Functional Connectivity & Network Analysis

Basic concepts and practical applications

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An introduction to the functional connectivity and network analysis

1. Functional connectivity: Overview
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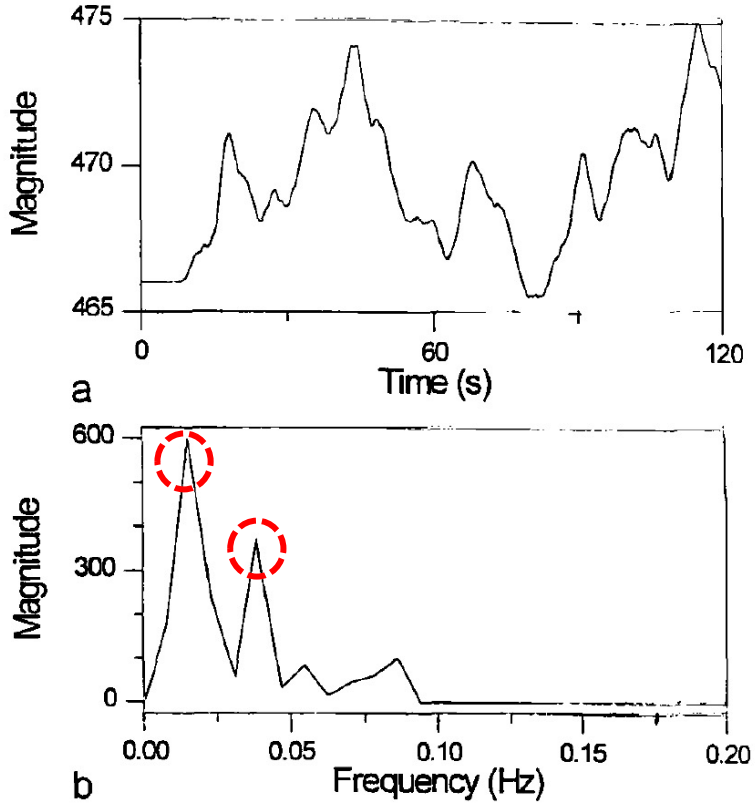
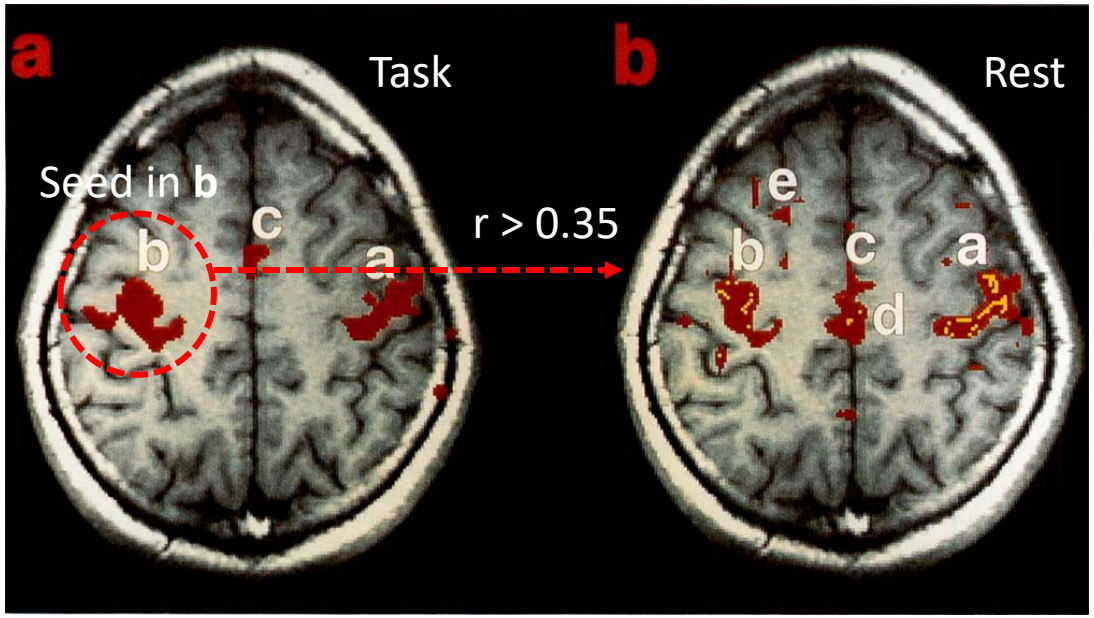
What is functional connectivity?

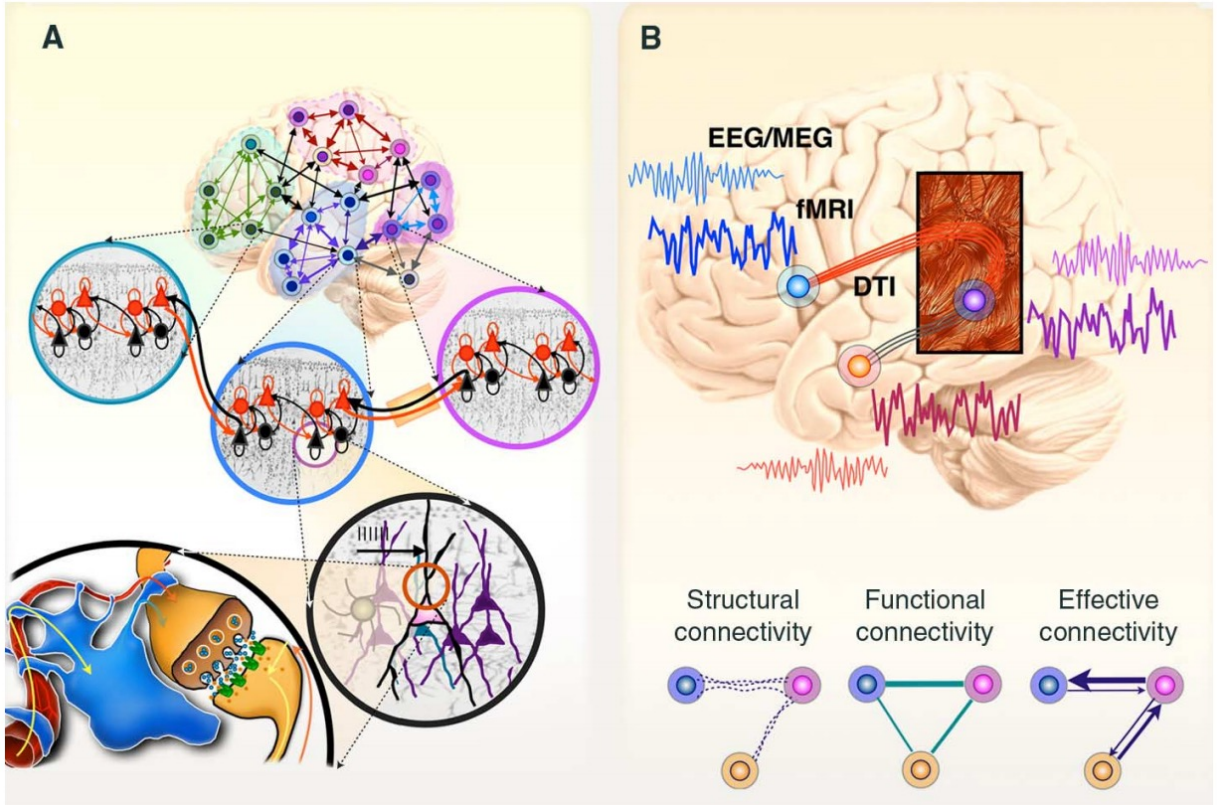
Low-frequency fluctuation seems to be a manifestation of neurophysiological “connection”.





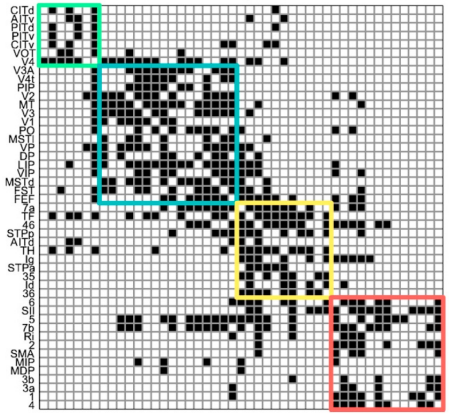
Biswal et al., 1995

What is functional connectivity?

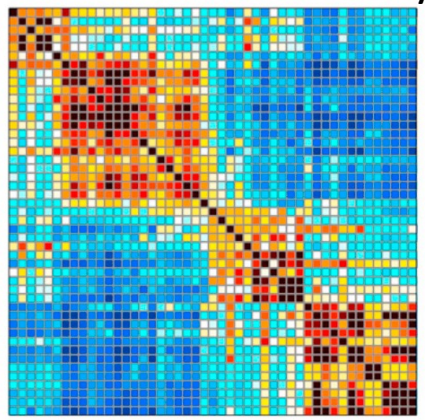


Park & Friston, 2013

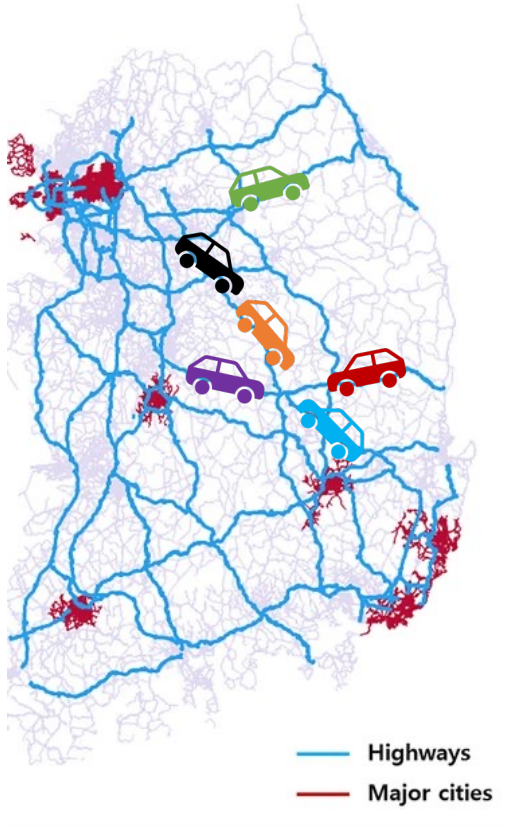
Structural connectivity



Functional connectivity

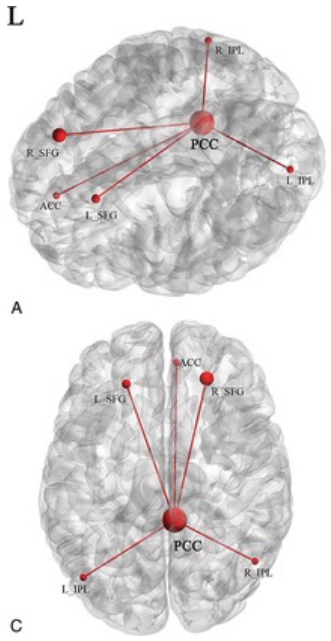


Rubinov & Sporns, 2013

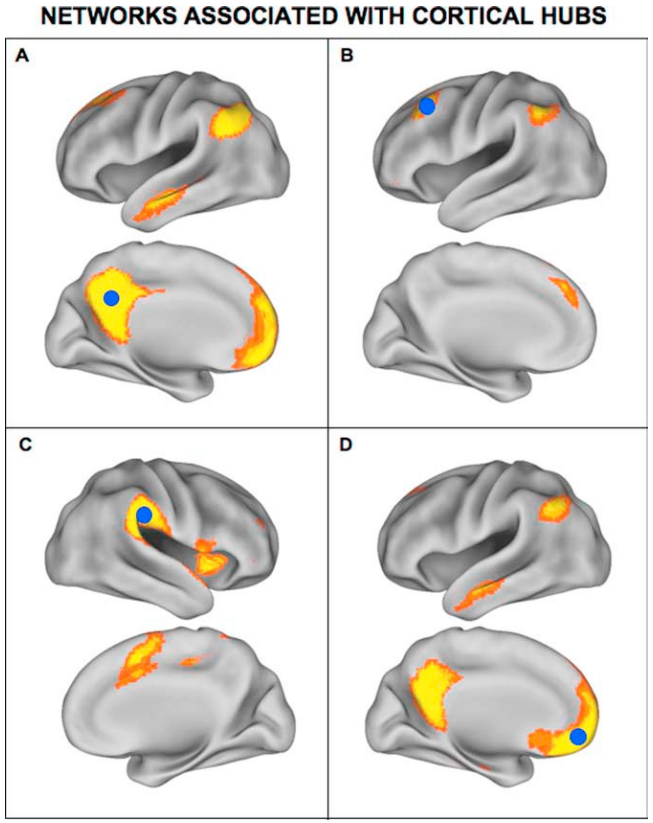


How to calculate functional connectivity?

Seed-based correlation

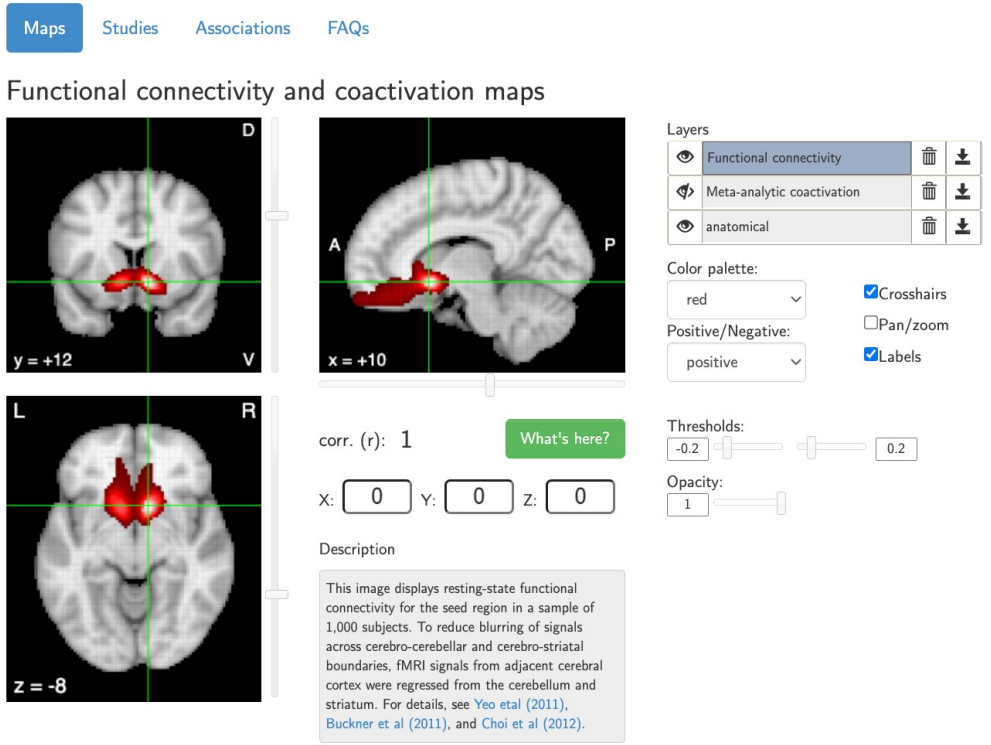


Wang et al., 2018



Buckner et al., 2009

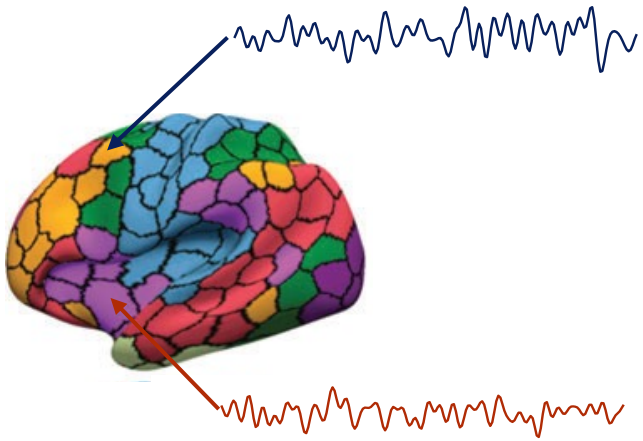
Data for coordinates: 10 12 -8



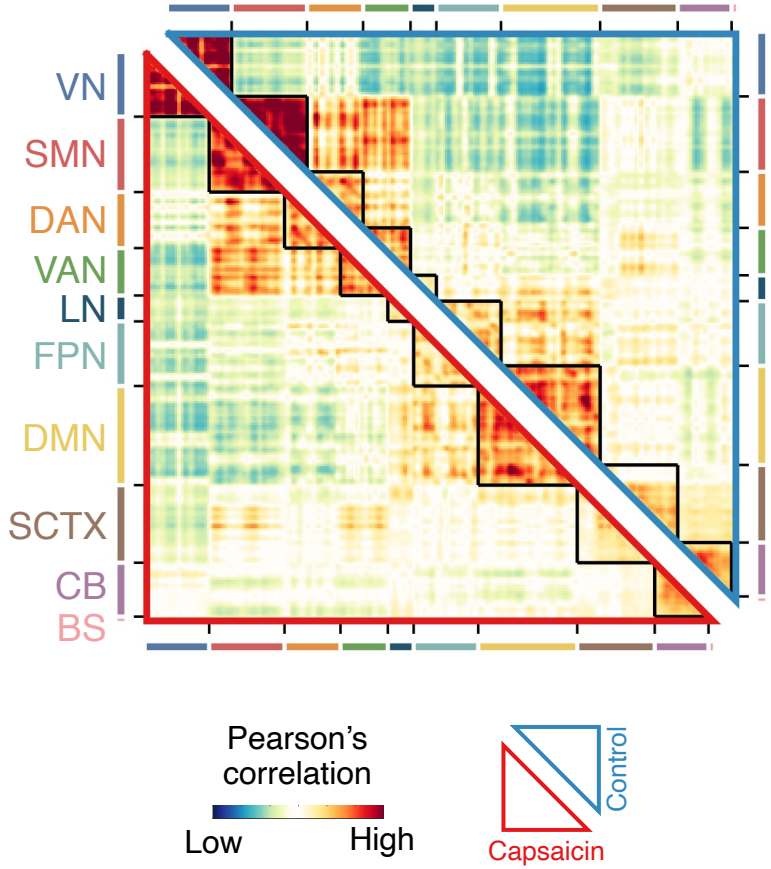
https://neurosynth.org/locations/10_12_-8_6/

How to calculate functional connectivity?

Parcellation-based correlation

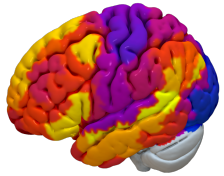


Average signals
within each ROI

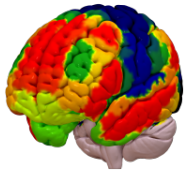


How to calculate functional connectivity?

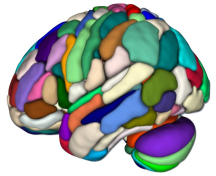
Parcellation



Schaefer

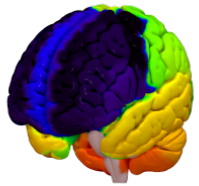


Yeo



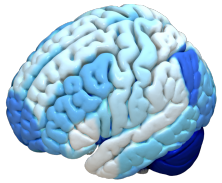
Gordon

Brainnetome



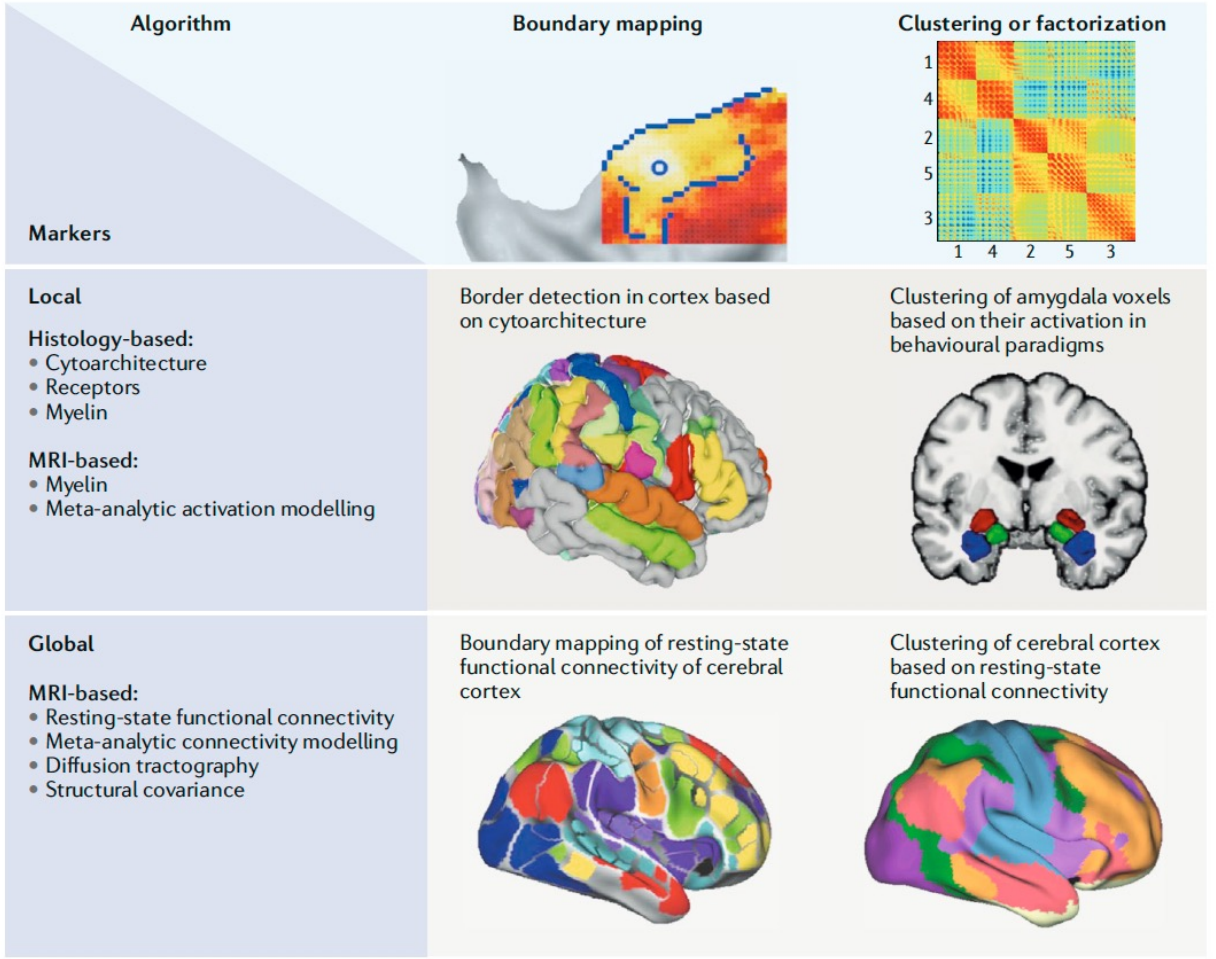
Harvard-Oxford

HCP-MMP 1.0



ICA-based

https://www.lead-dbs.org/helpsupport/knowledge-base/atlasesresources/cortical-atlas-parcellations-mni-space/

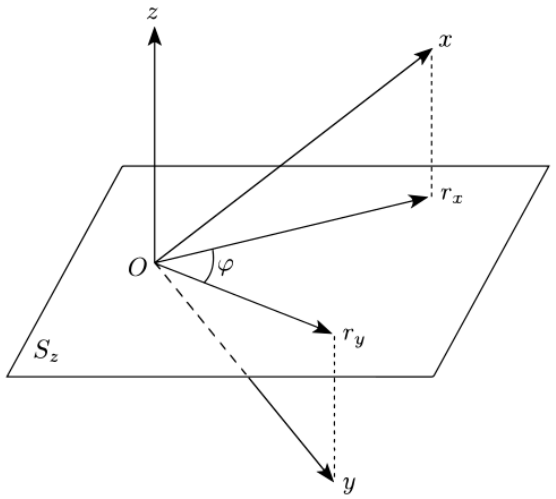


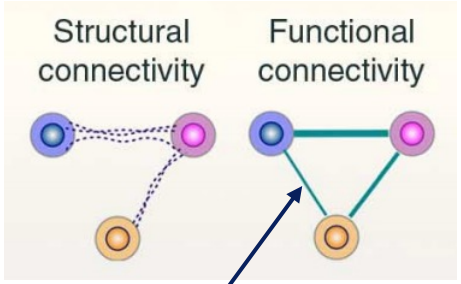
Eickhoff et al., 2018

How to calculate functional connectivity?

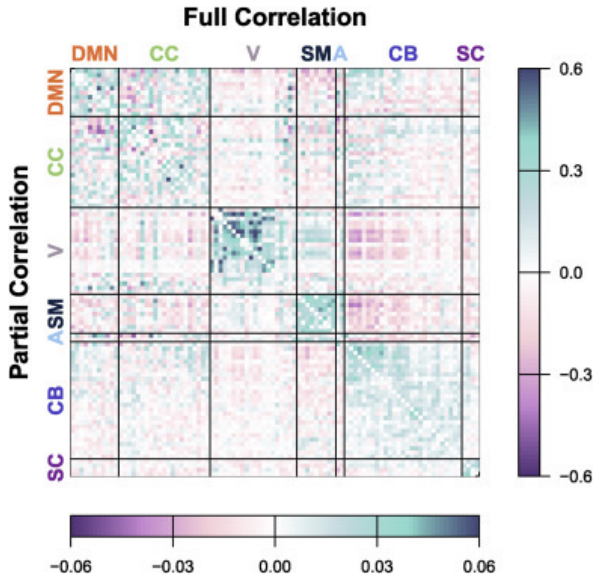
What else?

- Partial correlation



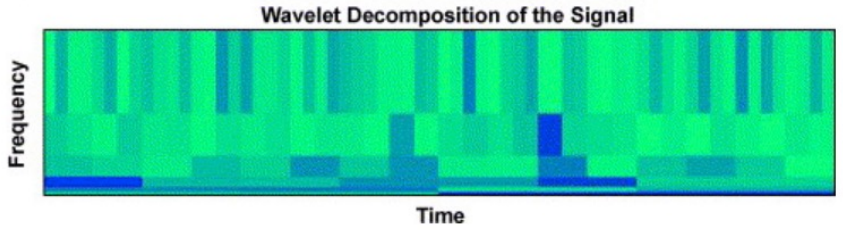


Indirect path



Mejia et al., 2018

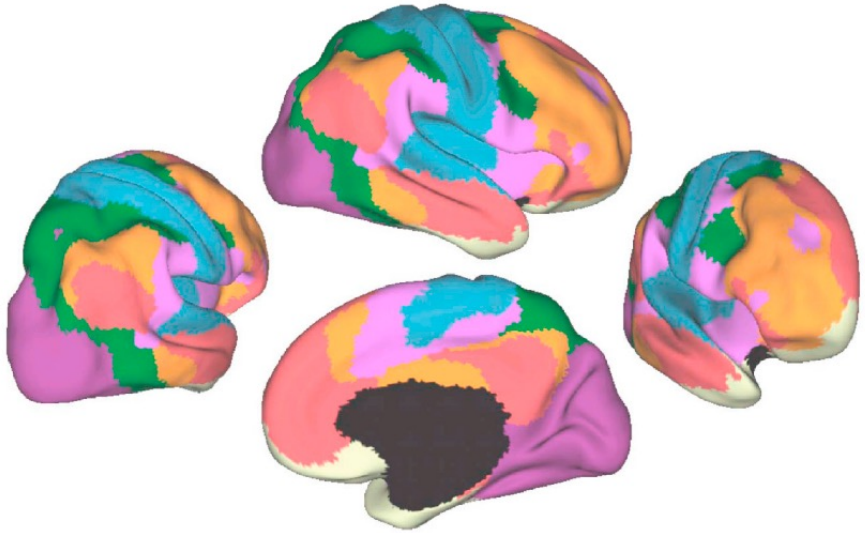
- Wavelet coherence



Bullmore et al., 2004

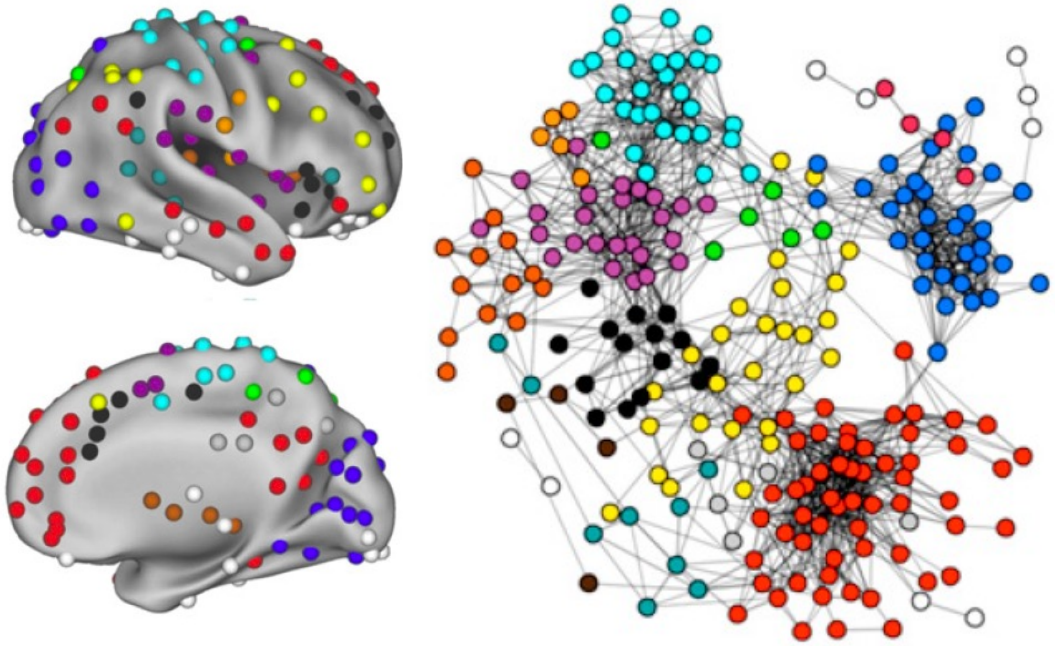
Why functional connectivity is important?

Functional architecture of brain – e.g., Resting state network



Purple (Visual)
Blue (Somatomotor)
Green (Dorsal Attention)
Violet (Ventral Attention)
Cream (Limbic)
Orange (Frontoparietal)
Red (Default)

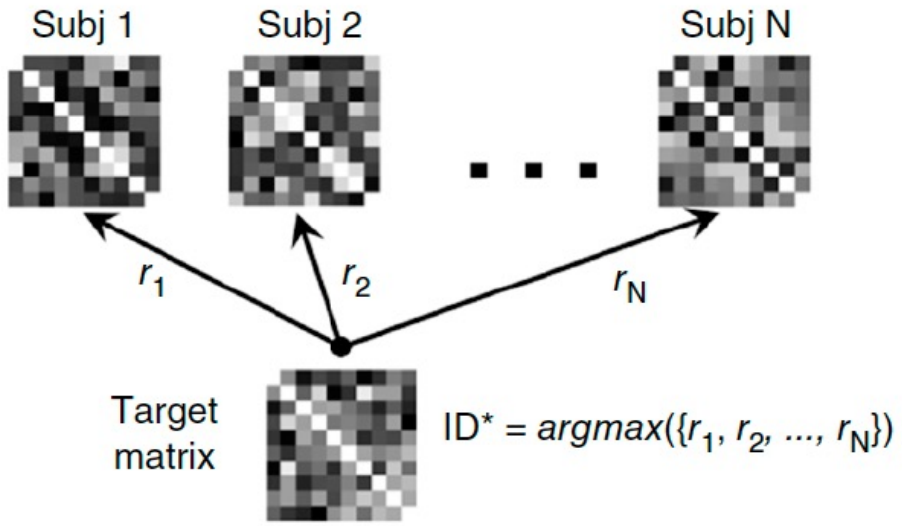
Yeo et al., 2011

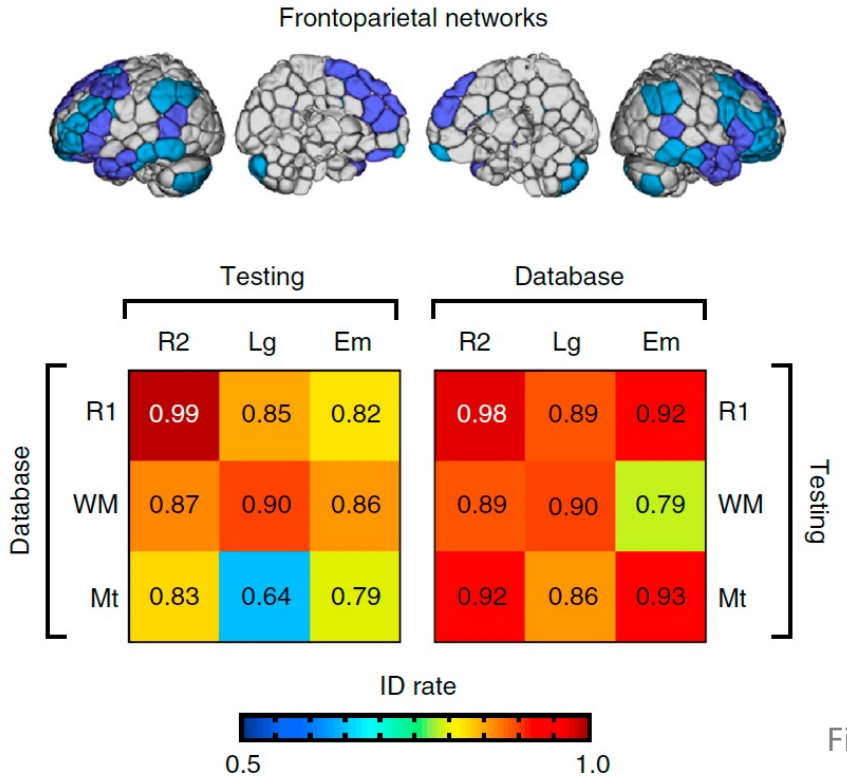


Power et al., 2011

Why functional connectivity is important?

Individual differences

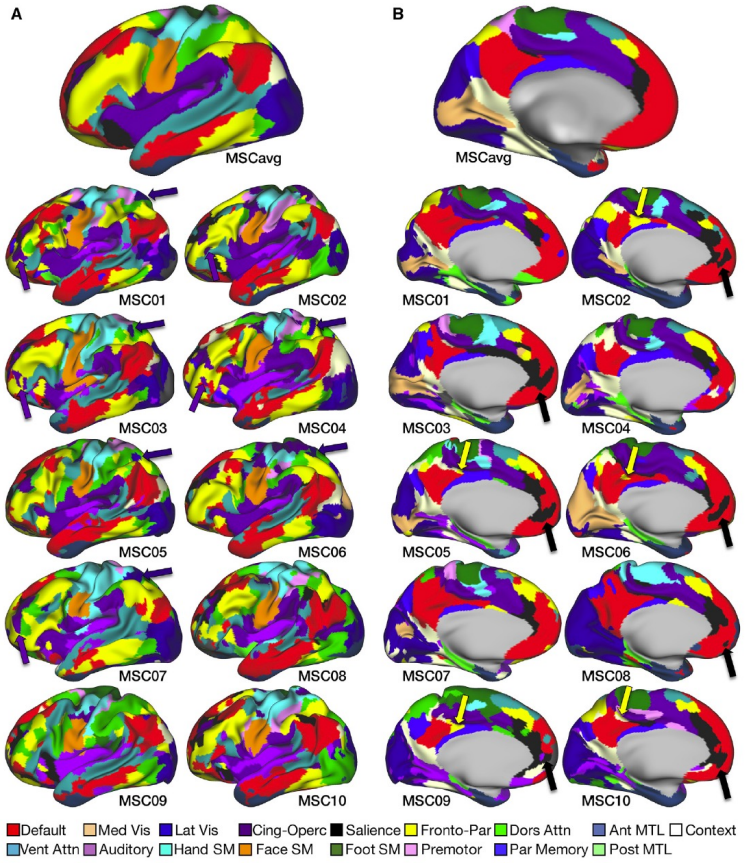




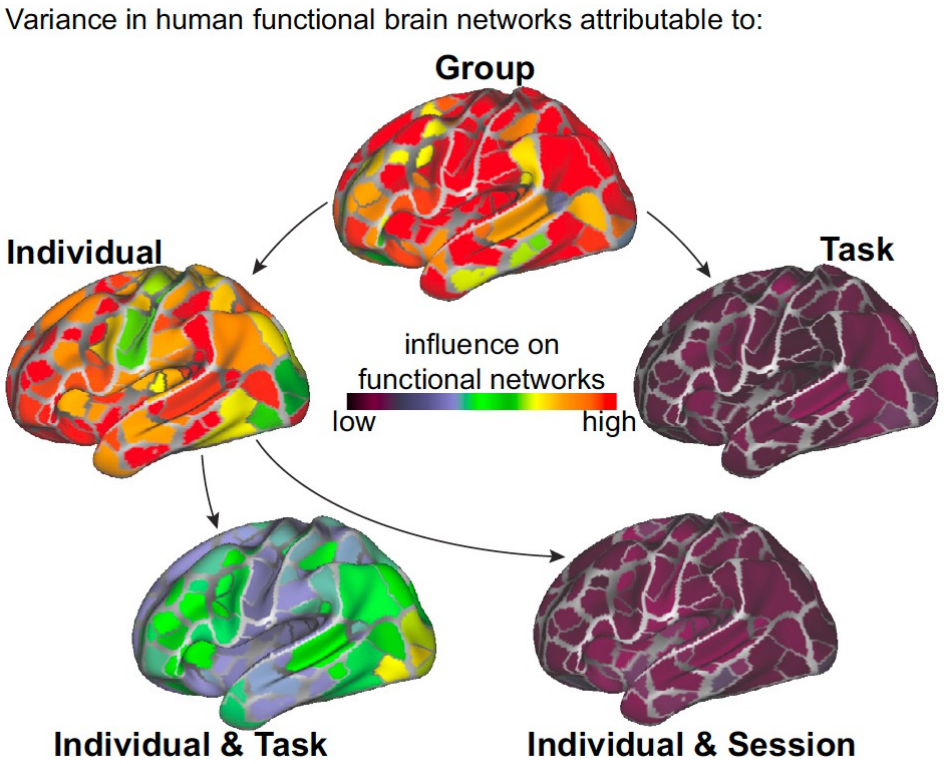
Finn et al., 2015

Why functional connectivity is important?

Individual differences



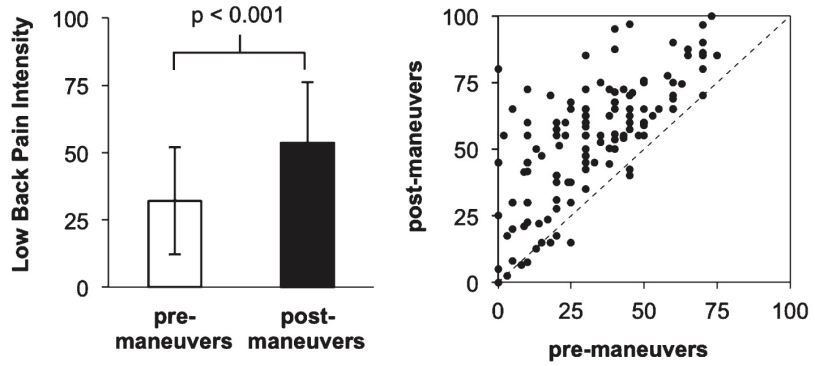
Gordon et al., 2017

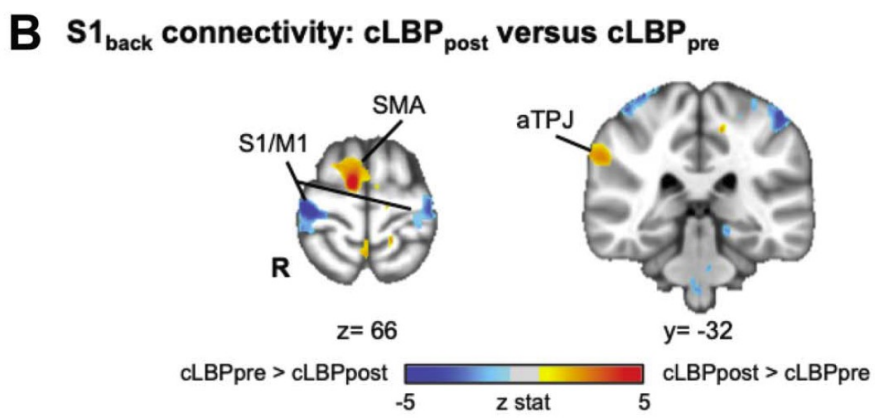


Gratton et al., 2018

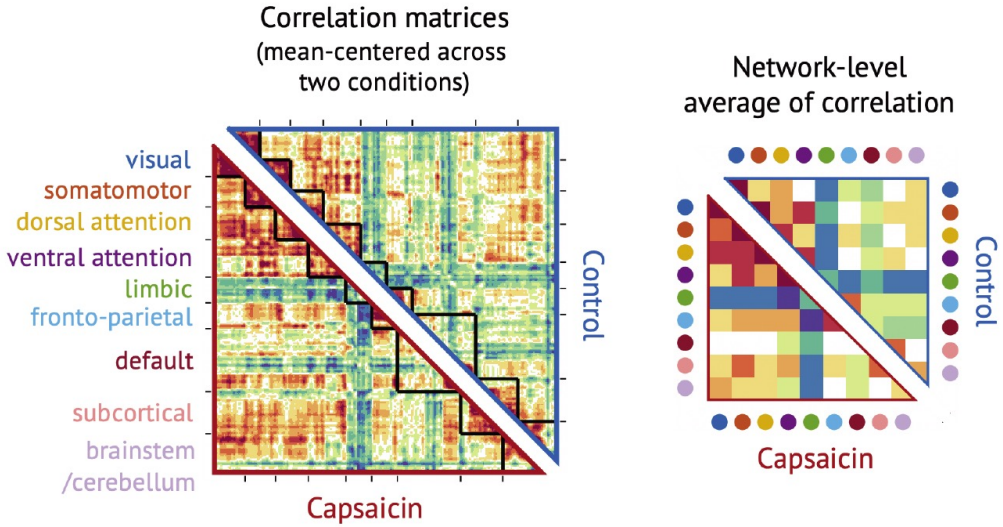
Why functional connectivity is important?

Task-induced changes of neural dynamics

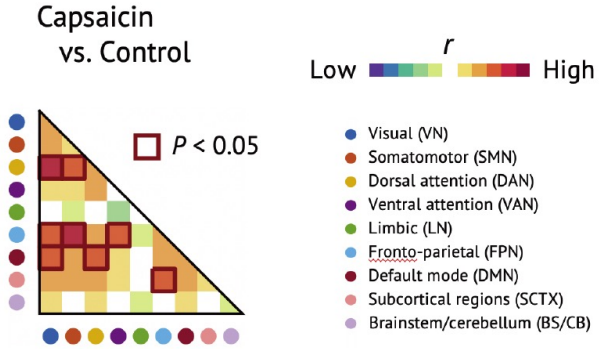




Kim et al., 2019

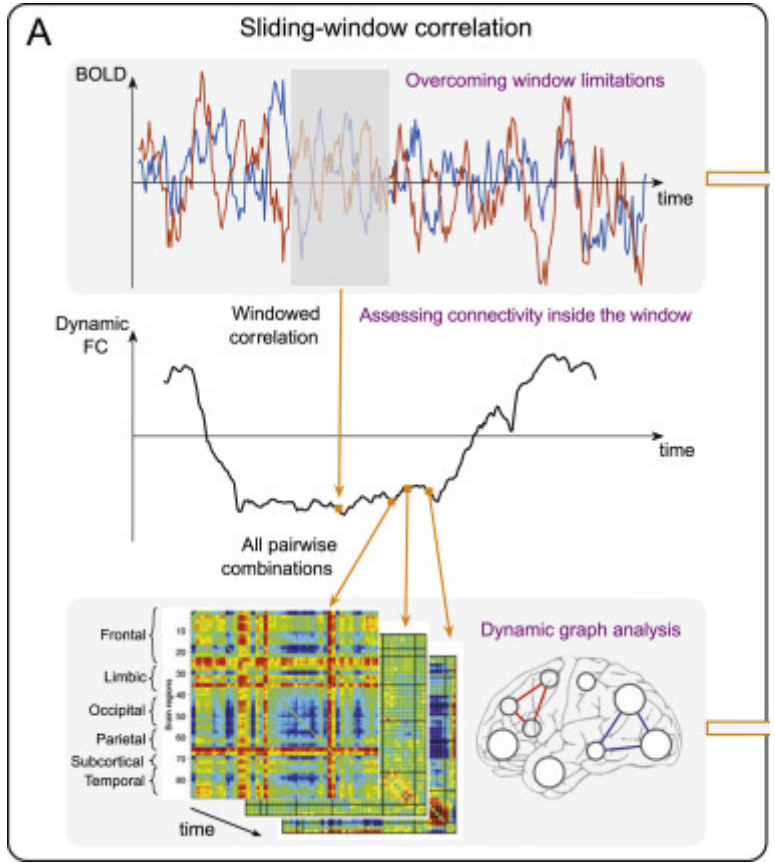


Lee et al., 2021



Dynamic functional connectivity

Time-varying changes of brain functional connectivity



Preti et al., 2017

Window type (length, volatility)

Time-frequency analysis (phase synchrony)