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Title: Verbal thought generation and auditory perception in schizophrenia: a follow-up fMRI study

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Introduction

Although overactive inner speech has been one of the major theoretical accounts of auditory verbal hallucinations (AVHs) in schizophrenia, inner speech associated with the mental generation of thoughts has only been rarely examined. In this study, we present a follow-up experiment (Rapin *et al.*, 2010) investigating the neural underpinnings of verbal thought generation and verbal auditory perception using fMRI. Constrained principal component analysis (CPCA; Takane & Hunter, 1991; Woodward *et al.*, 2006; Metzak *et al.*, 2010a,b) was used to identify networks of cerebral activation associated with generating thoughts and auditory perception.

Methods

Two experimental conditions were examined. In the first one, participants were required to mentally generate a definition of a common word presented on the screen. In the second condition, they were required to listen to the definition of a common word presented on the screen. All definitions started with the phrase “Something you” (e.g., pen: something you use for writing). To avoid semantic ambiguity, all words were accompanied by an illustration of the word. Each condition consisted of 30 words. 7 schizophrenia patients with AVHs, 7 schizophrenia patients without AVHs and 14 healthy controls participated. All were right-handed.

An event-related fMRI protocol was used in a 3T scanner for a total of 352 images. Preprocessing was performed using SPM5 and statistical analyses were carried out using CPCA with a finite impulse response (FIR) model, and an orthogonal rotation applied on both conditions simultaneously.

Results

Four reliable components were extracted. The first component extracted (Figure 1) included the superior temporal cortex and the visual cortex bilaterally and showed a higher intensity for the auditory perception condition relative to the generation condition, but did not differ between groups. The second component (Figure 2) mainly involved the primary visual cortex (and the superior parietal lobule). It also included deactivations in the ventral anterior cingulate cortex (ACC) bilaterally and showed a greater hemodynamic response (HDR) for the generating condition relative to the auditory perception condition. An interaction between time and group was also present whereby the non hallucinating group had a higher HDR peak value, closely followed by the hallucinating group. The third component (Figure 3) involved activations in the secondary auditory cortex as well as in the insula and deactivations in the

dorsal frontal regions and in the premotor and somato-sensory cortices. This component showed higher HDR in the auditory perception condition compared to the generation one. A trend towards higher intensity for the hallucinating group relative to the others was also observed. The fourth component (Figure 4) represented both the task positive and the task negative networks (Fox *et al.*, 2005) and differed between conditions, whereby higher activity was found for the thought generation condition compared to the auditory perception condition.

Conclusions

These results verified our pilot study (Rapin *et al.*, 2010) by confirming that, regardless of group and relative to the auditory perception condition, the thought generation involves more visual cortex activation as well as an overall intensified task positive network, suggesting increased cognitive effort for this condition. One component, involving the bilateral visual cortices associated with deactivations in the ventral ACC showed a greater HDR for both groups of patients relative to controls regardless of condition, suggesting inefficiency in this network (increased activity required to perform difficult task). Moreover, a trend towards overactivation of the secondary auditory cortex was found in hallucinating patients, supporting the hypothesis of heightened left auditory cortex in hallucinating schizophrenia patients (Hoffman & McGlashan, 1997).

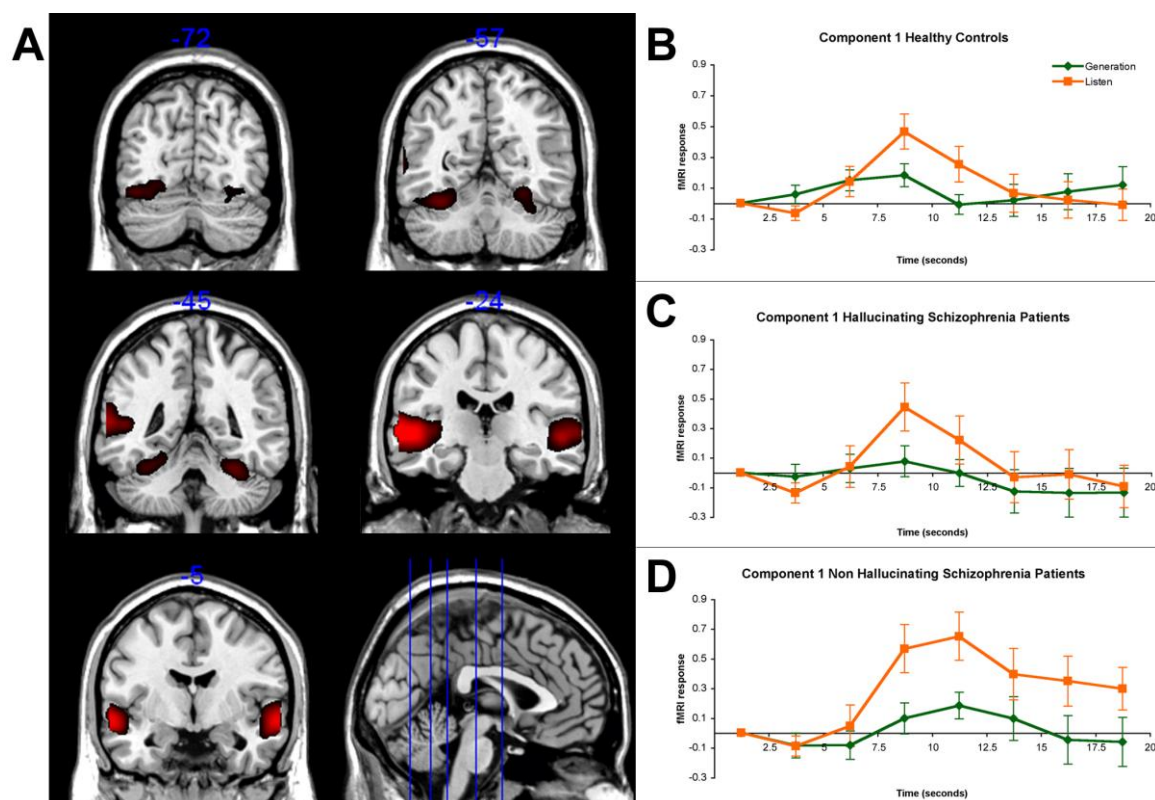


Figure 1: Images, plots of BOLD signal, and plots of predictor weights for Component 1.

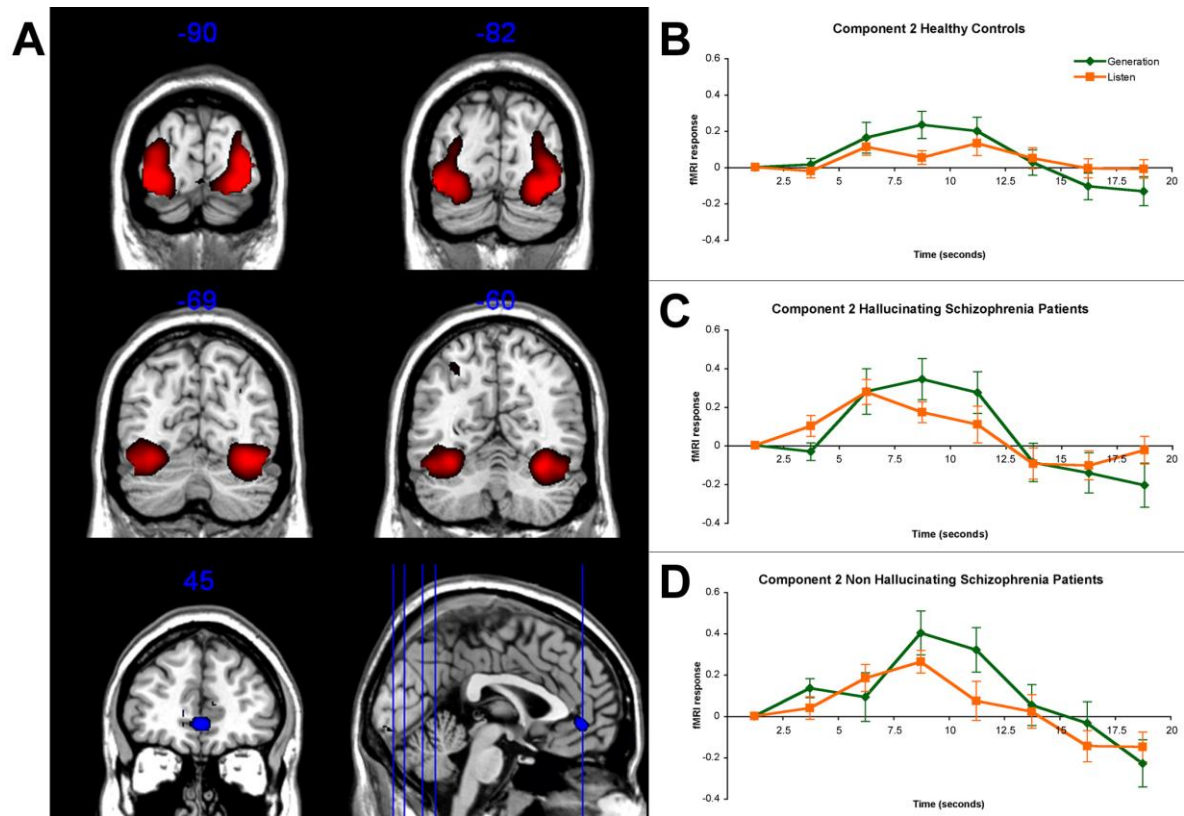


Figure 2: Images, plots of BOLD signal, and plots of predictor weights for Component 2.

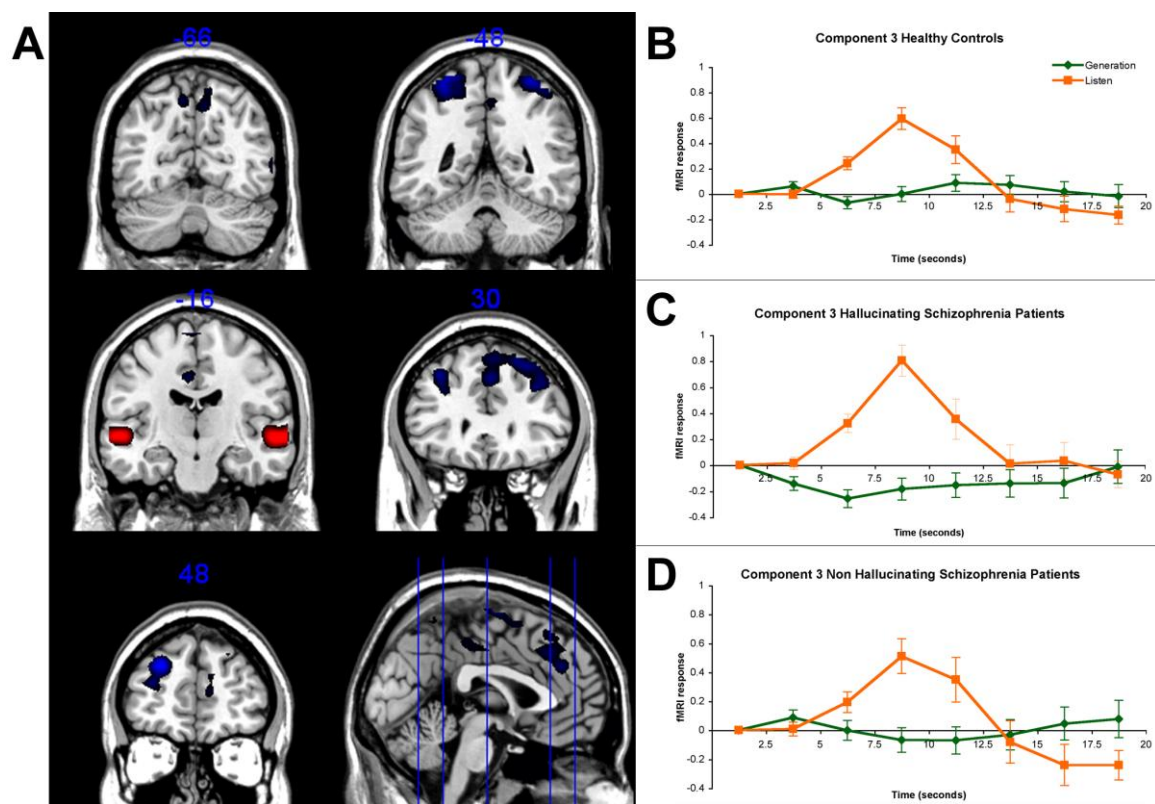


Figure 3: Images, plots of BOLD signal, and plots of predictor weights for Component 3.

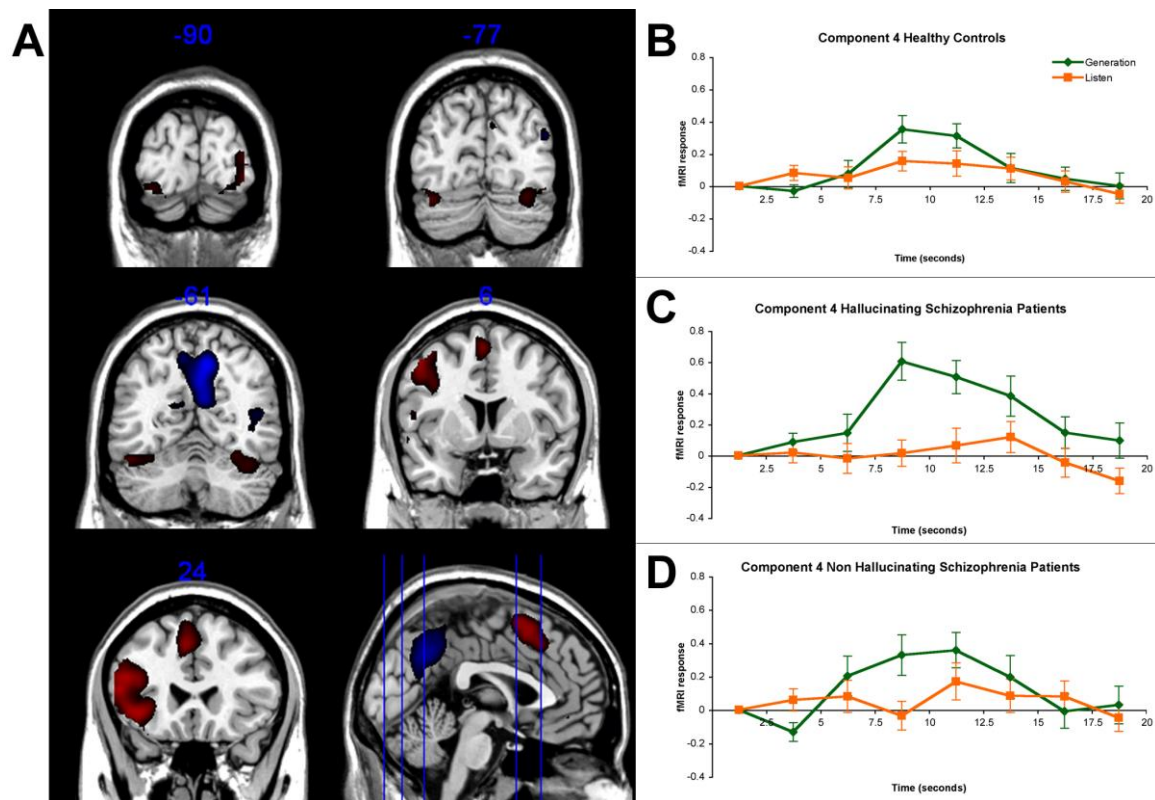


Figure 4: Images, plots of BOLD signal, and plots of predictor weights for Component 4.

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Categories

- Executive Function (Cognition and Attention)
- Perception, Imagery, Awareness (Cognition and Attention)
- Schizophrenia (Disorders of the Nervous System)

- Functional MRI (Imaging Techniques and Contrast Mechanism)
- Comprehension (Language)
- Production (Language)
- Multivariate Modeling, PCA and ICA (Modeling and Analysis)