

**Neuropsychological bases of reality-monitoring deficits  
in schizophrenic patients with hallucinations**

**Final report**

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## **Neuropsychological bases of reality-monitoring deficits in schizophrenic patients with hallucinations**

### **Background**

This study was designed to investigate reality monitoring in schizophrenic patients with hallucinations. Reality monitoring is a cognitive function that enables discrimination between imagination and perception. It has been suggested that a deficit in this function was a basis for hallucinations. We designed a task in which various reality-monitoring errors in both verbal and visual material could be explored. We studied the relationships between these errors and auditory and visual hallucinations. The relationships with delusions were studied as well, to show the specificity of the associations with hallucinations.

### **Final report**

Forty schizophrenic patients were tested (see table 1). They were recruited at the Outpatient Department of the Maudsley Psychiatric Hospital, London. They were on atypical antipsychotic agents. Their clinical symptoms were rated by clinicians who were blind to the cognitive results, as well as to the hypotheses of the study.

Twenty-two of the patients had hallucinations (score  $\geq 2$  on the hallucination item of the SAPS). Among them, 15 had auditory hallucinations and 7 had visual hallucinations. Twelve of the schizophrenic patients had no hallucinations (score = 0 on the hallucination item of the SAPS). No clinical rating was available for the remaining 6 patients.

Forty healthy control participants were tested as well. They were recruited by local announcements in the community. They were screened to rule out any current or recent psychiatric history.

The three subject groups (hallucinators, non-hallucinators, and healthy controls) were not significantly different with regard to age, gender, ethnicity, education level, and premorbid IQ assessed by the NART. The cognitive assessment was carried out by the principal investigator, who was blind to patients' symptomatology.

Several hypotheses concerning the relationships between hallucinations and reality-monitoring impairments were tested.

## 1/ Verbal material

Two equivalent lists of words were presented. Each list was made up of 8 frequent and 8 rare words in random order. The subjects were required to learn the list for 45 seconds, then to write down as many words as they could remember. After this free recall they were provided with a recognition sheet displaying the 16 words of the list mixed with 16 equivalent distractors, and required to circle the presented target words. The first list was followed by recall and recognition after a delay of 5 minutes. The second list was presented 10 minutes after the first list, and followed by immediate recall and recognition.

After presentation and recall/recognition of the two lists, a temporal discrimination task was administered. The subjects were read aloud in random order all the words they had learnt, and required to indicate for each word whether it was presented in the first or in the second list.

The reality-monitoring errors derived from this task were:

- intrusions in free recall (recall of words that were not presented in the list)
- false recognitions of non-presented words. The index Br which assesses the tendency to make false recognitions of non-presented words rather than omissions of target words was computed.
- temporal context errors (misattribution of a word to the wrong list)

The index Pr assessing recognition accuracy, that is, ability to discriminate target words from distractors, was computed as well.

### Results:

In the 40 patients intrusions in free recall were significantly correlated with the false recognition index Br ( $\rho = .44, p < .005$ ). However, intrusions were not correlated at all with the recognition accuracy index Pr ( $\rho = 0$ ). This pattern of results suggests a cluster of memory errors in patients, different from the efficiency deficit.

In the subsample of patients with hallucinations, Br was correlated with the hallucinations score, as expected ( $r = .48, p < .05$ ). The direction of the correlation indicated that higher ratings of hallucinations were associated with increased tendency to make false recognitions of non-presented words. However, hallucinations score was not correlated with the recognition accuracy index Pr. Besides, delusions score was not correlated at all with the Br index. Thus our data reveal a specific association between hallucinations and false recognitions of non-presented words.

With regard to the temporal discrimination task, it was observed that the total number of temporal context errors was significantly correlated with hallucinations scores ( $r = .35, p < .05$ ). In particular, these errors were correlated with auditory hallucinations ( $r = .40, p < .025$ ), whereas they were not correlated at all with visual

hallucinations ( $r = 0$ ). Besides, they were not correlated at all with delusions. In other words, patients with auditory hallucinations were as efficient as the other patients in remembering the words they had learnt, but they were impaired in discriminating whether these words were presented in the first or in the second list.

The temporal misattributions of frequent and rare words were investigated separately. Patients with auditory hallucinations were more likely than healthy controls to misattribute the frequent words to the 1<sup>st</sup> ( $p < .006$ ) or to the 2<sup>nd</sup> list ( $p < .006$ ). The pattern was different for the temporal misattributions of rare words: patients with auditory hallucinations were much more likely than controls to misattribute them to the recent list ( $p < .004$ ), whereas they were not significantly more likely than controls to misattribute them to the 1<sup>st</sup> list ( $p > .10$ ). The patients with no auditory hallucinations were not significantly different from the control group in any of the four types of temporal misattribution.

Thus, as expected, hallucinations were associated with temporal context errors. Furthermore, the pattern of errors shows that the patients with auditory hallucinations had an increased tendency to believe that the rare words presented in the 1st list were presented in the 2nd list. In other words, they mistook the stronger memory traces of these rare words—due to their distinctiveness—for an indication of recency. This suggests that these patients were not able to make proper use of temporal context cues and had to rely on memory traces instead.

## **2/ Visual material**

16 pictures—8 black and 8 coloured—were laid on the table by groups of 4, on specific locations. The subjects had to watch each group of 4 pictures for 20 seconds. 5 minutes after all the pictures had been seen the subjects were presented with the 16 target pictures mixed with 16 other pictures, and asked to indicate which had been presented in the learning phase.

The recognition task was followed by a spatial discrimination task. The subjects were presented again with the 16 target pictures and asked to remember their spatial location at the presentation phase.

The reality-monitoring errors derived from this task were:

- False recognitions of non-presented pictures. The Br index was computed for black and coloured pictures.
- spatial discrimination errors.

The recognition index Pr reflecting the ability to discriminate target pictures from non-presented pictures was computed for black and coloured pictures.

## **Results**

### Recognition accuracy

The healthy controls recognised the coloured pictures better than the black pictures (.70 vs .63,  $p < .05$ ). This colour superiority effect was also observed in the patients without auditory hallucinations (.69 vs .59,  $p < .05$ ). However, the patients with auditory hallucinations demonstrated a deficit in colour processing: their recognition accuracy index was not significantly different for coloured than for black pictures (.48 vs .47). Besides, a strong negative correlation between Pr-colour and auditory hallucinations scores was revealed ( $r = -.63$ ,  $p < .002$ ). There was no significant correlation with Pr-black. The direction of the correlation with Pr-colour indicates that higher ratings of auditory hallucinations were associated with poorer recognition of the coloured pictures.

These results are compatible with the interpretation that patients with auditory hallucinations have a deficit in the visual modality. Therefore the auditory modality would appear relatively more salient.

### False recognitions

Hallucinations scores were not correlated at all with the Br index. This indicates that hallucinations were not associated with tendency to erroneously recognize pictures that had not been presented.

### Spatial context errors

The total number of spatial errors was strongly correlated with auditory hallucinations after controlling for recognition accuracy ( $r = .53$ ,  $p < .025$ ). No correlation with visual hallucinations was observed. Thus auditory hallucinations were associated with failure to remember the spatial context, independently of the correct recognition of the pictures.

## **3/ Imagination/perception task**

Subjects were presented with 32 cards showing in random order 16 pictures of common objects and 16 words designating common objects. Then they were read a list of 64 items including all the items they had seen mixed with an equivalent number of distractors. Subjects were required to recognise the items that were presented.

After the recognition phase, a task for discrimination between reality and imagination was administered. The list of the 32 target items was read aloud, and the subjects were required to remember for each item whether it was presented as a word or as a picture. It was assumed that, in case of reality-monitoring failure, the mental pictures triggered by the words at the presentation phase would be remembered as perceived pictures.

### The reality-monitoring errors were:

- False recognitions of words in the recognition task (Br-words)
- false recognitions of pictures in the recognition task (Br-pictures)
- Remembering the presented words as presented pictures (Br-imagination)

The three corresponding recognition accuracy Pr indices were computed.

## **Results**

### Recognition accuracy

The patients with visual hallucinations were equivalent to the other patients for recognition of words and recognition of pictures.

Pr-pictures was significantly higher than Pr-words in controls (.81 vs .74,  $p < .001$ ). This picture superiority effect was also observed in patients with auditory hallucinations (.71 vs .62). On the contrary, the patients with visual hallucinations remembered the words better than the pictures (Pr-Pictures: .62; Pr-words: .67). The patients without visual hallucinations showed the normal Picture superiority effect (.69 vs .60,  $p < .025$ ). It may be that the patients with visual hallucinations are parasitized by their own mental images, so that they cannot properly encode external pictures.

### False recognitions

In patients with visual hallucinations, Br-pictures, reflecting the tendency to make false recognitions of non-presented pictures, was exactly similar to that of the other patients (Br-pictures = .14 in both subgroups). However, their Br-imagination was much higher (.60 vs .40,  $p < .008$ ). This indicates that the patients with visual hallucinations were more prone than the other patients to remember the words presented at the encoding stage as if they were pictures. In addition, Br-imagination was strongly correlated with visual hallucinations score ( $r = .51$ ,  $p < .025$ ), whereas it was not correlated at all with auditory hallucination score ( $r = 0$ ). This indicates that higher ratings of visual hallucinations were associated with greater tendency to remember the words as pictures. Thus, visual hallucinators were either more prone to make mental images on the basis of presented words, or more ready to give their mental images the status of perceived pictures.

In summary, our results show that hallucinations were associated with a liberal bias in a verbal recognition task, that is, an increased tendency to erroneously recognize stimuli that were not presented. In addition, auditory hallucinations were associated with temporal and spatial context confusion, and with deficit in colour processing. Visual hallucinations were associated with poor memory of visual material, and with confusion between mental pictures and perceived pictures.

## **4/ Neuropsychological testing**

A computerised battery of tests (Cambridge Neuropsychological Test Automated Battery -CANTAB-2) for deficit in frontal and temporal lobe functions was administered. Several paper and pencil tests for frontal and for temporal lobe deficits were added to the battery.

## Results

The tendency to make false recognitions of non-presented words, associated with hallucinations in this research as well as in our previous research, was correlated with measures of frontal deficit (wisconsin perseverative errors:  $r = .32$ ,  $p < .08$ ; perseverative errors in visual search:  $.37$ ,  $p < .05$ ; planning errors in the Tower of London:  $r = .42$ ,  $p < .025$ ). The recognition accuracy index was not correlated with any of these frontal measures, which shows the specificity of the association with reality-monitoring deficit, rather than recognition deficit.

The tendency to make false recognitions of non-presented words was also associated with one measure of temporal lobe deficit (visual recognition:  $-.43$ ,  $p < .025$ ).

The measure associated with visual hallucinations (Br-imagination) was not correlated at all with any frontal measure, even though most of these measures were derived from visual tests. However, Br-imagination was correlated with one measure of temporal lobe deficit (visual recognition:  $r = -.39$ ,  $p < .05$ ). By contrast, Br-picture was not correlated with this temporal lobe measure. This suggests that it is actually the confusion between mental and real pictures that is involved in this association with temporal dysfunction.

This pattern of results suggests that both frontal and temporal lobe dysfunctions, or perhaps the connexion between them, are involved in hallucinations. However, visual hallucinations may rely on different brain mechanisms.

This research has implications for cognitive and psychopharmacological treatment of hallucinations in patients with schizophrenia. Indeed, determining the neurocognitive mechanisms that underlie visual and auditory hallucinations unable a more focussed therapeutical approach. Further research should use these paradigms and combine them with brain imaging techniques.

These results will be reported in numerous publications. *Bial Foundation* support will be gratefully acknowledged in each of them.

**Table 1. Socio-demographic information**

	Hallucinators n = 22	Non- hallucinators n = 12	Healthy controls n = 40
Age	33.7 (7.8)	31.3 (6.0)	34.5 (9.5)
Gender	15 M, 7 F	9 M, 3 F	25 M, 15 F
Ethnicity	10 caucasian 9 black 3 ind/asiatic	8 caucasian 4 black	27 caucasian 11 black 2 ind/asiatic
Education years	12.2 (2.1)	13.4 (2.0)	13.1 (2.8)
NART	99.9 (11.4)	106.2 (12.9)	106.3 (11.6)
SAPS	23.1 (20.0)	3.3 (4.4)	/
SANS	24.4 (16.0)	17.8 (12.9)	/