Analysis of fMRI Data by Decomposition into Independent Components

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OBJECTIVE: To develop a general analytical approach to functional Magnetic Resonance Imaging (fMRI) capable of separating both task-related and non-task related areas of activitation as well as movement and mechanical artifacts.

BACKGROUND: fMRI studies in neurological patient populations present special challenges for signal interpretation as pathological conditions may alter task and non-task related brain responses and movement artifacts may be more prominent.

DESIGN/METHODS: Using a new algorithm for Independent Components Analysis (ICA), we decomposed the fMRI data sets from 4 normal subjects performing two trials of "Stroop" or mental arithmetic tasks into virtually indepedent, overlapping BOLD signal "sources". Each source consisted of a spatial extent of 3-D activity, and its associated time course. The robustness and replicability of the ICA results were explored.

RESULTS: Without using any a priori information, ICA extracted > 140 sources for each run. In all cases where significant activation was detected by traditional correlational analysis, ICA found one source with similar anatomic foci, and a corresponding square-wave time course closely matching that of the original experimental design. Other sources demonstrated transient activations, artifacts from CSF, and slowly varying non-task related time courses. ICA results were robust to added noise, consistent across sessions, and reliably detected induced movement artifact.

CONCLUSIONS: ICA appears to be a powerful technique for decomposing fMRI data. Its ability to detect and separate non-task related sources, movement and other artifacts as well as task-related changes in fMRI data make it a highly promising method for the study of neurological patient and other populations.

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