Exploring Cerebrovascular Dynamics in the Human Brain

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Introduction
- Understanding the regulatory mechanisms of cerebral blood flow (CBF) and its dysfunction remains a central topic in the neurological scientific literature
- Ample evidence now indicates that certain factors related to age, disease, and medication can dramatically alter cerebrovascular regulation (Tablet 1)
- Studying the effects of these factors on the living human brain may be possible by exploratory analyses of functional neuroimaging modalities, e.g., MRI and PET

Methods
- We propose a unified exploratory method for the analysis of the cerebrovascular response to event-related stimuli as measured by the blood oxygen level-dependent (BOLD) MRI signal (Tablet 2)
- A key difficulty in employing exploratory analysis methods is that after the voxels have been clustered into groups having similar dynamics, the statistical significance of each cluster remains unknown
- We apply a modern Bayesian technique to calculate each cluster’s significance in the overall hierarchical structure of the data (Tablet 3)

Data acquisition and analysis
- 25 data sets from 6 normal subjects (28-55)
- Visually cued event-related hand motor task
- 1.5 T MRI scanner (SE-EPI pulse sequence)
- Simulated data using a phantom noise model
- Clustering using fuzzy k-means algorithm
- Temporal feature: centroid cross-correlation
- Spatial feature: cluster contiguity
- Statistical inference: Bayesian hierarchical model
- Model parameters are obtained by Markov Chain Monte Carlo simulation

Results and Conclusion
Simulated data (Tablet 4)
- Designed simulations using reported BOLD response characteristics in imaging studies
- Proposed method was capable of distinguishing the 3 response signals used
- Classical hypothesis testing found fewer responding voxels and did not distinguish between positive responses (norm., mod.)

Event-related MRI data (Tablet 5)
- The proposed method agreed well with hypothesis testing; moreover, it distinguished between various responding regions (e.g., motor cortex, putamen, and cerebellum) based on their temporal characteristics

Conclusion
- The proposed exploratory method provides an objective framework to identify voxel patterns in neuroimaging data and may be useful to study CBF regulation and its dysfunction

Short References:

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