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Sentence verification and delusions: a content-specific deficit

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ABSTRACT

Background. A sentence verification task was developed to investigate semantic memory in schizophrenia.

Methods. The test consisted of three types of sentence (true, unlikely and nonsense) and seven different types of content (neutral, persecutory, grandiose, political, religious, relationships and somatic) representing common delusional themes present in schizophrenic patients. Sixty-three schizophrenic patients and 66 matched control subjects were asked to make true/false judgements to 143 sentences.

Results. Overall accuracy was similar across the two groups; sentences with some emotional themes and sentences of the unlikely type produced the most violations. Significant differences between the two subject groups were found specifically on nonsense sentences with persecutory and religious themes. Patients made significantly more incorrect responses (acceptance) to nonsense sentences that had an emotional content congruent with their delusional beliefs, past or present, and also on unlikely sentences (incorrect rejections) whose content was not congruent with their delusions. Further analysis of response bias in the patients showed, overall, that there were more incorrect rejections (a reflection of the large number of unlikely sentence errors) and more incorrect responses to sentences congruent with patients delusions. Furthermore, analysis of those patients currently experiencing delusions revealed more incorrect responses to sentences congruent with their delusional ideas compared with patients not currently deluded.

Conclusions. These findings are indicative of cognitive bias in schizophrenia towards certain emotional themes that may underlie illogical semantic connections and delusions.

INTRODUCTION

There has been much recent interest in the semantic memory of schizophrenic patients (Tamlyn *et al.* 1992; McKay *et al.* 1996). However, suggestions of semantic memory deficits in schizophrenia may be traced back to an earlier literature where they are framed using different terminology: Hemsley (1987) referred to a 'weakness of stored regularities' about the world during moment to moment processing, while Cutting & Murphy (1988) suggested schizophrenics have 'deficient real world knowledge'. Empirical evidence of semantic memory deficits in schizophrenia can also be gleaned from semantic priming paradigms (for a review see Neely, 1991). The results of these studies in schizophrenia are plagued with inconsistencies. Evidence for deficient (Barch *et al.* 1996), anomalous (Chapin *et al.* 1992) and overactive (Spitzer *et al.* 1994) semantic networks in schizophrenia has been claimed, but such claims are complicated by different stimulus presentation times, intervals between stimulus presentation and types and frequency of word pairs used (see Barch *et al.* 1996).

Alternative tests of semantic memory include the 'silly sentences test' used by Tamlyn *et al.*

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(1992; Clare *et al*. 1993; Duffy & O'Carroll, 1994), who showed that not only were the patients slower in verifying or rejecting simple true or false statements but they also made more errors (although the number of errors was small). McKay *et al*. (1996) employed a semantic memory battery which included category fluency, word to picture matching and definitions, and found evidence of substantial semantic memory impairment on all of these tasks in patients with schizophrenia. Normal subjects would be expected to perform at ceiling on most of these tests, which are devised for patients with obvious brain disease.

Semantic deficits may also be inferred from abnormalities in schizophrenic speech (thought disorder) and language processing (de Bonis *et al*. 1990). Patients with schizophrenia are additionally less accurate at detecting contradictions (de Bonis *et al*. 1992) and comprehending metaphors (de Bonis *et al*. 1997), leading de Bonis *et al*. (1992) to postulate that schizophrenics do not share the same 'symbolic meanings' as normal controls. Anand *et al*. (1994) examined linguistic deficits in schizophrenia, by asking subjects to identify the anomaly in a given sentence (i.e. Birds fly in green sky). They concluded that, although impairments were elicited in syntax, semantics, cohesion and metaphors, the impairment that most clearly differentiated the patients and control subjects was at the level of semantics. Further, psycholinguistics investigations have shown that schizophrenics have difficulty in placing word–association pairs in the context of a meaningful sentence (Johnson & Shean, 1993) and are less sensitive to linguistic violations during on- and off-line sentence processing (Kuperberg *et al*. 1998).

The study of cognitive dysfunction in schizophrenia has begun to exploit the symptom-based approach (David, 1993), as not all schizophrenics demonstrate the same symptoms or cognitive deficits. A natural link between abnormal semantics and psychopathology is the delusion. Delusions are commonly defined as abnormal beliefs but could also be construed as statements and inferences based on a faulty knowledge-base or semantic system.

As well as the study of semantic memory in schizophrenia, attentional bias has become an important area of research into cognitive processes of deluded patients. For example, Leafhead *et al*. (1996) demonstrated that a schizophrenic patient exhibited attentional bias towards material related to the theme of her delusion on a Stroop-type paradigm. Patients with persecutory delusions have also been shown preferentially to attend to (Bentall & Kaney, 1989) and recall threat-related information (Bentall *et al*. 1995). These results indicate that preferential encoding of delusion sensitive material could be occurring, continually reinforcing delusional beliefs.

Haddock *et al*. (1995) examined the effect of general emotional salience on symptoms in patients with schizophrenia, using two interviews. The first included personal questions, while the second was impersonal. Patients exhibited significantly greater thought disorder during the emotionally salient interview. These studies raise questions about the effect of the emotionality of the stimuli on cognitive processes, especially when they are related to a patient's thought processes or preoccupations. Therefore, this investigation took into account the emotional salience of material used in a sentence verification task.

The aim of the present study was to assess semantic performance in schizophrenic patients using a sentence verification task designed to produce 'errors' in both patients and controls. The task consists of grammatically correct sentences or statements that the subject is asked to judge true or false. There are three types of sentence: true, nonsense and unlikely, which vary in terms of their semantic accuracy. In terms of common sense rationality, true sentences obviously reflect the real world, nonsense sentences are obviously false, and unlikely sentences present scenarios that are possible but unlikely, thus in some situations are true.[1] The task also contains material that is frequently commented upon in delusions: these include persecutory, grandiose and religious themes. This study is therefore novel, first, in its manipulation of the 'plausibility' of each sentence; there has been no other study to date that examines the effects of unlikely sentence content on error production in either controls or

[1] Labelling of the truth value of these sentences was based on consensus. As a shorthand we describe sentences as 'true' where the content was deemed correct or realistic, 'unlikely' if merely plausible or possible, and 'nonsense' if the content was implausible.

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schizophrenic subjects. The second innovation is the manipulation of emotional content; specifically the use of emotional content typical of delusional ideas.

We predicted first, that patients with schizophrenia would make significantly more errors on this more challenging sentence verification task, especially on sentences that have an emotional content; secondly, that schizophrenic patients would be more accepting of sentences that were congruent with their delusional ideas, particularly the ambiguous 'unlikely' sentences. Thirdly, we predicted the pattern of accepting sentences congruent with delusional ideas would be most evident in schizophrenic patients currently experiencing delusions compared with previously deluded patients.

METHOD

Subjects

A sample of 63 male schizophrenics was recruited from in-patients and out-patients of the Maudsley/Bethlem Hospital and out-patient clinics in Bromley, Croydon and Maidstone. Subjects were recruited as part of a larger neuropsychological and brain imaging study in schizophrenia; since sex is known to be a confounding factor in some of the other neuropsychological tests administered only male schizophrenic subjects were recruited. All patients were diagnosed as suffering from schizophrenia ($N = 58$) or schizo-affective disorder ($N = 5$) according to DSM-IV criteria (APA, 1994). Patients with a history of traumatic brain injury, epilepsy or other diagnosable neurological or psychiatric conditions were excluded. All subjects were between the ages of 18 and 55 years and had an estimated pre-morbid IQ as scored by the National Adult Reading Test (NART; Nelson, 1981) of > 90. Their mean (S.D.) dosage of medication in chlorpromazine equivalent units was 718·7 mg (528·2). Current and lifetime psychopathology was rated using the Schedule for the Assessment of Negative Symptoms (SANS) and the Schedule for the Assessment of Positive Symptoms (SAPS) (Andreasen & Olsen, 1982). All patients recruited had experienced delusions at some point during their illness; 48 were currently experiencing delusions while 15 had no current delusions. There was no significant difference in age, education, IQ, medication dosage or severity of other positive or negative symptoms (using each subscore of the SAPS and SANS) between the two groups of schizophrenic subjects (deluded or not currently deluded) (see Table 1).

Sixty-six normal controls (male $N = 41$, female $N = 25$) were also recruited for the study by advertisement in two local London job centres and a local college. Age, IQ and education are given in Table 1. There was no significant difference in age, number of years in education or IQ as scored by the NART between the schizophrenics and controls. Informed consent was obtained from both subject groups. There were no correlations between any sociodemographic variables and sex.

The Sentence Verification Task

A list of 143 sentences was employed, 50 of which were true, 39 unlikely and 54 nonsense. True sentences were correct representations of the world, i.e. 'A rose is a flower.'. Nonsense

Table 1. *Demographic characteristics of the subjects: controls and schizophrenics* (*with and without delusions*)

		Schizophrenics			
	Controls $N = 66$	Total group $N = 63$	Not deluded $N = 15$	Deluded $N = 48$	F (P)*
Age	30·4 (14·4)	33·3 (8·4)	35·6 (8·7)	32·6 (8·2)	1·92 (0·17)
No. years in education	14·2 (2·8)	13·9 (2·5)	14·8 (2·6)	13·7 (2·4)	0·25 (0·62)
NART	115·8 (9·8)	113·9 (10·8)	116·7 (8·1)	113·0 (11·4)	0·41 (0·53)
Sex male/female	41/25	63/0	15/0	48/0	—
Age of onset	—	28·3 (10·8)	27·2 (10·3)	28·9 (11·3)	NS†
No. of years illness	—	18·6 (15·7)	19·5 (14·6)	17·9 (16·1)	NS†
Medication dosage mg	—	718·7 (528·2)	700·4 (504·8)	732·9 (541·2)	NS†

* Analysis of variance between deluded, non-deluded and control subjects.
† t tests: deluded *versus* non-deluded subjects.

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Table 2. *Examples of content for each sentence type used in the sentence verification task*

Content type	Description	Example (true (T), unlikely (U), nonsense (N))	No. in test	Response required
Neutral	No particularly emotional content, e.g. about plants and animals	T: Fish swim in rivers	20	True
		U: Leaves are red	15	True
		N: Cricket is a lottery	24	False
Persecutory	Associated with violent acts, spying plotting etc.	T: Knives are dangerous	5	True
		U: Joy riders can return the cars they steal	4	True
		N: A cactus can bite	5	False
Grandiose	Associated with unusual ideas of superiority	T: Inventors are talented and clever	5	True
		U: Dentists can be talented artists	4	True
		N: Scientists can turn grass blue	5	False
Political	Associated with politicians and government	T: The PrimeMinister lives on Downing Street	5	True
		U: Politicians may have four wives	4	True
		N: Politicians are sparrows	5	False
Religious	People associated with religious activities and different religions	T: Vicars work on Sundays	5	True
		U: Monks are alcoholics	4	True
		N: The bible is a car catalogue	5	False
Relationships	Associated with sexual activities and relationships	T: Incest is sex with relatives	5	True
		U: Passengers have sex on trains	4	True
		N: Rapists have ten foot arms	5	False
Somatic	Concerned with body image and illness	T: Blood is red	5	True
		U: Eyes can be plastic	4	True
		N: Blackbirds eat fingers	5	False

sentence were not accurate representations of the world and were produced by combining two true sentences i.e. 'Doors can sing.' is the product of 'choir boys can sing' and 'doors can close'. The unlikely sentences were also plausible or possible representations of the world, but were unlikely or unusual constructions, i.e. 'Leaves are red.' and 'Passengers have sex on trains.'. All the sentences were syntactically correct; the manipulation in this study was in semantics only. The unlikely sentences were considered useful because they required a degree of concentration and attention from subjects, and the use of reasoning and deductive abilities to search their semantic memory to distinguish such sentences from nonsense. Initially, a pool of 154 sentences was graded by 10 members of Institute of Psychiatry staff as to whether they were true, unlikely or nonsense according to their own common-sense criteria. It was made clear that grading a sentence as true or unlikely meant they were true or possible, and nonsense meant they were false. Eleven sentences were discarded where classification could not be reached (i.e. less than 9 out of the 10 members agreed on classification).

The content of the remaining 143 sentences was also manipulated. Seven different content types were selected: neutral, persecutory, grandiose, political, religious, relationships (sexual) and somatic (see Table 2 for examples); again each sentence was categorized by the 10 members of Institute of Psychiatry staff according to type. As mentioned previously these content types were selected to relate to some of the common delusional ideas seen in patients with schizophrenia. There were approximately equal proportions of the different content types in each of the sentence types, although in each case (true, unlikely, nonsense) there were slightly more emotionally neutral sentences. When constructing the sentences, care was taken to match the number of words in each sentence, the length of the words, their frequency in the English language (Kucera & Francis, 1967) and the grammatical construction of each sentence (i.e. most had the form noun–verb–noun although there were some variations) across both the different sentence types and content types.

Additionally, all the sentences were graded by a further 33 students/members of staff according to a single affective dimension from positive, though neutral to negative on a 7-point scale. This confirmed that all sentences in the neutral content type were not regarded as emotional.

Procedure

All subjects were tested individually. They were required to read the list of statements out loud and indicate whether each one was true or false, i.e. if true, the statement was a true representation of the world and could happen (and not

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'metaphorically' true). If the statement was false however, it should be an inadequate representation of the world and could not happen (see Table 2 for examples of correct responses). The task was scored by calculating the total number of errors made. We regarded the unlikely sentences as true, hence errors were incorrect rejections. The other errors were rejections of true sentences and incorrect acceptance of nonsense sentences.

RESULTS

Contrary to our initial prediction, a one-way ANOVA demonstrated schizophrenics were well matched to the control subjects on this task making a similar number of errors ($F(1,127) = 0{\cdot}398$ $P > 0{\cdot}05$). Throughout the rest of the analysis the dependent variable used was the percentage of incorrect responses made in any particular sentence type or content type. This was to eliminate the effect of different set sizes; for example there were more true sentences within the task than unlikely, etc. There was no sex difference in performance within the control group, suggesting that it is unlikely to confound group differences.

A $2 \times 3 \times 7$ MANOVA involving two subject groups (controls and schizophrenics), three sentence types (true, unlikely and nonsense), seven types of emotional content of sentence (neutral, persecutory, grandiose, religious, political, somatic and relationships) revealed the following significant main effects: sentence type ($F(2,254) = 456{\cdot}45$ $P < 0{\cdot}001$) with the greatest percentage incorrect on the unlikely sentences; emotional content ($F(6,762) = 12{\cdot}97$ $P < 0{\cdot}001$) with variation in incorrect responses on some content types (data not shown), but no main effect for subject group, as noted above. There was a significant subject group × sentence type × emotional content interaction ($F(12,1524) = 5{\cdot}27$ $P < 0{\cdot}001$) with sentence type and emotional content both influencing the percentage incorrect

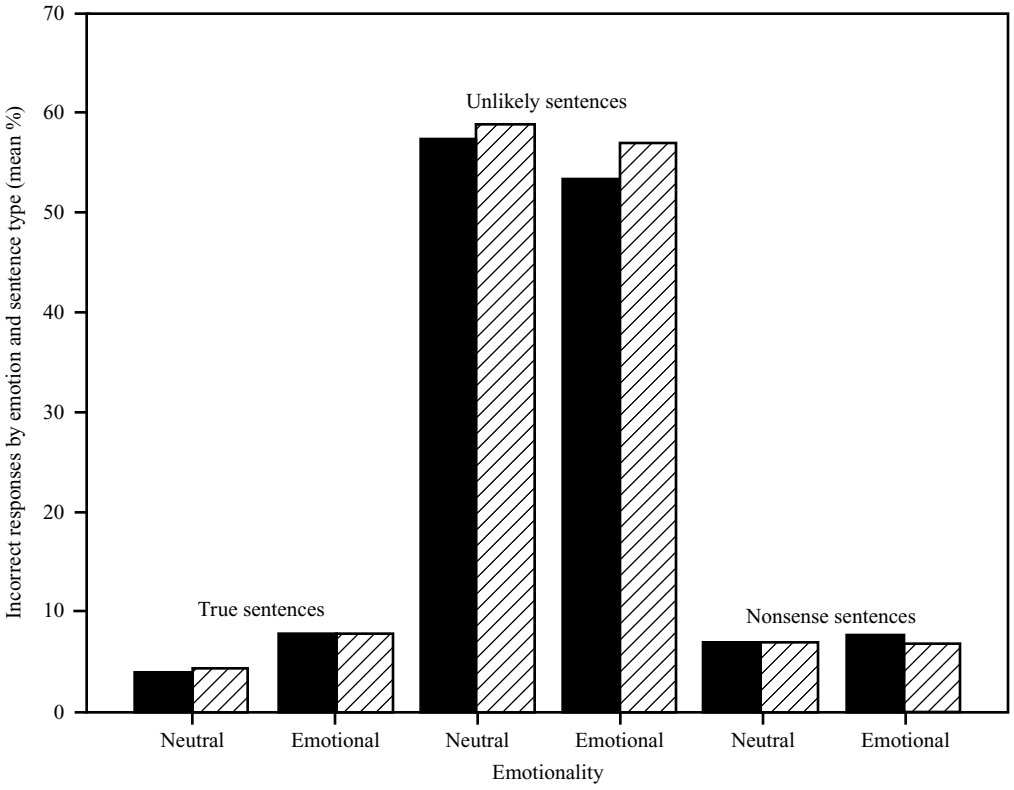


FIG. 1. Mean percentage of incorrect responses across the three sentence types divided by emotionality (■, controls; ▨, schizophrenic patients). SV performance according to sentence and content type.

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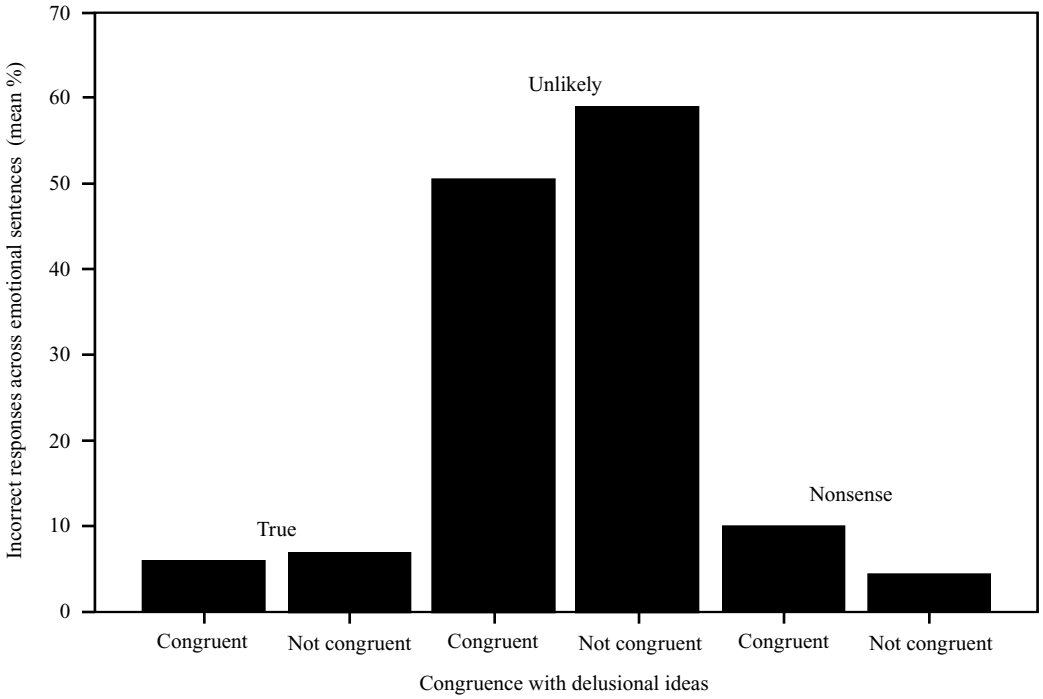


FIG. 2. Mean percentage incorrect in patients across emotional sentences according to congruence with delusional ideas. SV performance according to sentence type and delusion congruity ($N = 63$).

made in each subject group differently. There was a subject group × emotional content interaction ($F(6,762) = 3{\cdot}51$ $P < 0{\cdot}002$) suggesting emotional content influenced the percentage of incorrect responses differently in the two subject groups regardless of sentence type; and a sentence type × emotional content interaction ($F(12,1524) = 30{\cdot}22$ $P < 0{\cdot}001$) with emotional content also influencing the percentage incorrect differently across the three sentence types. However, there was no significant interaction between subject group × sentence type ($F(2,254) = 0{\cdot}14$ $P < 0{\cdot}867$) with both groups making a comparable number incorrect across true, unlikely and nonsense sentence types. Fig. 1 displays a bar chart of the percentage of incorrect responses across the three sentence types also divided by emotion for the two subject groups. The figure shows both subject groups made an equivalent percentage of incorrect responses across the three types of sentences (unlikely > nonsense > true) but did differ when the emotionality of the sentence was considered.

In order for us to test our hypothesis of differences on sentences with a specific emotional content, planned comparisons using one-way ANOVA were performed. Further analysis showed that there were significant differences between the groups with sentences with religious content ($F(1,127) = 4{\cdot}33$ $P < 0{\cdot}04$) and a trend towards a significant interaction between persecutory content type and subject group ($F(1,127) = 3{\cdot}37$ $P < 0{\cdot}07$). None of the other content types was significant. These results indicate controls made a greater percentage incorrect in the persecutory content type 30·9 (S.D. 18·7) compared with 25·1 (S.D. 17·1) in the schizophrenics; whereas the reverse pattern was seen in the religious content type (5·9 (S.D. 7·6) *v.* 9·43 (S.D. 11·5) in the two groups, respectively).

One-way ANOVAs were performed across all the data taking sentence type into consideration. There was no significant difference between the subject groups and any of the seven different content types when examining the true sentences only. Analysis of the nonsense sentences alone revealed significant differences between the subject groups on persecutory ($F = 9{\cdot}77$ $P < 0{\cdot}002$), grandiose ($F(1,127) = 22{\cdot}57$ $P < 0{\cdot}001$), religious ($F(1,127) = 6{\cdot}77$ $P < 0{\cdot}01$) and so-

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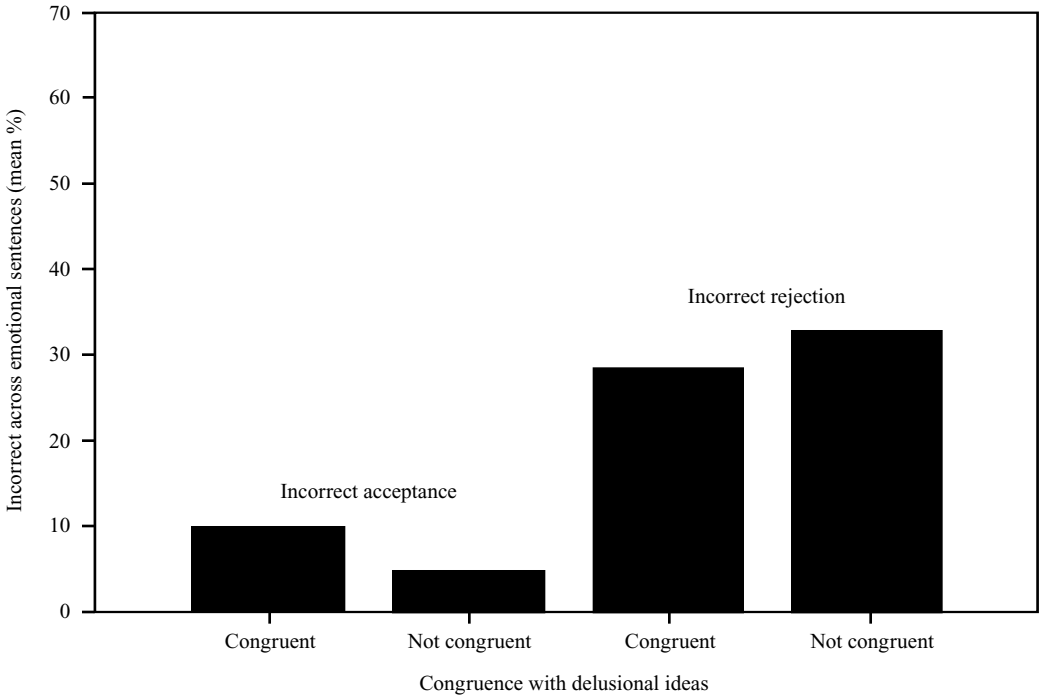


FIG. 3. Mean percentage incorrect, acceptance of rejection, in patients across emotional sentences according to congruence with delusional ideas. Error analysis on SV task by congruence of content delusions ($N = 63$).

matic ($F(1,127) = 4{\cdot}76$ $P < 0{\cdot}03$) content types; controls making more errors on persecutory and somatic and schizophrenics on grandiose and religious sentences. There was only one significant difference between the subject groups on the unlikely sentences, i.e. those with somatic content ($F(1,127) = 3{\cdot}99$ $P < 0{\cdot}05$); the patients made more errors than the controls. It is important to note here that overall, the schizophrenics were well matched to the controls on this task, therefore, further examination of the error data and their possible relationship to delusions is all the more interesting since this would be unlikely to be due to a generalized cognitive deficit.

Delusions

In order to understand the relationship between psychopathology, particularly delusions and the incorrect responses made on the sentence verification task, the data were reorganized using information collected on the delusion section of the SAPS (current and lifetime from case-notes) and an interview. The two to three most common delusions throughout a patient's history were rated for each patient using the six categories of delusion (persecutory, grandiose, political, religious, relationships and somatic). Consequently, the percentage incorrect in these two to three 'congruent with delusions' categories was separated from the percentage incorrect on the other 'not congruent with delusions' categories, Paired t tests were performed comparing 'delusion congruent' and 'not delusion congruent' performance. The initial results showed that schizophrenics made a similar number of errors on the emotional sentences congruent and not congruent to their delusions ($t(62) = -1{\cdot}09$ $P = 0{\cdot}279$). Next, each of the sentence types was examined; there was a significant difference in the % incorrect between congruent and not congruent categories on nonsense, and as expected, unlikely sentences ($t(62) = 3{\cdot}51$ $P < 0{\cdot}001$; $t(62) = 2{\cdot}66$ $P < 0{\cdot}01$, respectively), but not true sentences ($P < 0{\cdot}05$). Fig. 2 displays the percentage scores across the sentence types and shows that patients made the most incorrect responses on unlikely sentences on themes not congruent with their delusions, and nonsense sentences on themes they were deluded about.

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Response bias and delusions

The two types of incorrect verification, acceptance and rejection, were examined according to the congruence of emotional categories with the patient's delusions. Incorrect acceptance was answering true to a nonsense sentence, while incorrect rejection was answering false to true and unlikely sentences. A 2×2 ANOVA was performed involving two types of erroneous response modes (acceptance and rejection) and two types of congruence with delusions (delusion congruent, not delusion congruent). There were main effects for error type ($F(61) = 90{\cdot}3$ $P < 0{\cdot}001$) with more incorrect rejections; and congruence ($F(61) = 57{\cdot}8$ $P < 0{\cdot}001$) with the most incorrect responses on sentences with content congruent with the patients' delusional ideas. There was also an interaction between error type $\times$ congruence ($F(61) = 65{\cdot}2$ $P < 0{\cdot}001$). Inspection of the data (see Fig. 3) shows that first, there is a greater percentage of incorrect rejections than acceptance in the data overall for the schizophrenics. Secondly, there is a greater percentage of incorrect responses overall to sentences that were congruent with the patients' delusional ideas. The most incorrect responses were to rejecting sentences that did not correspond to the subjects' delusions.

An additional $2 \times 2 \times 2$ ANOVA was performed considering the current delusional state of the patients, thus, two patient groups (currently deluded, not currently deluded) by erroneous response by congruence; this analysis also revealed a main effect for patient group ($F(61) = 4{\cdot}08$ $P < 0{\cdot}05$), with those patients that were deluded at the time of testing showing a tendency to make more errors overall. There was also an interaction between patient group $\times$ congruence ($F(61) = 4{\cdot}05$ $P < 0{\cdot}05$), with deluded patients making the most incorrect responses on sentences congruent with their delusions.

Demographic characteristics

Pearson's product moment correlations between the mean percentage of incorrect responses and demographic variables were not significant; however, with the symptom ratings of the patients from the subscores of the SANS and SAPS there were significant correlations between global ratings of delusions and mean percentage incorrect on each of the three sentence types (true $r(62) = 0{\cdot}25$ $P < 0{\cdot}05$; unlikely $r(62) = 0{\cdot}28$ $P < 0{\cdot}02$; nonsense $r(62) = 0{\cdot}29$ $P < 0{\cdot}02$), but no correlations with any other patient characteristics (medication dosage, age of onset and years illness).

DISCUSSION

We can summarize the findings as follows; using a sentence verification task designed to produce errors, both schizophrenics and control subjects were well matched in their performance. In contrast to our hypotheses both subject groups produced an equal number of incorrect responses across sentence types, true, unlikely and nonsense, but differed slightly according to the emotionality of the sentences. The main novel finding is the interaction between the content of the test material and the themes of patients' delusions. Deluded patients are more likely to accept sentences congruent and reject sentences incongruent with the overall theme of their abnormal beliefs. This finding is especially significant as it is in the absence of a generalized deficit on the task.

It is unclear why some emotional sentence types caused differences in the number of violations between the two subject groups, especially as the violations recorded on persecutory and religious sentences were in the opposite directions. Such differences may be due to chance although schizophrenics' heightened preoccupation with persecutory information in this study may have actually benefited them on verifying sentences of this type. The large number of violations in patients on the religious sentences is harder to explain. Further research that examines the effects of processing different emotional categories in schizophrenia and control subjects is needed to explain these findings.

As predicted, both subject groups made the most errors when verifying unlikely sentences, although the high number of incorrect acceptances on unlikely sentences was not expected. It is possible that intelligence plays a role in this findings as the 10 members of staff originally asked to rate the sentences were presumably of above average IQ, however, many individuals in both patient and control groups achieved a high score on the NART, a measure of pre-morbid IQ. Nevertheless, the large number of incorrect

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responses made to unlikely sentences made it possible to examine whether a cognitive bias to sentences related to delusional ideas was evident in the schizophrenic subjects.

Cognitive bias and delusions

Further analysis of patient performance according to whether the theme of emotional sentence was congruent with their delusional ideas, showed no difference overall in the number of incorrect responses. However, when answering strategies were examined to these congruent emotional sentences, a pattern of responses and reasoning becomes apparent. Schizophrenic patients did demonstrate a tendency to accept ambiguous sentences (nonsense and unlikely, and as such showed significantly more errors to nonsense and obtained more correct to unlikely), specifically when they were congruent with the content of their delusions. This finding suggests patients may be more believing of ambiguous or implausible information which coincides with their delusions. This example of cognitive bias was somewhat more pronounced in patients who were currently experiencing delusions when compared with those whose delusions were in remission: a state-dependent effect. This finding suggests that patients with delusions become focused on certain types of information/stimuli within their environment and allow illogical associations to be formed with regard to this information. As previously mentioned, it is unclear why certain emotional material preoccupies some individuals but not others. This sensitivity to certain emotions may be a product of cultural issues or important life events, however, the more fantastical a delusion the less likely this explanation holds true. It is also important to note that the performance of the patients in this study was related only to delusions and not to any other symptom of schizophrenia.

The lack of an overall difference in performance between patients and controls contradicts the small amount of literature that exists on sentence verification in schizophrenia (Tamlyn *et al*. 1992; Clare *et al*. 1993; Duffy & O'Carroll, 1994). Duffy & O'Carroll (1994) also reported a relationship between the number of errors on their 'silly sentence task' and age and chronicity of their schizophrenics, again this was not replicated here with no correlations between age or number of years ill and task errors. We suggest the present task has greater ecological validity covering a broader range of everyday topics and degrees of difficulty, with the subjects not placed under any time constraints to perform. Additionally, we had the largest group of subjects with wide-ranging severity and chronicity of illness, however, we excluded patients with low pre-morbid IQ.

Neuropsychology

Juncos-Rabadan (1992) examined the performance of fluent Wernicke's aphasics and patients with right temporal lobe lesions but no aphasia on a sentence verification task. He showed that aphasics were impaired on the task and showed a predilection for affirmative answering strategies, whereas the right temporal lobe patients showed slower reaction times only. Using functional magnetic resonance imaging, Just *et al*. (1996) reported that comprehension of visually presented sentences produces brain activation that increases with the linguistic complexity of the sentences, i.e. the volume of the neuronal tissue activated. The activation pattern was observed across a network of left hemisphere areas, including superior temporal cortex and Wernicke's area. These results suggest that state-related changes in Wernicke's area could be occurring in patients who are experiencing delusions (see Friston *et al*. 1992), influencing their ability to process semantic information and thus, accurately verify sentences.

Finally, as well as demonstrating delusion-related 'trait' effects in evaluating ambiguous sentences, we have presented preliminary work comparing deluded patients whose delusions were either current or in remission. This indicates that higher order semantic processes may be disturbed as a product of state features of delusions but further investigation in this area appears essential. It would be interesting to use a discriminability index during sentence verification with emotional content manipulation (i.e. using reaction time to correct and incorrect responses). It appears that those patients diagnosed as having had delusions, process certain types of content-specific material in a particular or 'biased' way. This is not an obvious distinguishing characteristic of such patients in comparison to normals, who are also affected by emotional content, but does go some way to

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explain why delusions may recur. Furthermore, such biases may become even more extreme in delusional states leading to a positive-feedback cycle and hence entrenchment of the beliefs in question. This content specific processing deficit can be framed in terms of a distortion in the way information is stored in semantic memory, as opposed to encoding or retrieval deficits. However, cross-sectional research is unable to determine whether such processes are causal.

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