

Functional Coherence Index for fMRI Network Analysis Using k-Means Cluster

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INTRODUCTION

Network analysis of paradigm free functional MRI data has gained popularity for investigations of functional networks in different brain states, such as the default network during rest. There is no standard metric for the integrity of a functional network but such a measure is necessary for quantitatively comparing networks between subjects and groups. The k-means clustering algorithm can be used to segment fMRI data into functional networks or clusters in a very fast and efficient way, especially when using advances in parallel computing using graphics processors (Garcia 2008). In this abstract we present a metric for quantifying the overall functional coherence of a network.

METHODS

Subjects

The subjects were screened for medical and psychiatric illnesses including a history of head injury and substance abuse. Included were 20 males and 19 females, aged 18-35 years (mean age = 26.6, SD = 4.9; mean age for male is 26 and for female is 27).

Image Acquisition

Imaging was performed using a Siemens 3T Allegra MRI. Imaging protocols: Axial 3D-MPRage (TR = 2500 ms, TE = 4.4 ms, FOV = 23 cm, matrix size = 256x256, 208 slices with thickness = 0.9 mm). EPI Bold scans were acquired using a GE-EPI sequence with the parameters: TR=2s, TE=27ms, FOV=21cm, 2.5mm thick, skip = 0.5mm, Matrix size=64x64, 34 slices. The resting state protocol acquired 70 measurements. Subjects were told to lie quietly and close their eyes during the resting state scan.

Image Processing and Functional Network Quantification

Image pre-processing was performed with SPM5. Segmentation of the high resolution T1 image was performed and the results were coregistered to the BOLD data. The gray matter mask resulting from the segmentation was used to mask out non-gray matter voxels for the k-means cluster algorithm. Resting state scans were motion corrected and temporally smoothed and then analyzed using the k-means clustering algorithm, random seedpoints were generated for 10 clusters. The resting state network that encompasses the posterior cingulate cortex (PCC) and the parietal cortices (PC) was selected for analysis. Images were normalized using the high resolution T1 to ease comparisons with other default network analysis studies (Fig 1). The functional coherence index was computed

as follows

$$FCI = \frac{1}{nGMV} \sum_{i \in GMV} (TC_i - \overline{TC})^2$$

where the functional coherence index (FCI) is the total Euclidean distance of each timecourse signal vector (TC_i) to the mean timecourse vector of the cluster (\overline{TC}) scaled by the inverse of the size of the gray matter volume of the cluster (nGMV).

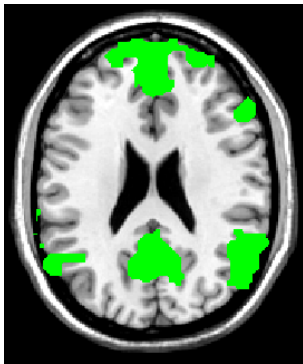


Figure 1.
k-means cluster of the default network.

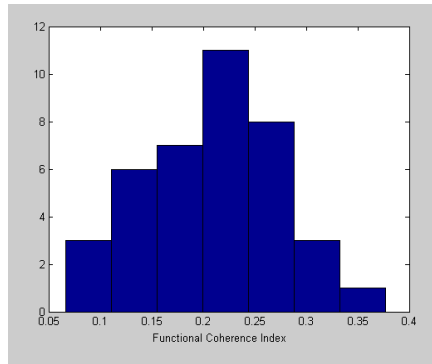


Figure 2.
Histogram of 39 subjects' functional coherence index.

RESULTS

Figure 1 shows the results of the k-means clustering algorithm applied to a paradigm free fMRI of a subject at rest. One cluster, the cluster commonly identified as the default network, is segmented by the algorithm and displayed here in figure 1. The range of functional coherence for 39 subjects is given here in figure 2. The results are roughly normally distributed, a characteristic of a metric that is necessary for use in many statistics.

DISCUSSION

A quantitative metric for measuring the integrity of a network in the brain is necessary for studies that compare networks across subjects and between groups. Here we suggest a method that can be easily integrated into a k-means network analysis to give a global measure of functional coherence.

V. Garcia, E. Debreuve, and M. Barlaud, Fast k Nearest Neighbor Search using GPU, Tech. Rep. arXiv:0804.1448, I3S Laboratory, University of Nice Sophia-Antipolis / CNRS, Apr. 2008.

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