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Resting-State Functional Magnetic Resonance Imaging

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Research and application is slowly and predictably moving from Task related fMRI to Resting state fMRI (rsf MRI). Task-based or stimulus-driven f MRI paradigms have been critical to our current understanding of brain function. Activity in the task based fMRI is based on relative changes of the BOLD signal from baseline during the performance of a task or in response to a stimulus. However, rsfMRI or functional connectivity MR imaging investigates synchronous activations between regions that are spatially distinct, occurring in the absence of a task or stimulus. These activities observed in multiple distinct regions are presumed to indicate functional connectivity within and between the highly organized neuroanatomical networks.

Rsf MRI provided further evidence to support the existence of previously hypothesised networks in the brain based on PET studies. Current rsf MRI studies propose two large opposing networking systems in the brain; one including the Default Mode Network (DMN) and the other Resting State Network (RSN) composed of task-based systems, such as somatosensory, visual, or attention. Terms used to refer to these systems include "task-positive or intrinsic " and "task-negative or extrinsic. The somatosensory network includes primary and higher order motor and sensory areas, the visual network is highly consistent across various studies and involves much of the occipital cortex; the auditory network consisting of the Heschl gyrus, the superior temporal gyrus, and the posterior insula and a language network that includes Broca and Wernicke areas extending to involve the prefrontal, temporal, parietal, and subcortical regions. RSNs involved in attentional modulation and cognitive control have also been identified.

Two networks identified by using both rsf MRI and task-based f MRI include the dorsal and ventral attention networks. The dorsal attention network includes the intraparietal sulcus and the frontal eye field and is involved in the executive control of attention. The ventral attention network which includes the temporoparietal junction and ventral frontal cortex is involved in the detection of salient cues. The frontoparietal control network which includes the lateral prefrontal cortex and the inferior parietal lobule is thought to be involved in decision-making processes. Finally, the cingulo-opercular network, which includes the medial superior frontal cortex, anterior insula, and anterior prefrontal cortex, is thought to play a role in performing goal-directed tasks.

Unlike the task-based f MRI, the subject is instructed to lie in the scanner and think of nothing in particular. Rsf MRI can be performed even when subjects are asleep or anaesthetized, and more easily in small children, restless patients or cognitively impaired subjects as there is no dependency on patient cooperation, on task design or task performance. Additionally, several networks can be obtained from the same data set; typically within 10–15 min. Comparative studies have found positive correlation between primary sensorimotor networks assessed with rsfMRI and task-based f MRI.

Traditionally f MRI has been used most frequently in patients with brain tumors in terms of displacement or involvement of functional cortex and thereby improve the safety and prognosis. Synthesis of diffusion tractography (DTI), rsf MRI data and Electrical Cortical Mapping has only further improved the outcome of the neurosurgical procedures. Rsf MRI has improved our understanding of stroke and has shown the possibility of contributing to acute stroke management and also stroke rehabilitation. Recent studies of rsfMRI in patients with acute stroke has shown decrease in neural connectivity with a few hours and even before motor impairment only to be re-established in those who recovered, suggesting that rsf MRI may be useful as a tool for selecting appropriate stroke therapies and monitoring. Although structural damage from stroke is focal, remote dysfunction can occur in regions connected to the area of lesion. Disruption of inter-hemispheric connectivity in the somatomotor network and the dorsal attention network has been found to be more strongly associated with behavioral impairment. Decreased inter-hemispheric connectivity has been found to be an

important contributor to neuromotor impairment after stroke. F MRI has been used as a part of the investigating algorithm in patients with intractable. Recent advances in rsf MRI due to its spatial resolution better than EEG could provide a better localization of the functional areas in patients with lesions close to the eloquent regions of the brain such as the sensorymotor cortex and the mesial temporal lobe.

Degenerative disorders such as Alzheimer's disease has been well studied with rsf MRI and several studies have identified RSN and DMN abnormalities and hippocampal clustering in patients with Alzheimer Disease, mild cognitive impairment, frontotemporal dementia as compared to controlled normal population groups. F MRI is being used in a number of ways to improve our understanding of psychiatric disorders. Some of the clinical applications include; helping to redefine clinical diagnoses on a less subjective, biological basis; identifying important psychological processes to emphasize in psychological interventions including major depressive disorders and schizophrenia. Recent work has demonstrated the ability of RS-f MRI to assist in the diagnosis of disorders of consciousness, demonstrating a negative correlation between the connectivity of the DMN and the level of consciousness impairment. RS-f MRI has also been used to identify patients with autism and attention deficit/hyperactivity disorder. Rsf MRI is also being tried to address novel targeting in psychopharmacological interventions and clarifying the heterogeneity and comorbidity of many diseases. Pharmacological f MRI, assaying brain activity after drug administration is being tried to assess blood –brain barrier penetration and evaluate dose vs effect information of the medication.

Rsf MRI has opened new vistas in understanding the evolutionary concepts in human cerebral functional development in terms of sensory motor, emotion, memory and language. Recent studies have shown it is now been possible to correlate anatomical development of the brain and its maturation and growth with its functional development in terms of the biological and cognitive needs.