Functional connectivity

- Network-based analysis of candidate oncogenes and pathways in hepatocellular carcinoma
- Anisomycin selectively inhibits orientation tuning shifts in mouse visual cortex
- Aberrant dynamics of the default mode network activity in patients with obsessive-compulsive disorder
- Interictal spikes and evoked cortical potentials share common spatiotemporal constraints in human epilepsy
- Striatal interdependencies in focal seizures: Insights from stereoelectroencephalographic functional connectivity analysis
- Asymmetric Cingulum Bundle Connectivity Is Modulated by Paracingulate Sulcus Morphology
- Anatomo-functional approach to multimodal motor mapping in diffuse glioma surgery: hierarchical networks
- Sex differences in structural and functional connectivity in healthy young adults from the Amsterdam Open MRI Collection

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Functional Connectivity (FC) refers to the temporal correlation between spatially remote neurophysiological events, often measured through non-invasive imaging techniques like functional Magnetic Resonance Imaging (fMRI), Electroencephalography (EEG), or Magnetoencephalography (MEG). It is used to understand how different regions of the brain communicate and coordinate their activity in various cognitive and behavioral states.

Key Points about Functional Connectivity: Definition:

Represents statistical dependencies or relationships between neural signals from different brain areas. Often described in terms of synchronization or coherence in activity patterns. Measurement Techniques:

fMRI: Measures the Blood Oxygen Level-Dependent (BOLD) signal to infer connectivity based on fluctuations in brain activity. EEG/MEG: Examines phase and amplitude relationships between oscillatory signals from different brain regions. Local Field Potentials (LFPs): Directly measures neural activity in animal studies. Methods of Analysis:

Correlation Analysis: Identifies temporal correlations between BOLD signals from different regions. Seed-based Connectivity: Focuses on specific “seed” regions and their connectivity with others. Independent Component Analysis (ICA): Identifies networks of correlated activity without pre-defined seeds. Graph Theory: Models the brain as a network with nodes (regions) and edges (connectivity measures). Functional Networks:

Commonly identified networks include: Default Mode Network (DMN): Active during rest and self-referential thought. Salience Network: Detects and filters salient stimuli. Executive Control Network: Associated with decision-making and working memory. Motor and Visual Networks: Linked to sensory and motor functions. Applications:

Understanding Disease: FC abnormalities are studied in neurological and psychiatric conditions like Alzheimer's disease, schizophrenia, and epilepsy. Developmental Studies: Examines changes in connectivity patterns across different life stages. Brain-Computer Interfaces: Utilizes FC patterns for controlling external devices. Limitations:

Indirect Measurement: FC does not indicate direct causal relationships (connectivity can be mediated by other regions). Static vs. Dynamic Connectivity: Traditional FC assumes stationarity, while real brain dynamics often vary over time. Noise and Artifacts: Confounds like head motion can affect measurements. Future Directions: Integration with structural connectivity (e.g., diffusion tensor imaging) to explore relationships between anatomical and functional connections. Exploring dynamic functional connectivity to understand how network relationships evolve over time. Machine learning applications to analyze large-scale FC data for predictive modeling and personalized medicine.

Functional connectivity is defined as the temporal dependency of neuronal activation patterns of anatomically separated brain regions and in the past years an increasing body of neuroimaging studies has started to explore functional connectivity by measuring the level of co-activation of resting-state functional magnetic resonance imaging time-series between brain regions.

Brain functional connectivity features can predict cognition and behavior at the level of the individual. Most studies measure univariate signals, correlating timecourses from the average of constituent voxels in each node. While straightforward, this approach overlooks the spatial patterns of voxel-wise signals within individual nodes. Given that multivariate spatial activity patterns across voxels can improve fMRI measures of mental representations, here we asked whether using voxel-wise timecourses can better characterize region-by-region interactions relative to univariate approaches. Using two fMRI datasets, the Human Connectome Project sample and a local test-retest sample, we measured multivariate functional connectivity with multivariate distance correlation and univariate connectivity with Pearson's correlation. We compared multivariate and univariate connectivity estimates, demonstrating that relative to univariate estimates, multivariate estimates exhibited higher reliability at both the edge-level and connectome-level, stronger prediction of individual differences, and greater sensitivity to brain states within individuals. Our findings suggest that multivariate estimates reliably provide more powerful information about an individual's functional brain organization and its relation to cognitive skills [1)].

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see Insular functional connectivity

The FC was analyzed in 10 pituitary neuroendocrine tumor patients under propofol anesthesia before and after tumor resection. The FC of each session (totally 20 sessions) was correlated to a reference matrix of a group of healthy subjects to evaluate the variations of the overall, interhemispheric and intrahemispheric FC between sessions.

The resting state patterns could be detected during anesthesia (F(1,9)= 112.14; p<0.001)There was a significant effect of session (F(1,9)= 19,401; p=0.002), which included a reduction in resting state from first to the second session. There was no effect of connection type (F(2,8)=1,498; p=0.280), nor was there an interaction between connection type and session (F(2,8),=0.187; p=0.833). The correlation between the observed reduction in resting state activity between the sessions, and the time span between sessions was not significant (r=0.25;p=0.29). The FC of the first session showed a significant correlation to the initial dose of anesthesia (r= 0.7, P= 0.007). However, there was no significant correlation between the total dose of propofol and the FC of the second session (r=1.7; p=0.6).

Significant FC could be detected under anesthesia but showed a significant decrease in the second session. To implement the FC intraoperative brain mapping, further studies are required to optimize the depth sedation in order to obtain stable FC between sessions [2].

Resting-state networks (RSNs) show spatial patterns generally consistent with networks revealed during cognitive tasks. However, the exact degree of overlap between these networks has not been clearly quantified. Such an investigation shows promise for decoding altered functional connectivity (FC) related to abnormal language functioning in clinical populations such as temporal lobe epilepsy (TLE). In this context, we investigated the network configurations during a language task and during resting state using FC. Twenty-four healthy controls, 24 right and 24 left TLE patients completed a verb generation (VG) task and a resting-state fMRI scan. We compared the language network revealed by the VG task with three FC-based networks (seeding the left inferior frontal cortex (IFC)/Broca): two from the task (ON, OFF blocks) and one from the resting state. We found that, for both left TLE patients and controls, the RSN recruited regions bilaterally, whereas both VG-on and VG-off conditions produced more left-lateralized FC networks, matching more closely with the activated language network. TLE brings with it variability in both task-dependent and task-independent networks, reflective of atypical language organization. Overall, our findings suggest that our RSN captured bilateral activity, reflecting a set of prepotent language regions. We propose that this relationship can be best understood by the notion of pruning or winnowing down of the larger language-ready RSN to carry out specific task demands. Our data suggest that multiple types of network analyses may be needed to decode the association between language deficits and the underlying functional mechanisms altered by disease [3].

Functional connectivity is defined as the temporal dependency of neuronal activation patterns of anatomically separated brain regions and in the past years an increasing body of neuroimaging studies has started to explore functional connectivity by measuring the level of co-activation of resting-state functional magnetic resonance imaging time-series between brain regions. These studies have revealed interesting new findings about the functional connections of specific brain regions and local networks, as well as important new insights in the overall organization of functional communication in the brain network. Here we present an overview of these new methods and discuss how they have led to new insights in core aspects of the human brain, providing an overview of these novel imaging techniques and their implication to neuroscience. We discuss the use of spontaneous resting-state fMRI in determining functional connectivity, discuss suggested origins of these signals, how functional connections tend to be related to structural connections in the brain network and how functional brain communication may form a key role in cognitive performance. Furthermore, we will discuss the upcoming field of examining functional connectivity patterns using graph theory, focusing on the overall organization of the functional brain network. Specifically, we will discuss the value of these new functional connectivity tools in examining believed connectivity diseases, like Alzheimer's disease, dementia, schizophrenia and multiple sclerosis [4].

Impaired functional connectivity

Impaired functional connectivity

Observational studies

A study attempted to elucidate whether deep brain stimulation for Parkinson's disease alters the functional connectivity pattern of cognitive networks.

The study obtained fMRI and cognitive scale data from 37 PD patients before and after the DBS surgery. Seed-based FC analysis helped demonstrate the FC changes of the default mode network (DMN), executive control network (ECN), and dorsal attention network (DAN).

PD patients indicated significant network connectivity decline in DMN [such as in right precuneus, left angular gyrus, and left middle frontal gyrus (MFG)], ECN [such as in left inferior parietal gyrus, left MFG, and left supplementary motor area (SMA)], and DAN [such as in left inferior frontal gyrus and left MFG] post-DBS surgery. The phonemic fluency score was positively associated with the FC value of the right precuneus and left angular gyrus in DMN before DBS.

The general reduction in FC in the major cognitive networks after DBS surgery depicted the presence of the corresponding network reorganization. Further research can help explore the mechanism of impaired cognitive function post-DBS [5)]

This study provides meaningful insights into the effects of DBS on cognitive network connectivity in PD, highlighting significant FC declines in major networks during the microlesion period. However, the small sample size, absence of a control group, and limited cognitive assessments constrain its conclusions. Further research with more robust designs and longer follow-ups is essential to deepen our understanding of DBS-induced cognitive changes and their clinical implications.

1)

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