizophrenia patients have source monitoring deficits that are not limited to the distinction between internally-generated and externally-perceived information. Rather, the generality of their deficits suggests that they have difficulty in discriminating the source of information regardless of whether the source is in perception or imagination. Furthermore, since patients with the 'target' symptoms performed similarly to other schizophrenic patients on all but one source monitoring task, these data do not support the notion that specific source monitoring and reality monitoring deficits underlie specific types of symptoms in patients with schizophrenia. Rather, it appears as though these deficits are present in patients with schizophrenia as a group. These results contrast earlier work suggesting that source monitoring deficits are associated with hallucinations (Benthall *et al*. 1991; Morrison & Haddock, 1997; Seal *et al*. 1997) and delusions of alien control (Frith & Done, 1989; Mlakar *et al*. 1994; Stirling *et al*. 1998). The current study identified the 'target' group by combining a greater number of symptoms than these previous studies. Configuring symptoms in this particular manner may have served to weaken the findings reported previously. Furthermore, it is possible that the absence of a difference between schizophrenia groups could be a function of the longer drug-free status of the patients without target symptoms. Although the patients with target symptoms had more severe Schneiderian symptoms, they may have had less time off of antipsychotic medication to allow for increases in autonoetic agnosia.

It is possible that the pattern of results reported in this study are due to unintended differences between the various conditions. The conditions may have differed in their relative difficulty and the extent to which they called upon memory for past actions. Since the discrimination between two internal sources of information or two external sources of information is more difficult than the discrimination between an internal and an external source of information (Hashtroudi *et al*. 1989) it is possible that schizophrenic patients performed poorly on the internal–internal test (Imagine Self–Imagine Other) and the external–external test (Female–Male) due primarily to their increased level of difficulty. Furthermore, some of the conditions required subjects to 'act' on the words such as saying them aloud or imaging them being said aloud. Other conditions, such as listening to the female and male voices in the audiotape, may have been more difficult to remember since there was no additional processing of the words. If this were the case, the absence of a differential deficit (Chapman & Chapman, 1973) among these tests could be due to their varying level of difficulty. Work is underway in our laboratory attempting to equate these conditions for level of difficulty.

This study did not attempt to address three important issues in the role of source monitoring in psychotic disorders. First, it is likely that emotions have a different effect on memory depending upon whether the information originated from internal or external sources (Eich & Metcalfe, 1989). Patients who have auditory hallucinations tend to specifically misattribute information to an external source only when the material elicits strong emotions (Morrison & Haddock, 1997). The stimuli in the current study were primarily comprised of words that would not normally elicit strong emotions, and thus would be more difficult to remember. Secondly, our study design required that patients recall the source of information immediately after all of the words had been presented. Thus, we were not able to test hypotheses about the impact of longer delay periods on source monitoring in psychotic patients. Previous work suggests that delay periods may diminish source monitoring deficits in patients with auditory hallucinations (Morrison & Haddock, 1997). Thirdly, we were also not able to determine whether the origin of autonoetic agnosia occurs at the stage of encoding source information or subsequent recall of encoded source information. The temporal relationship between a cognitive event that leads to symptoms such as delusions of control and a patient's actual verbal expression of the delusion has not been established. Since patients may have performed worse due to encoding or recall deficits, this study does not shed light on this important issue.

This study employed four different conditions of monitoring information that originated in one of two sources. Two-source paradigms have some significant limitations over paradigms employing more than two sources. First, some of the results of this study were dependent upon which multinomial model we chose. For instance, the source memory deficits in patients with schizophrenia in the Say–Imagine condition were found only when Model 5c was used; Model 5b did not support the between-group difference. A similar conflict existed in the Imagine Self–Imagine Other condition. Three-source models resolve this ambiguity by increasing the degrees of freedom, thus allowing more specific parameters to be determined (Riefer *et al.* 1994). In studies currently underway in our laboratory, we have employed three source paradigms to address these issues in further detail.

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