Interdependencies among Resting-State networks in Schizophrenia using Independent Component Analysis

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Introduction:

Functional magnetic resonance imaging (fMRI) has become an important neuroscientific tool for understanding aberrant behavior in human brain. Various analysis techniques have been used to analyze functional differences in fMRI data from healthy controls and diseased patients. Independent component analysis (ICA) is one such method which recovers underlying signals from linear mixtures of fMRI signals and draws upon higher-order signal statistics to determine a set of "components" that are maximally independent of each other [1]. A number of recent studies have examined dominant activation differences due to various tasks using independent component analysis (ICA) [1-3]. Researchers have also analyzed "resting state" scans, which are relatively easier to obtain and do not confound performance (e.g. difficulties of patients in performing a task) with brain activity [4-6]. In this paper, we use group spatial ICA to identify and analyze resting state components in patients with schizophrenia [7]. Though the spatial maps are maximally independent there still exists significant temporal dependencies among the components. We evaluate the inter-relationships among these components using temporal correlation of the individual subject ICA time courses and propose an algorithm which determines the lag-directionality among correlated components.

Methods:

Resting state fMRI data were collected on 38 patients with Schizophrenia, in which the subjects were asked to lay still in a 3T Siemens Allegra scanner at the Olin Neuropsychiatry Research Center. Seven resting state networks were identified using spatial group ICA. Inter-relationships among these components were evaluated using temporal correlation of the individual subject ICA time courses. Significant patient versus control differences were identified using a one-sample t-test thresholded at $p<0.01$ (corrected for multiple comparisons).

Results:

The identified resting-state networks in patients with schizophrenia were consistent with the networks found in healthy controls in [4]. Figure 1 shows the dominant components along with the correlation network in which an arrow is used to represent significantly correlated networks while the lag among correlated components is signified by the direction of the arrows.

Conclusions:

We present a novel approach for quantifying functional connectivity between brain networks in patients with schizophrenia identified with spatial ICA. Several networks were found to be more highly correlated in patients with schizophrenia. This may be due to decreased network specialization, perhaps reflecting inefficiencies in cortical processing compared to healthy controls. Our proposed approach provides a useful tool for examination of temporal dependencies between networks identified with spatial ICA.

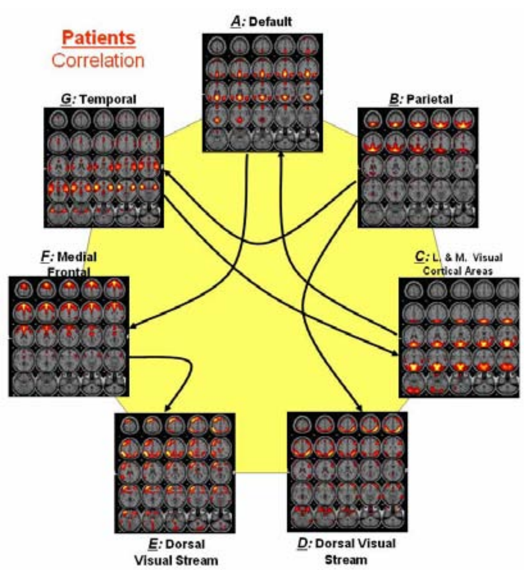

Figure 1: Dominant Resting State networks in schizophrenia

a) Default: activations in precuneus, cingulate and posterior cingulated gyrus, superior and middle temporal gyrus, interior and superior parietal lobule, and medial and superior frontal gyrus
b) Parietal: activations in precuneus, inferior and superior parietal lobule, postcentral gyrus and lobule, cingulated gyrus, cuneus and middle frontal gyrus
c) Visual Cortical Areas: activations in cuneus and precuneus, posterior cingulated and lingual gyrus, occipital and temporal gyrus, and fusiform gyrus
d) Bilateral Visual Stream: activations in superior and inferior parietal lobule, middle frontal and temporal gyrus.
e) Laterized Visual Stream: activations in inferior parietal lobule, superior, middle and inferior frontal gyrus, superior parietal lobule and precuneus
f) Medial Frontal: activations in superior, middle, medial and inferior frontal gyrus, cingulated and anterior cingulate gyrus, and caudate.
g) Temporal: activations in superior, transverse and middle temporal gyrus, post and precentral gyrus, inferior parietal and frontal lobule, and claustrum

The solid lines represent significantly correlated components, while the direction of the arrows represents the direction of lag among the components. For example, components A and C are significantly correlated where component C lags component A.

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