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Impaired verbal self-monitoring in psychosis: effects of state, trait and diagnosis

LOUISE C. JOHNS[1]*, LYNSEY GREGG[2], PAUL ALLEN[1] AND PHILIP K. McGUIRE[1]

[1] *Department of Psychological Medicine, Institute of Psychiatry, London, UK*; [2] *Academic Division of Clinical Psychology, School of Psychiatry and Behavioural Sciences, University of Manchester, UK*

ABSTRACT

Background. Cognitive models propose that auditory verbal hallucinations arise through defective self-monitoring and external attribution of inner speech. We used a paradigm that engages verbal self-monitoring to examine how deficits in this process are related to symptoms and diagnosis in patients with psychosis.

Method. We tested 45 patients with schizophrenia. Fifteen had current auditory hallucinations, 15 had a history of (but no current) auditory hallucinations, and 15 had delusions but neither current nor previous hallucinations. We also tested 10 patients with affective psychosis and current auditory hallucinations, and 20 healthy volunteers. Participants read single adjectives aloud while the source and the pitch of the on-line auditory verbal feedback was manipulated, then immediately identified the source of the speech they heard ('self'/'other'/'unsure').

Results. When reading aloud with distorted feedback of their own voice, patients with schizophrenia who had auditory hallucinations were more likely than controls to misidentify its source as 'other'. Patients with delusions but no current hallucinations displayed a similar deficit, although there was a trend for this to be less marked. Patients with a history of hallucinations did not differ from controls. Patients with hallucinations in the context of an affective disorder made more unsure responses rather than misattributions.

Conclusions. Difficulty with source monitoring was related to the acute psychotic state rather than a predisposition to hallucinations, and was evident in patients with affective psychosis as well as schizophrenia. External misattribution of source may reflect an impairment in verbal self-monitoring and/or the appraisal of ambiguous sensory material.

INTRODUCTION

Auditory verbal hallucinations (voices) in psychosis are perceptions of speech in the absence of a corresponding external stimulus. Cognitive models propose that they arise through a deficit or bias in source monitoring, whereby an individual mistakes their inner speech for an external event (Frith, 1987; Bentall, 1990; Keefe *et al*. 1999). Hallucinating patients and individuals predisposed to hallucinations show a bias toward detecting signals and toward misattributing internal events to an external source on a range of reality-discrimination and source-monitoring tasks (Bentall & Slade, 1985; Rankin & O'Carroll, 1995; Baker & Morrison, 1998). Frith (1987, 1996) has proposed that auditory verbal hallucinations result from defective monitoring of thoughts as they are generated, leading to misidentification of self-generated thoughts as 'alien' voices. According to Frith's model, self-monitoring applies to all thoughts and actions, and there are experimental data linking positive symptoms of schizophrenia with defective cognitive self-monitoring (Frith & Done, 1989; Daprati *et al.*

* Address for correspondence: Dr Louise C. Johns, Section of Neuroimaging, PO Box 67, Department of Psychological Medicine, Institute of Psychiatry, De Crespigny Park, London SE5 8AF, UK. (Email: l.johns@iop.kcl.ac.uk)

1997). More specifically, Cahill *et al.* (1996) and Johns *et al.* (2001) engaged self-monitoring of speech by manipulating auditory verbal feedback while participants spoke out loud. This introduced a disparity between what individuals expected to hear and what they actually perceived. When speaking aloud with distorted feedback of their own voice, patients with schizophrenia who had auditory hallucinations and/or delusions tended to misidentify their distorted voice as someone else's. In the Cahill *et al.* study, misattributions were associated with severity of delusions, whereas in the Johns *et al.* study, it was the patients with auditory hallucinations who tended to make more misattributions.

Nearly all studies have involved patients with schizophrenia, and it is not known whether a similar self-monitoring deficit is associated with auditory hallucinations in other psychotic disorders. One study (Blakemore *et al.* 2000) did report that defective self-monitoring was associated with the presence of auditory hallucinations and/or passivity symptoms regardless of diagnosis (schizophrenia or affective disorder).

The findings indicate that auditory hallucinations are associated with impaired verbal self-monitoring, but it is unclear whether the deficit is related to the presence of hallucinations at the time of testing or a vulnerability to hallucinations (i.e. is state or trait-related). Furthermore, it is possible that the deficit is related to aspects of the acute psychotic state other than hallucinations, such as delusions. Finally, it is not known whether the deficit is specific to patients with schizophrenia.

The present study was designed to address these issues using an established paradigm that manipulates auditory verbal feedback while participants speak out loud (Johns *et al.* 2003). We tested the hypothesis that external misattribution of self-generated speech in the presence of distorted feedback:

(1) Would be evident in both patients with schizophrenia with *current* auditory hallucinations and in patients who had a history of hallucinations but were currently hallucination-free.
(2) Would *not* be evident in patients with schizophrenia with delusions but no current or previous auditory hallucinations.
(3) Would be evident in patients currently experiencing auditory hallucinations in the context of an affective psychosis.

METHOD

Participants

Fifty-five patients were tested. Forty-five met DSM-IV (APA, 1994) diagnostic criteria for schizophrenia or schizoaffective disorder and 10 met criteria for affective psychosis (bipolar disorder or psychotic depression). They were either in-patients or out-patients, and were all receiving antipsychotic medication. Their symptoms were assessed on the day of testing using the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen, 1984*a*), the Scale for the Assessment of Negative Symptoms (SANS; Andreasen, 1984*b*), and the Calgary Depression Scale (Addington *et al.* 1993). Reports of symptoms were corroborated by the medical case-notes. Patients with schizophrenia or schizoaffective disorder were selected for inclusion if they had either current auditory verbal hallucinations ($n=15$), a history of auditory verbal hallucinations but no hallucinations for at least 1 month ($n=15$), or no current or previous auditory hallucinations ($n=15$). Affective psychotic patients were selected if they had current auditory verbal hallucinations ($n=10$). Lifetime history of auditory hallucinations was assessed from the case-notes and patient self-report. The number of participants recruited was determined by a power calculation based on data reported by Johns *et al.* (2001). The sample size necessary to detect differences in error rates was estimated to be 15 per group, based on comparisons between two groups using a *t* test with power set at 0·7, effect size of 0·8, and an alpha of 0·05 (GPOWER).

The currently hallucinating patient groups (schizophrenia and affective psychosis) were matched for severity of current auditory hallucinations and delusions. The group with no current or previous hallucinations scored highest on the delusions subscale. There were no significant differences between the four patient groups in the severity of negative symptoms and thought disorder (Table 1). The patient groups were compared with a group of 20 control subjects. All groups were matched for mean age and pre-morbid IQ (estimated using the

Table 1. *Personal characteristics of the five groups. The number in each cell is the group mean, with the range in parentheses. Symptoms were assessed using the SAPS and SANS, and rated from 0–5 (0 = none, 1 = questionable, 2 = mild, 3 = moderate, 4 = marked, 5 = severe)*

Variable	Current hallucinators ($n=15$)	Trait hallucinators ($n=15$)	Non-hallucinators ($n=15$)	Affective hallucinators ($n=10$)	Controls ($n=20$)	Group comparisons
Age (years)	35·3 (18–56)	32·3 (18–57)	36·8 (26–50)	40·9 (22–59)	33·7 (18–57)	$F=1{\cdot}17$, N.S.
Estimated pre-morbid IQ	100 (77–125)	105 (78–123)	107 (81–124)	107 (82–126)	110 (80–123)	$F=1{\cdot}17$, N.S.
Gender ratio (M : F)	11 : 4	13 : 2	11 : 4	5 : 5	12 : 8	$\chi^2=4{\cdot}9$, N.S.
Duration of illness (yr)	10·0 (1–31)	8·01 (1–28)	9·36 (1–20)	18·0 (2–31)	—	$F=2{\cdot}84$, $p=0{\cdot}048$
In-patient : out-patient ratio	11 : 4	0 : 15	14 : 1	9 : 1	—	$\chi^2=34{\cdot}8$, $p=0{\cdot}000$
Auditory hallucinations	4·0 (3–5)	0·07 (0–1)	0·0 (0–0)	3·67 (3–5)	—	$F=187{\cdot}5$, $p=0{\cdot}000$
Non-auditory hallucinations	0·8 (0–4)	0·02 (0–1)	0·13 (0–2)	0·28 (0–2)	—	$F=7{\cdot}57$, $p=0{\cdot}000$
Delusions	2·42 (1–4)	0·2 (0–2)	3·43 (2–5)	2·25 (1–3)	—	$F=33{\cdot}37$, $p=0{\cdot}000$
Positive formal thought disorder	0·4 (0–2)	0·27 (0–2)	1·07 (0–4)	0·25 (0–2)	—	$F=2{\cdot}42$, $p=0{\cdot}08$
Negative symptoms	1·4 (0–4)	0·87 (0–4)	1·25 (0–4)	1·27 (0–5)	—	$F=1{\cdot}24$, N.S.

SAPS, Scale for the Assessment of Positive Symptoms; SANS, Scale for the Assessment of Negative Symptoms.

NART – 2nd edition; Nelson & Willison, 1991) (Table 1). Participants gave written informed consent to participate in the study.

MATERIALS (Fig. 1)

Auditory feedback

Participants wore a set of stereo headphones with a microphone attached. They spoke into the microphone (sensitivity -60 ± 3 dB at 1 kHz), which was connected to an audio switch box, an amplifier and a personal computer. Auditory input was transmitted through the headphones, and the volume of the signal was adjusted to a level at which participants reported that they could hear their voice only through the headphones when speaking aloud. Participants' speech was distorted on-line using a Digital Signal Processing (DSP) PCI card in the computer. Its pitch was either unchanged (no distortion), or lowered by 2 semitones (moderate distortion) or 4 semitones (severe distortion). In the Alien Feedback condition, participants heard someone else's pre-recorded voice instead of their own as they spoke. This voice was matched to that of the participant for gender and local accent. The words had been recorded using Cool Edit 96 and saved as .WAV files, and had been distorted (as described above) on two thirds of trials. The participant's voice triggered the playing of a .WAV file via an audio switch and trigger box. The software (programmed in Visual Basic Version 6; Microsoft Corporation) controlled the stimulus presentation and auditory feedback.

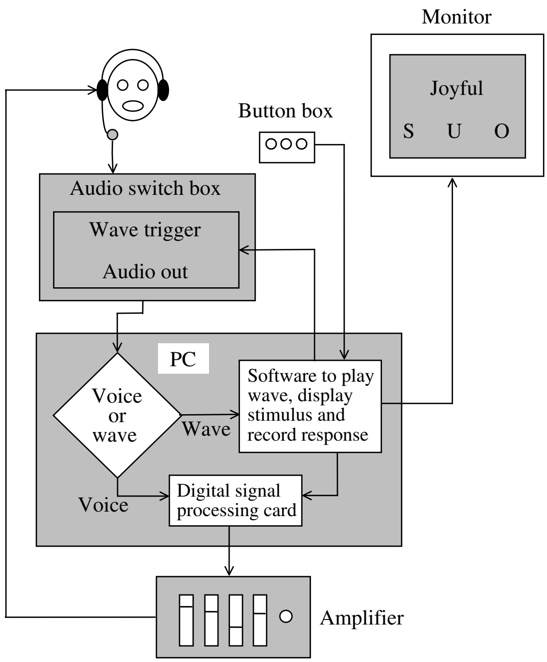

FIG. 1. Wiring diagram of the experimental paradigm.

Stimuli

The words presented were personal adjectives, chosen because they reflect the typically personal content of auditory hallucinations in psychotic disorders (Johns *et al.* 2001). Prior to the study, a list of 400 adjectives was given to 54 normal volunteers, who were asked to rate each adjective on a scale from −3 to +3 as to how 'negative', 'neutral', or 'positive' they

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thought it was when used to describe a person. The adjectives were ranked with respect to mean ratings of emotional valence, and 216 were selected to make up two comparable lists of positive, negative, and neutral word groups (see Appendix).

Design

Three experimental manipulations (feedback, distortion, and valence) were applied in a pseudo-randomized design. The 18 possible combinations of feedback, distortion, and valence were ordered randomly, with the constraint of no more than two consecutive trials of the same feedback and distortion combination. This procedure was repeated six times, and the six combination lists were ordered randomly to produce a complete playlist of 108 trials. Two playlists were generated for each word list, giving the following combinations: word list A, order1 (A1); word list A, order2 (A2); word list C, order1 (C1); word list C, order2 (C2). Participants were given one of four playlists (A1, A2, C1, C2), which were counterbalanced across the subject groups.

Procedure

Participants sat ~50 cm from the computer monitor, and responded by pressing buttons on a button box. They used their preferred hand, and rested their fingers in the same position between trials (indicated by a sticker). Participants were instructed to be as quick and as accurate as possible; and the computer recorded response choice. Participants completed the following tasks.

Practice 1: Reading Aloud (9 trials). Words were presented for 1000 ms, at 6-s intervals. Participants read each word aloud as soon it appeared, and heard their (undistorted) voice through the headphones.

Practice 2: Reading Aloud with Alien Feedback and/or Acoustic Distortion (12 trials). Participants heard either their voice or the pre-recorded 'alien' voice through the headphones as they read the words out loud; speech was distorted on half of these trials. The letters S, U, and O (for Self, Unsure, Other) were present at the bottom of the screen on each trial, and participants were required to indicate the source of the speech they heard by pressing the corresponding button on the box. The letter changed colour when participants pressed a button to indicate that their response had been recorded. Participants had 5 s in which to respond, then there was a 1-s interval before the next word appeared.

Experimental Task: Reading Aloud with Alien Feedback and/or Acoustic Distortion (108 trials). Participants heard either their own voice or the alien voice as they spoke, and the speech was distorted on two thirds of the trials. They made their decision about the source of the speech as described above. Their performance was observed by the investigator, and trials in which participants did not read the word, or read it incorrectly or after it had disappeared were subsequently discarded.

Data analyses

Analyses of variance (ANOVAs) for repeated measures used the general linear model (GLM) procedure. The reported results of tests of within-subjects factors are the univariate or averaged data. The significance of the F values was assessed using Greenhouse–Geisser corrected degrees of freedom.

An error was defined as either the misidentification of the source of feedback (Other instead of Self, and vice versa) or an Unsure response. The proportions of total errors and misidentification responses were calculated for each combination of feedback, level of distortion and word group, and these proportional data were transformed using the arcsine transformation. The transformed data were analysed using a four-way ANOVA for repeated measures. The within-subject factors were feedback (own voice, alien voice), distortion (none, moderate, severe), and word type (negative, positive, neutral). The between-subjects factor was participant group.

Not all the error data met the assumptions of normality and homogeneity of variance required for ANOVA. Nevertheless, ANOVA was used since it is robust against violations of these assumptions (Howell, 1992) and was the most appropriate analysis for the experimental design. Group comparisons were performed using independent samples t tests.

RESULTS

Table 2 shows the descriptive error data.

Specificity of findings to state and trait

These analyses compared patients with schizophrenia and current auditory hallucinations, patients with a history of auditory hallucinations who were currently hallucination-free, and controls. There was a significant interaction between feedback, level of distortion and group ($F=7{\cdot}53$, df=4, 94, $p<0{\cdot}001$). In the Reading Aloud condition, all participants made more errors as the acoustic distortion increased ($F=54{\cdot}36$, df=2, 47, $p<0{\cdot}001$) but the patients with current hallucinations made the most errors (distortion × group interaction: $F=4{\cdot}76$, df=4, 94, $p=0{\cdot}003$) (Fig. 2). The current hallucinators made more errors than both the controls (moderate distortion: $t=3{\cdot}93$, $p=0{\cdot}001$; severe distortion: $t=3{\cdot}93$, $p<0{\cdot}001$) and the trait hallucinators (moderate distortion: $t=2{\cdot}82$, $p=0{\cdot}01$; severe distortion: $t=2{\cdot}23$, $p=0{\cdot}034$). There was no difference in error rate between trait hallucinators and controls. The same pattern of results was obtained when the analysis was restricted to misidentification responses (i.e. excluded Unsure responses). There was a significant distortion × group interaction ($F=7{\cdot}22$, df=4, 94, $p<0{\cdot}001$), with the current hallucinators making more misidentification errors than both controls (moderate distortion: $t=3{\cdot}71$, $p=0{\cdot}002$; severe distortion: $t=3{\cdot}8$, $p=0{\cdot}001$) and trait hallucinators (moderate distortion: $t=3{\cdot}36$, $p=0{\cdot}004$; severe distortion: $t=2{\cdot}25$, $p=0{\cdot}03$) (Fig. 3).

In the Reading Aloud with Alien Feedback condition, there was an interaction between group and level of distortion ($F=4{\cdot}00$, df=4, 94, $p=0{\cdot}009$). When the alien feedback was *not* distorted, the current hallucinators made more total errors than controls [mean 41·7 (S.D.=21·9) *v.* mean 23·1 (S.D.=16·6); $t=2{\cdot}86$, $p=0{\cdot}007$], and there was a trend for the trait hallucinators to make more errors ($t=1{\cdot}88$, $p=0{\cdot}074$). The current hallucinators also made more misidentification responses than controls when the alien feedback was not distorted [mean 29·0 (S.D.=20·8) *v.* mean 15·1 (S.D.=14·1);=2·23, $p=0{\cdot}036$], but the trait hallucinators did not (distortion × group interaction: $F=3{\cdot}49$, df=4, 94, $p=0{\cdot}013$).

In summary, defective self-monitoring was evident in patients with schizophrenia with current auditory hallucinations but not in patients who had a history of hallucinations but were currently hallucination-free, i.e. it is state rather than trait-related.

Specificity of findings to current hallucinations

The analyses compared patients with schizophrenia and current auditory hallucinations, patients with schizophrenia with no current or previous auditory hallucinations, and controls. There was a significant interaction between feedback, level of distortion and group ($F=7{\cdot}35$, df=4, 94, $p<0{\cdot}001$). In the Reading Aloud condition, all participants made more errors as the acoustic distortion increased ($F=58{\cdot}3$, df=2, 47, $p<0{\cdot}001$) but the patients made proportionally more errors (distortion × group interaction: $F=4{\cdot}48$, df=4, 94, $p=0{\cdot}005$). Both patient groups made significantly more errors than controls (moderate distortion: $t=3{\cdot}93$, $p=0{\cdot}001$, $t=3{\cdot}14$, $p=0{\cdot}004$; severe distortion: $t=3{\cdot}93$, $p<0{\cdot}001$, $t=2{\cdot}08$, $p=0{\cdot}046$ respectively), and there was no significant difference between them (Fig. 2). When the analysis was restricted to misidentification (Other) responses, again both patient groups made more errors than controls when their speech was distorted (distortion × group interaction: $F=6{\cdot}23$, df=4, 94, $p=0{\cdot}001$; moderate distortion: $t=3{\cdot}71$, $p=0{\cdot}002$, and $t=3{\cdot}02$, $p=0{\cdot}006$; severe distortion: $t=3{\cdot}8$, $p=0{\cdot}001$ and $t=2{\cdot}51$, $p=0{\cdot}019$ for current hallucinators and non-hallucinators respectively) (Fig. 3). There was a trend for current hallucinators to make more misidentification responses than non-hallucinators when their speech was 'moderately' distorted ($t=1{\cdot}95$, $p=0{\cdot}065$) but the groups did not differ significantly when their speech was 'severely' distorted. There was an interaction between group and word type ($F=2{\cdot}54$, df=4, 94, $p=0{\cdot}046$). Both patient groups made more misattribution errors than controls for all word types, and the current hallucinators made significantly more errors than the non-hallucinators when the words presented were negative [mean 39·1 (S.D.=25·8) *v.* mean 21·2 (S.D.=15·6); $t=2{\cdot}3$, $p=0{\cdot}03$].

In order to examine whether the current hallucinators were particularly prone to misattributing their distorted voice to an external

Table 2. *Group means (standard deviations) for the percentage of total errors and misidentification responses for each combination of feedback, distortion level, and word type. There were six trials per combination*

Experimental combination			Current hallucinators		Trait hallucinators		Non-hallucinators		Affective hallucinators		Controls	
Feedback	Distortion	Word	All errors	Misidentif.	All errors	Misidentif.	All errors	Misidentif.	All errors	Misidentif.	All errors	Misidentif.
Self	None	Negative	15·9 (25·3)	5·4 (12·1)	6·1 (9·2)	3·3 (6·9)	6·1 (11·1)	2·2 (8·6)	26·3 (36·4)	12·3 (16·9)	0·0 (0·0)	0·0 (0·0)
		Positive	8·7 (16·4)	3·0 (7·9)	1·1 (4·3)	1·1 (4·3)	6·0 (10·8)	3·5 (9·7)	26·0 (34·5)	8·3 (17·9)	3·5 (6·4)	2·9 (5·9)
		Neutral	14·7 (23·6)	7·7 (14·7)	3·3 (9·3)	1·1 (4·3)	4·4 (9·9)	1·1 (4·3)	23·3 (31·6)	5·8 (12·4)	2·0 (8·9)	2·0 (8·9)
	Moderate	Negative	52·7 (37·5)	46·7 (40·1)	23·8 (29·6)	16·3 (20·6)	35·1 (32·2)	22·7 (20·9)	48·3 (37·6)	23·3 (34·4)	9·3 (16·7)	3·3 (8·7)
		Positive	44·2 (37·2)	37·9 (37·2)	14·9 (23·9)	4·7 (10·2)	32·9 (26·9)	19·3 (21·2)	43·3 (30·9)	12·0 (20·9)	12·5 (19·4)	7·5 (16·7)
		Neutral	53·0 (37·9)	40·8 (38·7)	19·7 (28·6)	3·8 (10·9)	33·6 (26·8)	21·1 (17·6)	33·7 (28·1)	10·3 (11·9)	10·8 (18·9)	3·3 (14·9)
	Severe	Negative	75·6 (30·8)	65·1 (34·8)	46·9 (34·4)	31·1 (32·4)	50·9 (35·3)	38·7 (33·6)	61·7 (36·0)	26·7 (28·5)	34·2 (32·6)	23·3 (25·0)
		Positive	71·5 (31·7)	54·2 (39·1)	44·3 (32·5)	29·1 (31·2)	51·3 (33·4)	40·2 (27·1)	66·7 (38·5)	29·2 (25·8)	30·8 (27·1)	15·0 (20·2)
		Neutral	69·6 (36·4)	57·3 (38·3)	47·3 (37·5)	35·1 (32·2)	57·5 (35·4)	48·7 (35·7)	70·7 (39·6)	28·3 (33·4)	28·3 (33·8)	19·2 (26·1)
Alien	None	Negative	45·6 (26·9)	32·0 (28·3)	39·1 (30·9)	18·2 (23·8)	36·2 (31·2)	29·6 (29·1)	41·8 (30·3)	22·2 (22·2)	15·0 (17·0)	11·7 (13·4)
		Positive	37·8 (31·9)	24·0 (21·8)	39·5 (30·8)	26·2 (22·7)	42·9 (24·6)	35·9 (25·6)	41·7 (37·9)	23·3 (30·6)	21·8 (20·9)	12·0 (17·3)
		Neutral	41·9 (26·1)	31·0 (23·6)	36·4 (29·8)	25·1 (26·0)	48·2 (31·9)	38·9 (35·0)	45·0 (27·3)	11·7 (13·7)	32·5 (20·6)	21·7 (21·0)
	Moderate	Negative	29·6 (29·1)	17·3 (23·9)	24·2 (28·9)	10·7 (19·3)	19·3 (22·1)	16·0 (21·8)	30·0 (25·8)	13·4 (15·3)	25·0 (19·9)	17·5 (19·9)
		Positive	33·8 (27·9)	22·2 (25·7)	31·3 (25·9)	21·3 (23·9)	33·1 (24·9)	24·9 (23·7)	50·8 (32·0)	27·5 (27·8)	31·8 (29·9)	21·7 (27·1)
		Neutral	19·6 (20·7)	6·7 (13·8)	21·6 (32·4)	12·4 (22·4)	27·8 (23·9)	20·6 (24·6)	32·7 (28·6)	17·7 (21·3)	23·2 (24·0)	12·0 (15·9)
	Severe	Negative	22·2 (21·0)	8·2 (13·4)	20·1 (26·5)	9·4 (20·6)	27·3 (26·6)	17·1 (25·6)	26·7 (35·3)	11·7 (22·3)	25·0 (25·6)	13·3 (17·6)
		Positive	33·2 (27·6)	18·0 (18·3)	24·0 (31·5)	14·1 (21·8)	37·1 (24·7)	24·0 (23·5)	40·3 (36·8)	29·2 (30·8)	25·6 (20·1)	12·7 (15·2)
		Neutral	18·0 (23·1)	10·0 (18·7)	24·4 (35·7)	11·3 (20·9)	29·7 (24·7)	21·4 (20·3)	52·7 (39·5)	28·0 (24·4)	30·8 (26·6)	10·8 (18·2)

Misidentif., Misidentification responses.

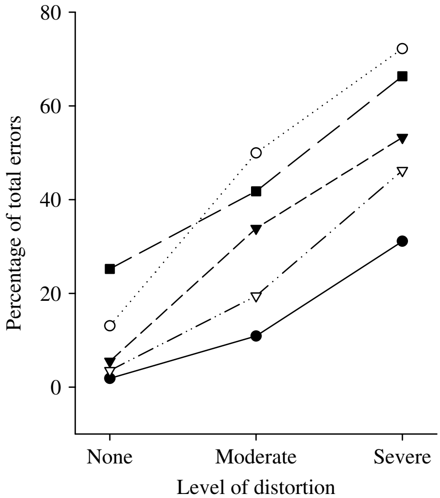

FIG. 2. Group means for the percentage of total errors at each level of distortion in the Reading Aloud condition. —●—, Controls; ····○····, patients with schizophrenia and current hallucinations (current hallucinators); – –▼– –, patients with schizophrenia and no current/previous hallucinations (non-hallucinators); –··▽··–, patients with a history of hallucinations but currently hallucination-free (trait hallucinators); – –■– –, patients with affective psychosis and current hallucinations (affective hallucinators).

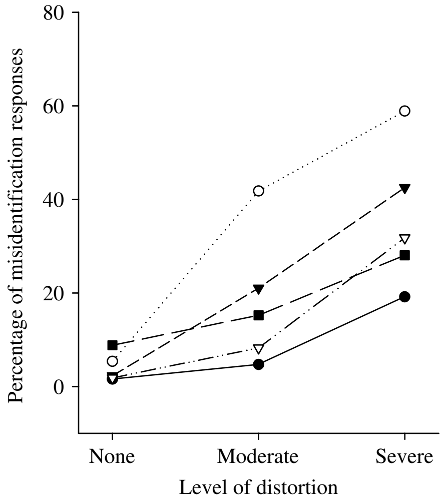

FIG. 3. Group means for the percentage of misidentification errors at each level of distortion in the Reading Aloud condition. —●—, Controls; ····○····, patients with schizophrenia and current hallucinations (current hallucinators); – –▼– –, patients with schizophrenia and no current/previous hallucinations (non-hallucinators); –··▽··–, patients with a history of hallucinations but currently hallucination-free (trait hallucinators); – –■– –, patients with affective psychosis and current hallucinations (affective hallucinators).

source, the proportion of Other relative to Unsure responses was calculated on the error trials. The data were transformed using the arcsine transformation, and the groups were compared using a one-way ANOVA. There was no significant difference between the three groups.

In the Reading Aloud with Alien Feedback condition, both patient groups made more errors than controls when the alien feedback was *not* distorted [distortion × group interaction: $F=3{\cdot}89$, df$=4$, 94, $p=0{\cdot}011$; mean 41·7 (S.D.$=21{\cdot}9$), $t=2{\cdot}86$, $p=0{\cdot}007$, and mean 42·5 (S.D.$=26{\cdot}2$), $t=2{\cdot}67$, $p=0{\cdot}012$ for current hallucinators and non-hallucinators respectively], but there was no difference between the patient groups. The pattern of results was the same for misidentification responses only [distortion × group interaction: $F=3{\cdot}40$, df$=4$, 94, $p=0{\cdot}024$; mean 29·0 (S.D.$=20{\cdot}8$), $t=2{\cdot}23$, $p=0{\cdot}036$, and mean 34·8 (S.D.$=27{\cdot}3$), $t=2{\cdot}55$, $p=0{\cdot}019$ for current hallucinators and non-hallucinators respectively].

In summary, misattributions of speech *were* apparent in patients with schizophrenia with delusions but no current or previous auditory hallucinations.

Specificity of findings to schizophrenia

These analyses compared the two groups with current auditory hallucinations (patients with schizophrenia and with affective psychosis) and controls. There was a significant interaction between feedback, level of distortion and group ($F=5{\cdot}42$, df$=4$, 84, $p=0{\cdot}001$). In the Reading Aloud condition, both patient groups made more total errors than the controls as acoustic distortion increased (distortion × group interaction: $F=3{\cdot}73$, df$=4$, 84, $p=0{\cdot}011$; for affective hallucinators, moderate distortion: $t=2{\cdot}95$, $p=0{\cdot}012$; severe distortion: $t=2{\cdot}84$, $p=0{\cdot}008$). There was no difference between the patient groups (Fig. 2). When the analysis was restricted to misidentification (Other) responses, there was again a distortion × group interaction ($F=7{\cdot}55$, df$=4$, 84, $p<0{\cdot}001$), but in this case the patients with schizophrenia made more misidentification errors than the affective patients (moderate distortion: $t=2{\cdot}47$, $p=0{\cdot}022$; severe distortion: $t=2{\cdot}45$, $p=0{\cdot}023$) as well as the controls (moderate distortion: $t=3{\cdot}71$, $p=0{\cdot}002$; severe distortion: $t=3{\cdot}8$, $p=0{\cdot}001$) (Fig. 3). There was a trend for the affective patients to make more misidentification errors than controls when their speech was 'moderately' distorted ($t=2{\cdot}01$, $p=0{\cdot}054$) but they did not differ from controls when their speech was 'severely' distorted.

In the Reading Aloud with Alien Feedback condition, the hallucinators with schizophrenia made more errors than controls when there was no distortion ($t=2{\cdot}86$, $p=0{\cdot}007$), whereas the affective hallucinators group made more errors than controls at all levels of distortion (distortion × group interaction: $F=3{\cdot}58$, df$=4$, 84, $p=0{\cdot}012$). When the analysis was restricted to misidentification responses, the pattern of results was the same for the schizophrenia group ($t=2{\cdot}23$, $p=0{\cdot}036$), but the affective hallucinators no longer differed from controls (distortion × group interaction: $F=4{\cdot}72$, df$=4$, 84, $p=0{\cdot}003$).

In summary, the tendency to make misidentification errors was not evident in patients currently experiencing auditory hallucinations in the context of an affective psychosis.

Summary

The percentage of total errors and misidentification responses made by each group in the Reading Aloud condition are shown in Figs 2 and 3 respectively.

DISCUSSION

This study examined defective verbal self-monitoring in psychosis, and evaluated the effects of state, trait, and diagnosis.

Specificity of findings to state and trait

Consistent with our first hypothesis, patients with schizophrenia who were currently experiencing auditory verbal hallucinations were more likely than controls to misattribute their own distorted speech to an alien source, replicating previous findings (Johns *et al.* 2001).

Contrary to our hypothesis, patients who had previously experienced auditory hallucinations but who were currently hallucination-free did not make more external misattributions than controls. If defective self-monitoring underlies auditory verbal hallucinations, then one might expect the deficit to be present in patients with a predisposition to hallucinate, even if they are not currently hallucinating. Indeed, neuroimaging studies have found that patients with a history of (but not current) hallucinations display abnormal regional activation when performing tasks that engage verbal self-monitoring, consistent with a trait phenomenon (McGuire *et al.* 1995; Shergill *et al.* 2000). It is possible that the vulnerability to hallucinations may be associated with impairments that are evident at the physiological but not the behavioural level. Ideally, the relationship between cognitive deficits and the hallucinatory state and trait would be investigated in the same individuals using a longitudinal design, but this approach is logistically difficult. In this study, although the patients with a history of hallucinations were matched with the current hallucinators clinically and demographically, the possibility that their better performance might have reflected some other difference cannot be excluded.

Specificity of findings to current hallucinations

An increased frequency of misattributions was also evident in patients with schizophrenia who had no hallucinations but were currently deluded, although there was a trend for this to be less marked than in the hallucinators. Errors were more common in the current hallucinators than in the non-hallucinators, but there was a considerable amount of within-group variance in the data (Table 2), and it is possible that the absence of a significant difference between the patient groups might reflect a type-2 error.

Nevertheless, while this finding was not predicted, it is consistent with a previous finding in a smaller group of deluded patients using the same paradigm (Johns *et al.* 2001), and with a report that misattributions were correlated with the severity of delusions (Cahill *et al.* 1996). Because patients with psychotic disorders with auditory hallucinations usually have delusions as well, it is even possible that misattributions in 'hallucinators' are related to their delusions rather than their hallucinations. According to Levelt (1983), verbal self-monitoring occurs at three levels: the level at which the command to speak is issued; the level of inner speech, when the intended output has been formulated, but not yet articulated; and the sensory level, when the speech is perceived following vocalization. Frith (1987) proposed that auditory verbal hallucinations reflect a deficit at the first level: impaired monitoring of the intention to generate speech. However, in the present study, as participants compared the perceived auditory feedback with their expected verbal output before responding, the paradigm also engaged the third level. The conscious appraisal of sensory information can be influenced by the participants' beliefs and decision-making style, both of which may be abnormal in patients with delusions (Garety *et al*. 1991).

The hallucinators made comparatively more misattribution errors than the non-hallucinators when the words they read were derogatory. This suggests that hallucinators might be particularly likely to attribute negative material to an external source, perhaps because they are currently experiencing hallucinations with negative content. The result is similar to previous findings (Johns *et al*. 2001).

Unexpectedly, both the hallucinators and the patients without hallucinations were also prone to misidentifying the source of someone else's undistorted speech, an impairment that was not evident when the alien speech was distorted. Similarly, Daprati *et al*. (1997) noted that patients with hallucinations or delusions tended to misattribute someone else's hand to themselves on a motor self-monitoring paradigm. These observations indicate that patients with hallucinations and/or delusions do not only make misattributions when speech is self-generated (Johns *et al*. 2001). They may be relatively more influenced than controls by the acoustic characteristics of speech when deciding on its source than by information generated internally (e.g. if the quality of this is compromised by faulty self-monitoring). In the present paradigm, the participant's and the alien voice were coincident, and the voices were matched for local accent and gender. This, plus the absence of acoustic distortion in the Alien Feedback condition, may have made 'self' seem a more plausible source to the patients. Conversely, because distortion made self-generated speech sound acoustically different to that of the patient, it may have made patients more likely to make an external attribution.

Specificity of findings to schizophrenia

Patients who were experiencing auditory hallucinations in the context of an affective psychosis had more difficulty than controls identifying the source of the auditory verbal feedback. However, while there was no difference in total error rate between this group and patients experiencing hallucinations in the context of schizophrenia, the patients with an affective psychosis were more likely to simply be unsure (rather than incorrect) about the source of the speech. Indeed, they made frequent unsure responses in all the conditions where the feedback differed from their usual voice, suggesting that they were prone to be uncertain in response to any perturbation to the normal auditory signal.

The extent to which the relationship between impairments in cognitive self-monitoring and psychopathology is specific to schizophrenia or generic to psychotic disorders is unclear. However, Blakemore *et al*. (2000) reported that defective self-monitoring was associated with the presence of auditory hallucinations and/or passivity symptoms in a mixed group of patients with either schizophrenia or affective disorder. This is consistent with other data suggesting that deficits in executive function in psychotic disorders are more related to symptom profile than to diagnosis (Kravariti *et al*. 2005). Nevertheless, the tendency for hallucinators with affective psychosis to make 'unsure' responses rather than the misattributions seen in hallucinators with schizophrenia suggests that factors related to the underlying disorder may also have influenced task performance.

CONCLUSIONS

External misattributions in the context of distorted auditory verbal feedback are associated with auditory verbal hallucinations, are more related to current symptoms than a trait vulnerability, and are less evident in patients with affective psychosis than schizophrenia. While these findings are consistent with a deficit in verbal self-monitoring, evidence that misattribution errors are also made by patients with delusions but no hallucinations suggests that impairment in other cognitive processes, such as the appraisal of anomalous sensory stimuli, are also involved. Further work is needed to examine the relationship between bottom-up (self-monitoring) and top-down (decision-making) factors in the formation of auditory verbal hallucinations.

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DECLARATION OF INTEREST

None.

APPENDIX. Adjectives used in the task

Word list A			Word list C		
Negative words	Positive words	Neutral words	Negative words	Positive words	Neutral words
smelly	wise	unlucky	feeble	kind	normal
brutal	joyful	standard	wicked	handsome	watchful
hated	loving	local	rotten	fantastic	tall
foolish	well	cheeky	sleazy	sensible	huge
lazy	free	familiar	doomed	good	modern
hurtful	cherished	right	useless	lucky	adult
dumb	relaxed	sharp	ugly	bold	conscious
sinful	charming	hot	horrible	superb	tiny
nosey	skilful	injured	dull	cheerful	awake
horrid	brave	average	wrong	special	busy
violent	lively	okay	vile	playful	dry
greedy	angelic	small	loser	positive	broad
dreadful	fresh	shy	harsh	warm	common
greasy	winning	alright	shameful	balanced	thirsty
crazy	friendly	modern	powerless	fit	young
inferior	perfect	straight	cheating	brilliant	dressed
despised	kind	skinny	bad	selfless	okay
rude	loyal	harmless	dirty	funny	slender
stupid	calm	busy	decayed	knowing	regular
worthless	special	private	failure	strong	rich
boring	gentle	living	dodgy	loving	suitable
scruffy	beautiful	common	hateful	happy	perplexed
foul	wealthy	old	awful	popular	ready
freakish	brainy	neutral	unkind	cuddly	short
sloppy	gifted	thirsty	insane	terrific	tired
evil	respected	working	loathed	bright	British
crude	lovable	thin	creepy	skilful	hungry
vulgar	fearless	hairy	battered	grand	living
faulty	thoughtful	young	hopeless	overjoyed	vague
disturbed	fair	orderly	damaged	elegant	slim
rejected	happy	awake	spiteful	blessed	neutral
cruel	powerful	usual	flabby	pure	factual
sick	clean	large	tragic	lively	proud
hostile	amazing	quiet	filthy	wise	odd
jealous	strong	sleepy	repulsive	lovable	placid
defective	cheerful	human	rubbish	creative	large

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