IMAGING BRAIN NETWORKS – SHORT PRESENTATION OF NEW TECHNIQUES

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ABSTRACT

The brain is organised into large-scale functional networks with interactions between them. For the purpose of imaging brain networks, two fMRI techniques are particulary helpful.
Diffusion tensor imaging (DTI) is based on the detection of water diffusion, which occurs preferentially in the longitudinal direction of axons, providing a mean to imagine the anatomy of axonal bundles.
Functional connectivity is based on the relative synchroy of the blood-oxygen-level-dependent (BOLD) signal across brain regions that work together.

Key words: brain network, functional connectivity, diffusion imaging, connectomics

The brain is organised into large-scale functional networks with interactions between them. The human brain is organised into regions of predominant local and distal functional connectivity.

Local hubs are located in primary and secondary information processing regions and also in a region of anterior congulate cortex previiously associalted with self and interceptive informations processing (Sepulcre J, 2010)

The cortical hubs of human brain link widespread brain regions most likely supprorting the integration of congtnitive functions (Buckner 2009).

The pivotal hubs or epicenters of the brain are the confluence of distinct networks in strategic cortical points (Mesulam MM, 1998).

Mars (2011) describe that temporo-parietal joint is critical articulator of the control (inferior parietal lobule), default mode (posterior temporo-parietal joint) and ventral attention (anterior temporoparietal joint) networks.

Investigating the entire connectivity of human brain is one of the most challenging task of today in neuroscience. Efforts are made to develop and apply novel techniques in order to achieve the reconstruction of human brain connectome. (Sporns 2011, 2005)

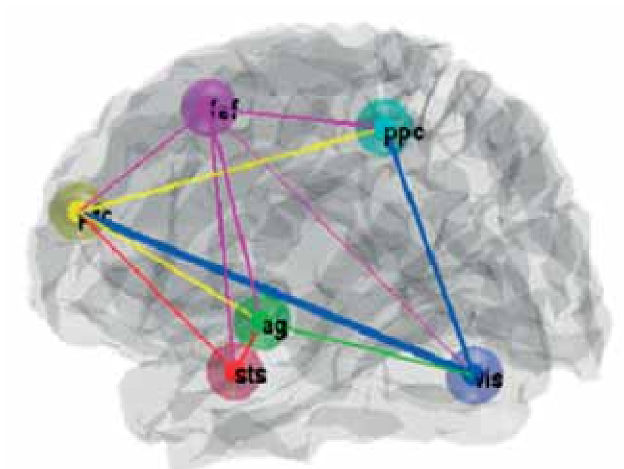

FIGURE 1. *Functional connectivity network between 6 coarse scale areas of the brain (adapted from Friston 2011)*

Magnetic resonance imaging (MRI) is a non-invasive imaging technique of the brain. For the purpose of imaging brain networks, two fMRI techniques are particulary helpful.

There is a strog correlation between the findings with both techniques, because anatomical connectivity supports functional connectivity.

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The first, **diffusion tensor imaging (DTI)** is based on the detection of water diffusion, which occurs preferentially in the longitudinal direction of axons, providing a mean to imagine the anatomy of axonal bundles.

DTI may help in the evaluation of white-matter damage in relapsing-remitting multiple sclerosis, useful for evaluation of effectivenes of new therapies for thie disorder.

The second, **functional connectivity**, is based on the relative synchroy of the blood-oxygen-level-dependent (BOLD) signal across brain regions that work together

Functional magnetic resonance imaging (fMRI) is a new, non-invasive technique for examining brain function that use changes in blood oxygen level-dependent (BOLD) signal in order to identify increase or decrease of neuronal activity.

Functional MRI (fMRI) is a MRI technique used in the study of brain metabolism and blood flow in subjects performing cognitive and motor tasks („**task-based" fMRI**). In patients with neurological and psychiatric diseases fMRI could provide proofs of patterns of cerebral activation, allowing the investigator to compare these patterns with the classical concepts of cortical function and localization.

During resting conditions, the brain remains functionally and metabolically active. In contrast to the traditional „task-based" approach, resting state fMRI observe the brain in the absence of overt task performance or stimulation, the subject lie quietly, with eyes closed and spontaneous fluctuations in the blood oxygen-level depend (BOLD) signal is recorded **(„resting state fMRI").** This technique allows us to identify correlations between remote brain areas, the **functional connectivity**.

The **resting state functional connectivity MRI (fcMRI)** identify correlation patterns of spontaneous BOLD fluctuations and could be useful in clinical practice.

For the study of normal neurobiology was used the correlation of BOLD signal accross various brain regions during the performance of a task.

Recently, for brain network studies in neurological diseases is used BOLD signal correlations among different brain regions during wakeful rest. Patient simply needs to lie in the scanner, awake. It is easier to perform and quicker (less than 10 min of scanning time).

The analysis of the synchrony of spontaneous low-frequency (<0,1 Hz) blood oxygen level-dependent (BOLD) fluctuations is epsecially useful in

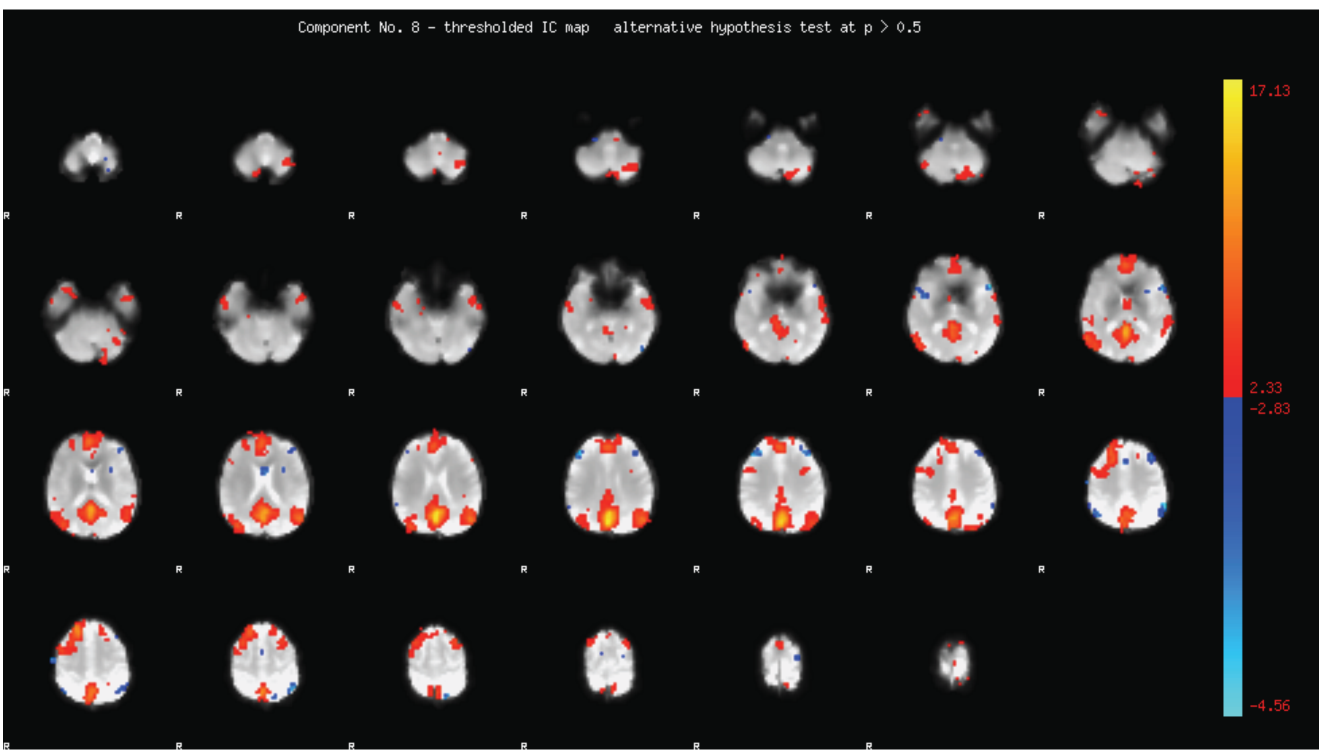

***FIGURE 2.** Resting state functional connectivity MRI (fcMRI) – Default mode network in a healthy subject (Research grant 84/2012 NEUROCON – Resting state functional connectivity in movement disorders – noninvasive biomarkers of pathology, University Emergency Hospital Bucharest, „Theodor Burghele" Hospital Bucharest – Radiology Department, National Institute for Research and Development in Informatics)*

sthe suty of human connectomics.(Biswal 1995, Fox 2007, Behrens 2011)

It is used in neurodegerative diseases such Parkinson and Alzheimer diseases.

There is a bimodal pattern of changes in resting state fMRi in neurodegenerative diseases. At the beginning, there is an increase of connectivity as compensatory mechanism. As the disease progresses both activity and connectivity decline to level lower than in healthy controls.

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