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Temporal Stability of Resting State fMRI Data Analysis by Independent Components Method.

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SUMMARY

This work is devoted to the analysis of the temporal stability of the independent components obtained by analyzing data of resting state functional Magnetic Resonance Imaging (fMRI). The result of ICA is robust to the choice of window size when analyzing a representative data sample. It was also shown that the time series of independent components, which topology corresponds to resting state networks, have a correlation with the global signal at the level of 0.4-0.5.

INTRODUCTION

Independent component analysis (ICA) is a computational method for separating a multivariate signal into additive subcomponents. ICA is used in a variety of applications, such as signal processing, image analysis, biomedical signal processing and data compression. Our research is based on functional Magnetic Resonance Imaging (fMRI) analysis. Resting-state functional magnetic resonance imaging (rs-fMRI) has been gradually applied to pre-surgical functional mapping. It provides essential information for intraoperative localization of brain regions. ICA-based mapping has shown advantage, as no a priori information is needed

APPROACH

To test the stability of independent components of the human brain regions identified by the method, the entire data array was divided into 3 time intervals:

Complete record of the experiment - 1000 time samples;

The first half of the experiment - 500 time samples;

The second half of the experiment - 500 time samples.

For each selected interval, brain regions were identified using the method of independent components.

METHODS

The experimental data were obtained at the National Research Center “Kurchatov Institute” on a Magnetom Verio tomograph with a magnetic field strength of 3 T. fMRI data were acquired with the following scan parameters: 42 slices, repetition time (TR) 2000 ms, echo time (TE) 20 ms, field of view (FOV) 192 × 192 mm2, voxel size 3 × 3 × 3 mm3. As part of the study, 1000 time samples for functional data were scanned, with a total duration of about 33.5 minutes. The total study time was 40 minutes. The study involved 25 healthy volunteers aged from 18 to 31, average age 24. The research was approved by the local ethical committee of the National Research Center “Kurchatov Institute”.

RESULTS

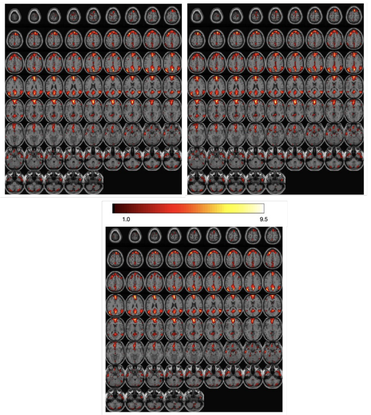

Fig. 1. An example of a topological map of a DMN network. Top left - obtained over the entire time range, top right - obtained over the first half of the time range, bottom - obtained over the second half of the time range.

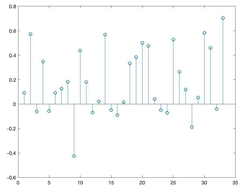

Fig. 2. An example of the results of correlation analysis of the ICA dynamics and the global signal obtained over the entire random time range for a randomly selected subject. DMN network - number 10, visual area - number 21, auditory area - numbers 25 and 33, motor artifacts - number 9.

ANALYSIS

For each selected interval, brain regions were identified using the method of independent components. The number of components varied from 11 to 17. Different number of components is explained by the strict condition to the percentage of the total time series variability described by the components: we chose the smallest number of components describing at least 80% of them. After selection of independent components, they were classified according to their association with resting state networks based on an expert assessment on the analysis of topology and time-frequency characteristics of each selected component.

DISCUSSION

With a sufficient number of time points their further increase does not lead to significant changes in spatiotemporal characteristics of the components obtained, and the components obtained by analyzing individual ranges have corresponding representation in the full data set. The influence of the global signal on networks of the resting state turned out to be about 0.5. This may be due to motion artifacts and the relative proximity of these networks to the boundary of the experimental scanning area.

CONCLUSIONS

1. The size of an experimental rs-fMRI session of 500 time samples can be considered sufficient for the application of ICA.
2. Relatively high (of the order of 0.4) correlations between the components corresponding to the DMN and the global signal can lead to erroneous estimates of functional connectivity during the resting state.
3. It is very important to analyze connectivity of the time series for selected neuronal networks of the brain with a noisy global signal.

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