

An fMRI study of manipulation and maintenance processes in verbal working memory.

R. A. E. Honey*†, J. M. Anderson‡, P. T. Michie*†, N. Papadakis‡§, E. T. Bullmore‡, T. Donovan§, V. C. Liversidge§, T. A. Carpenter§, P. C. Fletcher‡

*Department of Psychology, University of Western Australia

†Centre for Clinical Research in Neuropsychiatry, University of Western Australia

‡Research Department of Psychiatry, University of Cambridge

§Wolfson Brain Imaging Centre, University of Cambridge

Background

The purpose of this event-related fMRI study was to explore the sensitivity of prefrontal cortex (PFC) to maintenance and manipulation processes in verbal working memory. While previous studies have manipulated these two factors in isolation (D'Esposito et al., 1999), we used a 2x2 factorial design to investigate the differential effect within subjects.

Method

Imaging was carried out using a 3 Tesla Bruker Medspec scanner. A modified factorial version of D'Esposito et al.'s (1999) task was used on 12 healthy volunteers. The two factors were Maintenance (high vs low letter load) and Manipulation (letter strings were either maintained in the order that they were presented or were rearranged into alphabetical order). There were thus four conditions, namely, low load maintenance, low load manipulation, high load maintenance, and high load manipulation.

Data were analysed using SPM99, treating inter-subject variability as a random effect. For each of the 4 conditions, the delay period between task instructions (to manipulate or maintain) and a subsequent test probe was modelled as the event of interest. Parameter estimates for these condition-specific models were compared across conditions. We present two contrasts below: Figure 1 shows the effect of load (high vs low) and Figure 2 shows the effect of task type (manipulation vs maintenance). In view of our restricted area of interest, a threshold of $p < 0.001$ (uncorrected for multiple comparisons) was set.

Results

With respect to main effects, both contrasts (manipulation vs maintenance, and high load vs low load) were associated with activation of ventrolateral and dorsolateral PFC. However, activation of these areas was clearly more pronounced for task type, ie, when manipulation processes were compared to maintenance processes, ventrolateral and dorsolateral PFC activation appeared greater than the load effect. This dissociation was confirmed by the results of the interaction between load and task type.

Conclusion

Both ventrolateral and dorsolateral PFC regions are important in maintenance and manipulation processes in verbal working memory. Manipulation processes seem to involve increased activation in these regions, independent of load.

Reference

D'Esposito et al. (1999). Maintenance versus manipulation of information held in working memory: An event-related fMRI study. *Brain & Cognition*, 41, 66-86.

