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Referential delusions of communication and reality discrimination deficits in psychosis

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Background. There appear to be two kinds of delusion of reference, which vary independently: delusions of observation and delusions of communication. It has been suggested that delusions of communication might derive from an impairment in reality discrimination, though the impairment would be centred on non-verbal channels in delusions of communication as opposed to verbal channels in auditory hallucinations.

Method. Patients ($N = 64$) with acute psychotic symptoms were recruited according to a 2×2 design: presence versus absence of delusions of communication crossed with presence versus absence of auditory hallucinations. They were presented with 100 brief video clips in which an actor either made a well-known gesture or an incidental movement, with the clips being obscured by visual noise. For each clip, the patients indicated how confident they were that a gesture was portrayed.

Results. According to a signal detection analysis, all groups showed adequate sensitivity and the groups did not differ in sensitivity, but patients with delusions of communication showed a bias to report gestures which was not shown by patients with hallucinations. A control group of healthy volunteers ($N = 57$) showed significantly greater sensitivity than the patients and a more conservative bias than patients with delusions of communication.

Conclusions. A bias to report gestures is not part of a general tendency to externalize one's own thoughts but may be the result of a reality discrimination deficit that is specific to delusions of communication. A possible theoretical explanation for such a deficit is discussed.

Delusions of reference are one of the most common psychotic symptoms. For example, they have been found in 67% of people with a diagnosis of schizophrenia (World Health Organization, 1973) and in 64% of inpatients suffering from a psychotic disorder (Minas *et al.*, 1992). Despite this prevalence, only Frith (1992) has developed a theory about the

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cognitive processes involved in delusions of reference, and even this theory assumes that delusions of reference are closely associated with persecutory delusions and third-person auditory hallucinations. This now appears to be incorrect for at least some of the symptoms that are usually grouped together as delusions of reference. M. Startup and S. Startup (2005) noted that, among the variety of delusions of reference, some concern the mistaken sense that others are communicating by subtle and oblique non-verbal means (e.g. prosody, gestures, stances, arrangements of objects), while other delusions concern the false belief that others are surreptitiously observing or spying (e.g. using surveillance equipment). In order to test their hypothesis that delusions of communication and of observation are independent of each other, Startup and Startup conducted interviews with 57 participants with a diagnosis of schizophrenia using questions targeted at seven particular referential delusions. A factor analysis of ratings from these interviews revealed two factors. The first factor had high loadings from items representing beliefs that others were communicating through subtle non-verbal means, through the public media, and via the arrangement of inanimate objects, and thus represents delusions of communication. The second factor had high loadings from items representing beliefs that others were secretly gossiping and maintaining surveillance, and therefore represents delusions of observation. This second factor was strongly associated with hallucinations and persecutory delusions, but delusions of communication showed few significant correlations with other positive psychotic symptoms.

M. Startup and S. Startup (2005) noted that referential delusions of communication are similar to auditory hallucinations in that what seems to the patient to be communicated concerns the self and originates from the self, though the origin is not recognized but attributed externally. They suggested that these delusions might derive from tendencies to misattribute self-produced cognitions to an external source or, in other words, from impairments of what Bentall (1990) referred to as reality discrimination.[1] Startup and Startup proposed that the main difference between auditory hallucinations and delusions of communication is that the impairment of reality discrimination is centred on non-verbal channels (including speech prosody) in delusions of communication as opposed to verbal channels in auditory hallucinations. The plausibility of such a dissociation is supported by neuropsychological studies of affect perception among people with focal cortical lesions, which suggest that the right cerebral hemisphere contains a modularized lexicon of non-verbal affective signals (Bowers, Bauer, & Heilman, 1993).

The main aim of the present study was to use signal detection theory (SDT) to test the theory that delusions of communication derive from an impairment of reality discrimination which is centred on non-verbal channels of communication. According to SDT (McNicol, 1972), reporting of a signal from the environment is a function of both signal sensitivity and response bias. Sensitivity refers to the amount of evidence that is available to the person, while bias refers to the amount of evidence the person requires before

[1] *A variety of terms has been used, rather inconsistently, to refer to impairments in the ability to identify the source of information. The terms 'source monitoring' (Johnson, Hashtroudi, & Lindsay, 1993) and 'reality monitoring' (Johnson & Raye, 1981) generally refer to the ability to* remember *the origin of information, whereas the terms 'reality discrimination' (Bentall, 1990) and 'reality testing' (Bentall & Slade, 1985) have been used to describe the ability to distinguish between the current real and imagined events. Frith (1992) used the term 'self-monitoring' deficits to refer to the misattribution of self-generated actions or thoughts to an external source. However, this term tends to be associated with Frith's theory that the misattribution arises from a malfunction of the systems that monitor current intentions. We have adopted the term 'reality discrimination' here to avoid implying any particular causal mechanism.*

reporting a signal. In order to apply this framework, a novel task was developed in which participants were presented with brief video clips of equal numbers of well-known gestures (communicating some meaning) and incidental movements (not intending to communicate) and they were asked to indicate, immediately after each clip, how likely they thought it was that a gesture had been presented. All of the clips were partially obscured with visual 'noise'. If delusions of communication result from faulty reality discrimination, then people with these delusions are expected to show a bias towards detecting non-verbal communications. That is, they would require less evidence than other people that a video clip showed a gesture before reporting that a gesture was shown. According to the theory, this would happen because they would attribute internally generated cognitions, which had been activated by the video clips, to an external source.

It is also possible that delusions of communication result from sensory disorder or poor processing of external stimuli. If this were the case, then people with such delusions would have impoverished evidence for gestures and would show poor signal sensitivity. However, although poor sensitivity might lead to misinterpretations, there would be no reason to expect those misinterpretations to be self-referential. Therefore, it is expected that people with delusions of communication will show no less sensitivity than psychotic people without these delusions. However, since people with schizophrenia show wide-ranging deficits in non-verbal social perception (Toomey, Schuldberg, Corrigan, & Green, 2002), and in particular have been found to misinterpret averted gazes as directed at themselves (Hooker & Park, 2005) and to misinterpret body postures and movements (Bigelow *et al.*, 2006), it is expected that psychotic patients will show less sensitivity than the healthy control participants.

We are suggesting that auditory hallucinations and delusions of communication rely on different, largely independent information-processing systems; that the former rely on auditory–verbal systems of reception and production while the latter rely on the non-verbal affect lexicon. Thus, we expected that no bias to perceive gestures would be associated with the presence versus absence of auditory hallucinations, and that having hallucinations in addition to delusions of communication would not augment the bias of people with delusions of communication. However, since positive psychotic symptoms in general appear to be related to an externalizing bias in the processing of sensory stimuli (Allen *et al.*, 2004), we expected that the patients as a group would demonstrate more bias on the task than the healthy controls.

A secondary aim of the present study was to test whether M. Startup and S. Startup's (2005) finding of two kinds of delusion of reference could be replicated with an independent sample.

Method

Participants

Eighty-seven people with positive psychotic symptoms, who had recently been admitted to a psychiatric hospital, were invited to take part in the study once their psychiatrist had declared them capable of providing informed consent. Sixty-four (74%) accepted the invitation and completed the interview and experimental task. For the healthy control sample, 200 people from the volunteer panel of a medical research institute were invited to participate. Fifty-seven (29%) accepted the invitation and completed the questionnaires and experimental task. Only people over the age of 18 years were invited to participate and all provided written consent after the purpose and the procedures of the study had been explained. The exclusion criteria common to both samples were (i) evidence of organic brain impairment; (ii) inadequate English fluency; and (iii) visual impairment that could not be corrected to normal. In addition, the control participants were required never to have been diagnosed with a mental illness, and the patients were excluded if they had questionable, mild or infrequent delusions of communication or auditory hallucinations (to allow for clear separation between those with and without these symptoms); or mild, moderate, or severe visual hallucinations (necessary given the visual nature of the experimental task). Characteristics of both the control and patient participants are shown in Table 1.

Table 1. Key characteristics of the patients ($N = 64$) and control ($N = 57$) samples

Characteristic	Patients Mean (*SD*) or %	Controls Mean (*SD*) or %
Mean age in years (*SD*)	34.2 (11.7)	39.6 (16.3)
Male	62.5%	24.6%
Australian born	92.2%	84.2%
Never married	76.6%	42.1%
Living arrangements		
with parents	37.5%	12.3%
alone	39.1%	12.3%
other	23.4%	75.4%
No current employment	73.4%	7.0%
Mean estimated IQ (*SD*)	99.9 (12.5)	111.8 (7.7)
Diagnoses		
Schizophrenia spectrum	62.5%	
Affective psychoses	29.7%	
Other	7.8%	

Clinical measures

Auditory hallucinations among the patients were assessed using four items from the Scale for the Assessment of Positive Symptoms (SAPS; Andreasen, 1984): 'auditory hallucinations'; 'voices commenting'; 'voices conversing'; and 'global rating of the severity of auditory hallucinations'. Participants who scored 4 or 5 (marked or severe) on the global rating, and had experienced the symptoms within a week of assessment, were assigned to the 'auditory hallucinations present' group. Visual hallucinations were also measured by the SAPS 'visual hallucinations' item. No participant obtained a score of 2 or more on this item.

Questions and probes of the Referential Delusions Interview (M. Startup & S. Startup, 2005) were used to inquire about delusions of reference and ratings were made, using 6-point severity scales modelled on those of the SAPS, on seven kinds of delusions: whether the participant believed that information was being communicated (1) *verbally* (e.g. hints, double meanings); (2) *non-verbally* (e.g. gestures, stances); (3) by the *public media* (e.g. TV, radio); (4) by *animals*; (5) via *inanimate objects/processes* (e.g. lights flickering, arrangements of objects); and whether participants believed others were surreptitiously (6) *gossiping* or spreading rumours or (7) keeping them under *surveillance* or following them. Global ratings were also made on the severity of delusions of communication using a scale modelled on item no. 14 of the SAPS. Participants who scored 4 or 5 (marked or severe) on this item and had experienced the symptoms within a week of assessment were assigned to the 'delusions of communication present' group. The extent to which the content of the delusions reflected guilty, grandiose–elated–erotomanic, or persecutory themes was also rated on 4-point scales.

The global cognitive functioning of both patients and controls was assessed using the National Adult Reading Test (NART), which has been found to provide good estimates of premorbid IQ even in acutely ill, unmedicated, and chronic schizophrenia patients (Crawford *et al.*, 1992).

Signal detection task

The experimental task used short video clips of an actor making a series of movements towards a video-camera, with each movement being either a well-known gesture (intending to communicate a meaning) or an incidental movement (not intending to communicate). The clips showed a female actor in a well lit, quiet room. Each had a lead in and out time of one second where the actor was seated in a neutral and stationary position gazing at the camera. All clips were similar in duration (mean $= 3.7 \pm 0.4$ seconds). During a pilot study, ratings of confidence that a gesture had been presented were used to select, from a larger pool, 10 gestures with the greatest confidence scores, and 10 incidental movements with the lowest scores. These are described in the Appendix. During a second pilot study, an appropriate level of visual noise was chosen to obscure the video clips in order to avoid ceiling effects with healthy participants and floor effects with a clinical population. The amount of noise was set at a level to give a d' value of about 1.5 among the healthy pilot participants. Details of the piloting are available on request from the second author.

The selected video clips were displayed at full screen size on a colour monitor. Participants were informed that the experiment was about how people perceive gestures. The instructions were as follows:

> There are times when people deliberately communicate some meaning to you with gestures. For example, if you were on the other side of the room and I wanted to speak with you, I might wave my hand like this [*researcher demonstrates beckoning*] rather than yell across the room. However, there are also times when people make movements that are not meant to communicate anything at all [*researcher demonstrates brushing hair away from eyes*]. These are not gestures. What I would like you to do now is watch the clips on the computer screen and tell me whether you think the actress made a gesture or not. Does that make sense? [*Instructions were repeated if necessary*]. Over the next few clips you will see an actress making some movements. The first few clips will be clear, but the next few will have a fuzzy snow picture over the top of the clips so they will be a bit difficult to see. After each clip, I would like you make a response on the box here about whether you think you saw someone making a gesture or not. The task is a bit difficult, so rather than answer 'yes' or 'no', you will have a choice of four options. You press "1" on the box if you definitely saw a gesture; "2" if you think you saw a gesture, but can't be sure; "3" if you think you did not see a gesture, but can't be sure and "4" if you definitely did not see a gesture. How does that sound? [*Instructions were repeated if necessary*].

Experimental trials were preceded by eight easy practice trials: four non-obscured and four obscured clips of two gestures and two incidental movements each. Feedback was given after each one. The signal detection task consisted of 50 gesture trials and 50 incidental movement trials presented in 5 blocks of 20 trials. The same 20 clips were presented in each block but each participant was presented with a different random order of clips. Participants were able to take breaks between trials to prevent fatigue. No time limit was set for responses.

Signal detection analyses

Patients mainly used definite (1 or 4) ratings (92%), so we aggregated 1 and 2 (gesture) and 3 and 4 (non-gesture) ratings in all further analyses. Sensitivity was measured by $d' = Z(H) - Z(FA)$, where $Z(H)$ and $Z(FA)$ represent the inverse function of the standard normal cumulative distribution for hit (H, i.e. respond 'gesture' to gesture stimuli), and false alarm (FA, i.e. respond 'gesture' to non-gesture stimuli), probabilities (McNicol, 1972). Response bias was measured by $C = -(Z(H) + (Z(FA))/2$ (Snodgras & Corwin, 1988). A neutral responder has a C value of 0; positive values of C represent strict or conservative responding (i.e. non-gesture bias) while negative values represent liberal responding (i.e. gesture bias). In both of these measures, scores are undefined for a H probability of 1 and a FA probability of 0 as the corresponding Z scores are infinite. Therefore, corrected H and FA probabilities were calculated by adding 0.5 to gesture response frequencies and dividing by $N + 1$, where N is the number of trials (Snodgras & Corwin, 1988). All significance tests were two tailed. In view of the small sample, no adjustments for the number of statistical tests were made.

Results

The interviewer recorded patients' responses verbatim on the interview schedule and 19 interviews were then rated for symptom severity by the second author who was blind to the interviewer's ratings. The results are shown in Table 2 where it can be seen that inter-rater reliability (intra-class correlations) for all items was high and significant. Therefore, the interviewer's ratings were used in subsequent analyses.

Table 2. Reliabilities and factor loadings for categories

		Factor loadings[a]		
Categories	Inter-rater reliability	I	II	Correlation with hallucinations[b]
A. Communications				
Verbal	1.00*		0.60	0.08
Non-verbal	0.99*		0.35	0.16
Public media	0.89*		0.84	0.14
Animals	0.97*			0.06
Inanimate	0.99*		0.64	0.16
B. Observations				
Gossip	1.00*	0.33		0.40*
Surveillance	0.99*	0.85		−0.01
C. Content				
Guilt	1.00*			–
Grandiosity	0.80*			–
Persecution	0.89*	0.99		–

*$p < .01$.
[a] Only factor loadings >0.3 are shown.
[b] Correlation with global severity rating for auditory hallucinations.

Factor analysis

In order to check whether the clustering of referential delusions in the current study corresponds to the two factors found by M. Startup and S. Startup (2005), the items of the Referential Delusions Rating Scale were entered into a maximum-likelihood factor analysis. Two factors, as indicated by a scree plot, were extracted and then rotated via varimax. As with the previous analysis, *animals* and *guilt* were excluded due to their low frequencies. Salient item loadings on the two rotated factors are shown in Table 2 where it can be seen that the first rotated factor had salient loadings from *gossip* and *surveillance*, and therefore represented delusions of observation. This factor also had a very high loading from the thematic content *persecution*. The second rotated factor had salient loadings from *verbal*, *non-verbal*, *public media*, and *inanimate objects*, and therefore represented delusions of communication. Thus, the previous results were closely replicated. Table 2 also shows correlations between each of the delusions of reference and the global severity rating for auditory hallucinations. It can be seen that all of the correlations involving individual delusions of communication were non-significant and that the correlation with *gossip* was significant. These results replicate the findings of M. Startup and S. Startup (2005), though the non-significant correlation with *surveillance* does not.

Signal detection test

The patients were assigned to four groups based on the severity thresholds for the global rating of auditory hallucinations and the global rating of delusions of communication. There was perfect agreement between the interviewer and the independent assessor on the assignment to their respective groups of the 19 participants that they both assessed. The data for four participants were removed from the signal detection analyses, one because the participant responded the same to every clip, and three because they produced negative d' values. Table 3 provides summarized results for the remaining participants in each group.

These groups did not differ significantly on any of the categorical variables shown in Table 1, but schizophrenia spectrum disorders were rather more common in the groups with delusions of communication ($\chi^2(3) = 7.31$, $p = .06$). When the continuous

Table 3. Percentages and means of covariates, sensitivity (d') and bias (C), with standard errors, for five groups

	Delusions of communication				
	Present		Absent		
	Auditory hallucinations				
	Present	Absent	Present	Absent	Controls
N	17	15	11	17	57
Schizophrenia spectrum (%)	76	73	45	41	0
% male	65	73	73	59	25
Age in years (SE)	30.1 (2.0)	31.2 (2.7)	32.1 (3.9)	40.8 (3.0)	39.6 (16.3)
Estimated IQ (SE)	98.7 (2.8)	102.1 (3.4)	98.7 (4.6)	99.2 (3.3)	111.8 (1.0)
d' (SE)	1.35 (0.18)	1.10 (0.19)	1.13 (0.22)	1.49 (0.19)	1.71 (0.11)
C (SE)	−0.45 (0.13)	−0.54 (0.13)	−0.02 (0.15)	−0.31 (0.13)	0.19 (0.07)

variables were analyzed in a 2 (delusions of communication; present vs. absent) × 2 (auditory hallucinations; present vs. absent) design, no significant effects were found for IQ, but for age a marginally significant difference was found for the main effect of delusions of communication, $F(1, 56) = 3.31$; $p = .074$. Age was negatively correlated with bias ($r = -.24$, $p = .06$), indicating that older participants were more biased to detect a gesture.

The mean d' scores for the four groups are shown in Table 3. In all cases, d' was significantly greater than 0 (grand mean = 1.28), showing that all groups had good sensitivity. *C* was significantly less than zero, demonstrating a bias to detect gestures, for all but the group with auditory hallucinations alone. Group differences in mean d' and *C* were analyzed using a 2 (delusions of communication) × 2 (auditory hallucinations) ANCOVA with age as a covariate. Group means adjusted to an age of 33.8 years are shown in Table 3. No effects approached significance for d', but for *C* the main effect of delusions of communication was significant, $F(1, 55) = 6.32$, $p = .015$, with the adjusted marginal mean when delusions of communication were present (−0.49) being less than when absent (−0.14). This result indicates that participants with delusions of communication were more biased to detect gestures than participants with no delusions of communication. The main effect for hallucinations ($F(1, 55) = 2.42$, $p = .13$) and the interaction term, $F(1, 55) = 0.76$, $p = .39$) were both non-significant. When a diagnosis of a schizophrenia spectrum disorder, as a dichotomous variable, was entered as an additional covariate, the results for d' and *C* remained substantially the same.

The mean d' and *C* scores for the control group are shown in Table 3. The mean d' ($t = 16.8$, $p < .001$) and the mean *C* ($t = 3.41$, $p = .001$) scores were both significantly greater than 0. Thus, the controls were highly sensitive to gestures but slightly biased *against* reporting them. The controls differed significantly from the patients in age, $t(99.3) = 2.20$, $p = .03$, estimated IQ, $t(94.7) = 6.11$, $p < .001$, and gender ratio, $\chi^2(1) = 20.9$, $p < .001$. In a comparison with the patients, with these three variables entered as covariates, the controls were found to have a significantly higher mean d', $F(1, 112) = 6.83$, $p = .01$. In subsequent simple contrasts, the control group mean was found to be significantly higher than that of three of the psychotic patient groups but not the group which had neither delusions of communication nor auditory hallucinations ($p = .08$). When *C* was entered as the dependent variable in an ANCOVA with the same covariates, the mean *C* of the controls was found to be significantly larger than that of the patients as a group, $F(1, 112) = 33.03$, $p < .001$. Thus the controls had less bias to perceive gestures. In subsequent simple contrasts, the control group mean was found to be significantly larger than that of three of the psychotic patient groups but not the group which had auditory hallucinations without delusions of communication ($p = .32$). Since the patients and the controls differed significantly on d', these analyses were repeated with d' entered as an additional covariate, but the results remained essentially the same.

Discussion

One aim of the present research was to investigate whether the finding by M. Startup and S. Startup (2005) of two kinds of delusions of reference could be replicated. As in the previous study, it was found that seven delusions of reference could be reliably identified and a factor analysis revealed that ratings of these delusions separated into two distinct factors: delusions of observation and delusions of communication. These results substantially replicated the structure found previously, as did the findings that delusions of communication are independent of auditory hallucinations and that only delusions of observation are associated with persecutory themes. Possible relationships between delusions of observation, auditory hallucinations, and persecutory delusions have been discussed by M. Startup and S. Startup (2005).

Regarding the signal detection analyses, the results for sensitivity showed that all patient groups performed the task at greater than chance levels, indicating that their responses were not mere guesses. Although the patients in general showed less sensitivity than the healthy controls, there was no evidence that the presence versus absence of delusions of communication or of auditory hallucinations differentially impacted on perceptual sensitivity. This finding is similar to previous research investigating reality discrimination deficits among people with auditory hallucinations. For example, Bentall and Slade (1985) used an auditory signal detection task of words embedded in white noise and found no difference in perceptual sensitivity between people with hallucinations, and those highly disposed towards hallucinations, compared with patients without hallucinations and those not disposed to hallucinations, respectively.

The patients as a whole had lower sensitivity than the healthy controls. This is unlikely to be due to the difficulties people with schizophrenia have in recognizing emotions from faces or from eyes because the level of noise imposed on the video clips made it difficult for anyone to perceive facial features. However, the lower sensitivity might be partly due to the tendency of people with schizophrenia to misinterpret averted gazes as directed at themselves (Hooker & Park, 2005) and to misinterpret body postures and movements (Bigelow *et al.*, 2006).

The main hypotheses regarding the measure of bias were also supported. There was a significant main effect for the presence versus absence of delusions of communication showing that people with delusions of communication were more liberal responders on the signal detection task. That is, they needed less evidence to report that a gesture was present under conditions of uncertainty. This result is similar to those of Bentall and Slade (1985) who found that, compared with controls, people with auditory hallucinations, and those prone to hallucinations, were more biased to report hearing a voice embedded in white noise.

Bentall and Slade (1985) suggested that the bias they detected resulted from reality discrimination deficits, that is, because people with a disposition to auditory hallucinations misattribute self-generated events to an external source. Likewise, the bias we detected might be due to a similar misattribution of internally generated cognitions concerning gestures, but this is not the only possible interpretation. For example, it is well known that decision-making is influenced by the perceived costs and benefits associated with hits and false alarms (McNicol, 1972). However, there were no obvious costs or benefits in the current study and there is no reason to believe that people with delusions of communication would be more influenced by such contingencies than people without these symptoms even if there had been any. Another possibility is that the results were due to an externalizing response bias that was unrelated to internally generated cognitions. Such a possibility is suggested by a study by Allen *et al.* (2004) in which patients with schizophrenia were required to listen to distorted recordings of single adjectives spoken by themselves or another person. It was found that the patients who had positive psychotic symptoms were more likely than patients without those symptoms to misidentify recordings of their own speech as alien. Since the patients were not required to speak any of the words during the test, their bias could not have derived from faulty self-monitoring.

Such an externalizing response bias might help to explain why, in the present study, the patients as a group showed a more liberal bias than the controls. However, the patients with hallucinations but no delusions of communication did not differ from the controls in bias and, among the patient groups, the main effect for auditory hallucinations and the interaction term were non-significant. These findings suggest that the bias to report gestures cannot be wholly due to a general externalizing response bias. The bias to report gestures appears to be, at least in part, specific to delusions of communication. That is, in contrast to people with auditory hallucinations, who have impaired reality discrimination for verbal material, people with delusions of communication appear to be impaired in reality discrimination for non-verbal material. In other words, delusions of communication appear to involve reality discrimination errors similar to those found in hallucinations, except that in delusions of communication what is 'hallucinated' is not a verbal but a non-verbal communication.

If delusions of communication derive from the misattribution of self-generated internal events to an external source, this would help explain why these delusions are self-referential. How, though, are such misattributions to be explained? One possibility is that reality discrimination deficits reflect failure of intentional inhibition of currently irrelevant memories, and other mental associations, which are not recognized as such because of deficits in contextual memory. This theory has been supported when applied to auditory hallucinations (Badcock, Waters, Maybery, & Michie, 2005; Waters, Badcock, Maybery, Michie, 2003; Waters, Badcock, Michie, & Maybery, 2006; Waters, Maybery, Badcock, & Michie, 2004). It seems possible that delusions of communication might also be explained in these terms though, presumably, what would distinguish delusions of communication from auditory hallucinations would be that, in the former, the content of the intrusive memories would concern previous non-verbal communications, while the memories in the latter would concern verbal and other auditory stimuli. The plausibility of a dissociation between these different kinds of memories is supported by neuropsychological studies of affect perception among people with focal cortical lesions (Bowers *et al.*, 1993). It is possible, then, that the *difference* between delusions of communication and auditory hallucinations is that voices perceived in the absence of appropriate sensory stimulation (i.e. hallucinations) rely on the verbal route of communication, while non-verbal communications perceived in the absence of appropriate sensory stimulation (i.e. delusions of communication) are processed through non-verbal channels. Of course, further research is required to test this hypothesis.

Interpretations of the findings should be made in the light of methodological limitations. Firstly, according to chart diagnoses, schizophrenia spectrum disorders were more common in the groups with delusions of communication. This is not surprising, given that diagnoses are partly based on these symptoms, but it does mean that group membership, diagnosis and, perhaps, severity of illness, are confounded to some extent. Severity of illness was not assessed directly. However, since the group with neither delusions of communication nor auditory hallucinations did not have the smallest bias, and the results for the signal detection task remained essentially the same when diagnosis was controlled, this confounding is unlikely to be important. Another limitation is that the data of four of the participants needed to be excluded from the signal detection analyses. These exclusions were justified on the grounds that responding to every clip in the same way suggested the participant had misunderstood the task requirements, and obtaining negative d' values suggested that the participants were probably confused about the assignment of response buttons. However, the result was that the sample for these analyses was small and included only two-thirds of the eligible participants. Finally, it should be noted that the patients who had neither delusions of communication nor auditory hallucinations showed a rather elevated bias to report gestures. Although they did not differ significantly in bias from the patients with hallucinations but no delusions, they did differ significantly in this respect from the controls. Since it has been found that patients with delusions but no hallucinations are almost as likely as patients with current hallucinations to show an externalizing bias in a self-monitoring task (Johns, Gregg, Allen, & McGuire, 2006), our findings for this group might have been due to the presence of some kinds of delusions which were not assessed. This possibility deserves scrutiny in future research.

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Appendix

Movements used in the signal detection task.

Gestures	Incidental movements
Hand in front to indicate 'Stop'	Chew nails
Hand to ear to indicate 'I can't hear you'	Brush hair with hair brush
Hand in front to wave 'Hello'	Tuck hair behind ears
Hand to lips to blow a kiss	Fix an earring
Head shake from side to side to indicate 'No'	Swat a fly in front of face
Hand in front beckoning 'Come here'	Apply lipstick
Fingers crossed to indicate 'Good luck'	Scratch neck
Shrug shoulders to indicate 'I don't know'	Answer a mobile phone
Finger to lips to indicate be quiet ('Shh')	Tie up shoelace
Thumbs down to indicate 'No good'	Pull socks up