Spatiotemporal exploratory analysis of fMRI data

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Introduction

Most fMRI data display significant higher-order statistics representing tendencies to grouping along various shapes, even if such feature is commonly hidden by the overall distribution. Since the spatiotemporal characteristics of brain activity are frequently unknown and variable, their evaluation using hypothesis-driven methods only is rather difficult. Analysis of an fMRI block-based auditory stimulation paradigm was comparatively performed by stationary, noise free, linear spatial independent component analysis (sICA) [1] and temporally fuzzy cluster analysis (tFCA) [2].

Methods

Non-square sICA of fMRI data separates (latent) brain activity sources in terms of structured information from linear mixtures into estimated independent components (ICs) consisting of (relatively sparse, non-systematically overlapping, spatially independent) spatial maps and their (constrained and separable but not necessarily independent) associated time courses (TCs) of activation, which are more likely to admit interpretations that are neurophysiological meaningful since they presumably correspond to distinct physical or physiological processes. Data model selection was performed in compliance with a structural measure introduced in projection pursuit by Friedman [3], and double-checked by minimum description length (MDL) [4] and Akaike's information criterion (AIC) [5].

Results

Experimental design consisted in successive blocks alternating between rest and auditory stimulation by bi-syllabic words presented binaurally at a rate of 60/minute, starting with rest. Voxels with similarly structured TCs were grouped by tFCA into statistically significant homogeneous clusters. The centroid and all member TCs in each cluster underwent two significanttests, one in time domain and one in frequency domain, in order to reduce the number of false positives. Comparing ICA projections of surrogate data, Friedman's index was proved to constitute an optimal trade-off between MDL (statistically consistent but sensitive to spatial smoothness) and the more conservative AIC for data model selection. Both sICA (Fig1) and tFCA (Fig.2) revealed auditory modulated areas in the primary auditory cortex.

Conclusion

Groups of voxels associated with physiologically informative TCs fairly straightforward to interpret were disclosed by sICA and tFCA. No significant differences were noted between the activation areas identified by sICA and tFCA, suggesting that tFCA may validate the sICA decomposition of large functional brain imaging data sets. Exploratory analysis allows to improve or even to change the original hypotheses by revealing unanticipated or missed patterns of activation. Extra regressors may be added to the GLM enhancing the inferential model and increasing the statistical significance of fMRI data analysis.

References

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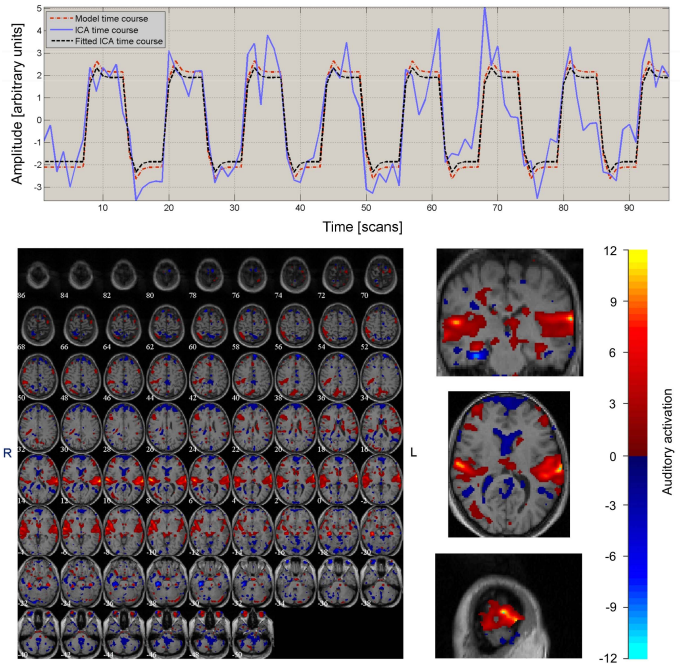

Fig.1 – Spatial ICA

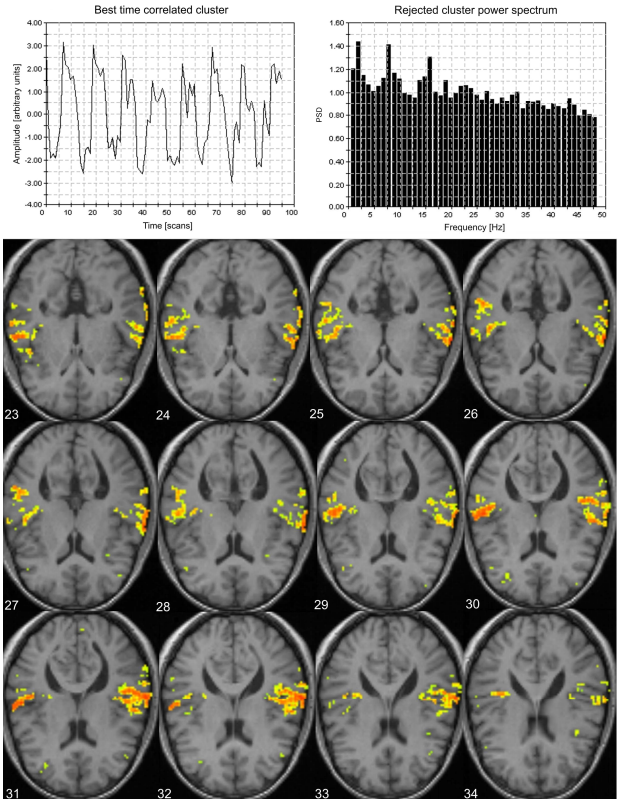

Fig.2 – Temporal FCA.