MEMORY

Cerebral effects of unexpected events: an fMRI study

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Background

One of the ways in which we understand associations in our environment is in terms of causal relationships. In this study, we explored the functional anatomy of contingency learning with a view to understanding the consequences, in terms of neuronal activity, of events that either violated or fulfilled a previously learned causal relationship. It was our prediction that such a violation would produce greater levels of activity in dorsolateral prefrontal cortex (DLPFC).

Method

12 healthy volunteers took part in this event-related fMRI study. Each subject underwent three scanning sessions, learning at the beginning of each the likelihood with which a fictitious drug would cause or prevent a fictitious illness. This learning was carried out over a series of "case studies" in which subjects would be told whether or not the drug was administered and whether or not the illness subsequently occurred. On the basis of the first fifteeen case studies, subjects built up background expectancy about the relationship between drug and illness. This contingency was experimentally manipulated to be 0.5 (drug is expected to usually cause illness), -0.5 (drug is expected to usually prevent illness) and 0 (no systematic relationship) over the three sessions. Over the succeeding 105 case studies in each session, this expectancy was fulfilled and violated in different trials and we compared the BOLD response associated with unexpected outcomes to that associated with expected outcomes.
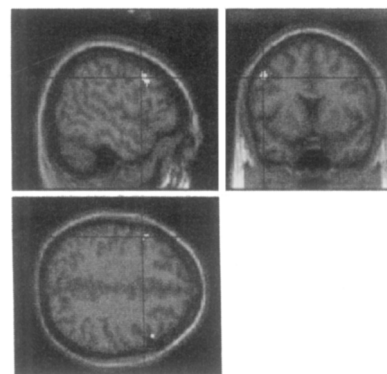

Figure 1. Effect of Unexpected

Imaging was carried out on a 3 Tesla Bruker Medspec scanner. Data were analysed using SPM99. Event-related BOLD responses were modeled separately for expected and unexpected events and directly compared to identify regions in which the response was significantly greater to case studies in which the learned causal relationship was violated. Inter-subject variability was treated as a random effect when looking for group effects. In view of the a priori hypothesis with respect to DLPFC, the statistical threshold was set to p<0.001, uncorrected for multiple comparisons, for this region.

Results

Behavioural data and post scan debriefing indicated that subjects learned the experimentally manipulated causal relationships without difficulty. As predicted, unexpected events were associated with greater BOLD responses in DLPFC (see figure). These results suggest the importance of frontal mediation in monitoring and dealing with unexpected events in our environment.