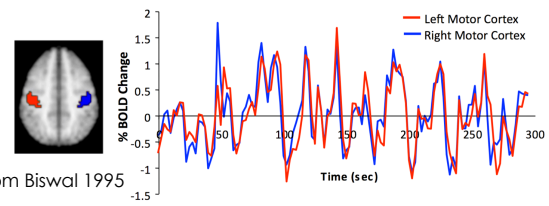
# ANALYSIS APPROACHES PART THREE

1

## Functional connectivity

- The core operation of FC: correlate activity in one voxel/region with activity in another voxel/region
- Often performed on resting-state data
  - "resting-state functional connectivity (RSFC)"




from Biswal 1995

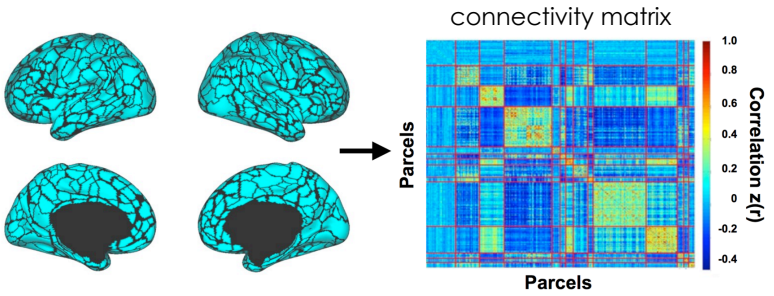
slide courtesy of S. Petersen

**Sets of voxels can correlate at rest at very low frequency (maybe .1-.01 Hz).**

2

# Functional connectivity

- Various flavors:
  - Correlate one voxel with every other voxel in the brain
  - Correlate ROIs with other ROIs
  - Use correlation structure to determine parcellation of the brain




slide courtesy of S. Petersen

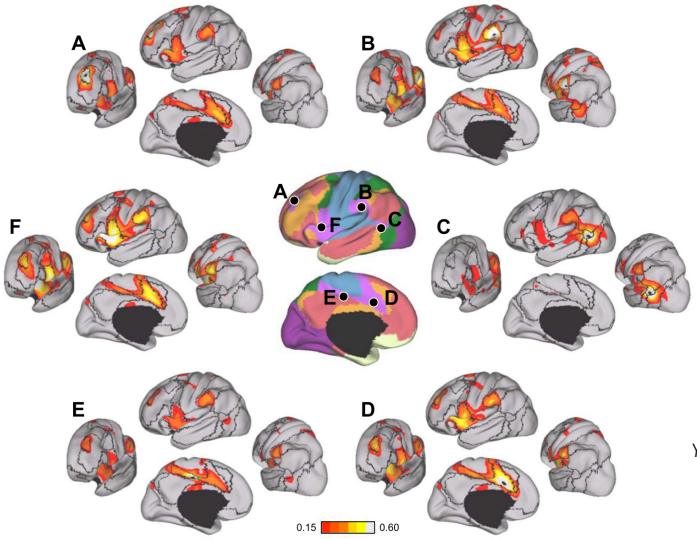
3

# Functional connectivity

- A few important observations:
  - FC has been shown to be correlated with structural connectivity (e.g. from diffusion MRI tractography) [e.g. Honey, *PNAS*, 2009]
  - Connectivity during rest is quite similar to connectivity during "tasks" (a catch-all term for cognitive neuroscience experiments)
  - Extremely popular in the clinical world, as connectivity measures correlate with various behavioral measures and are altered in disease states
    - I.e., maybe useful as a biomarker (even if not very interpretable)?

4

# A move towards networks...

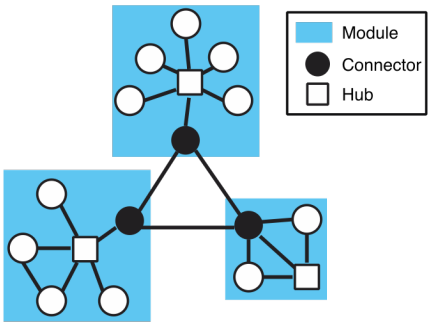



*Yeo et al, 2011*

6

# And then graph theory...

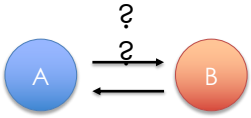
- For example, binarize the connectivity matrix and interpret as a graph with nodes and edges
- And then proceed to quantify myriad network properties

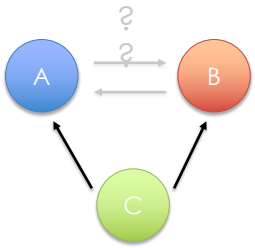



Slide adapted from Caterina Gratton

7

# Major problems




- No guarantee that an actual connection exists
  - E.g., a third confounder
- Some want to claim directionality (e.g. DCM, Granger Causality), but there are HRF delay issues…
- Extremely susceptible to motion artifacts and other global noise sources (see Power, *NeuroImage*, 2014)
- Subject is likely engaged in cognitive activity during rest

*…keep in mind that there is nothing intrinsically wrong with resting-state data; it depends on what OUR CLAIMS are about the data*

Figure adapted from Caterina Gratton

8

# How does this relate to other fMRI analysis approaches?

- Fundamentally different from subtraction/MVPA/RSA/encoding
  These relate **experimental manipulation to responses**
  FC relates **responses to responses**
- A shift in mindset towards thinking about neural communication
- To the cognitive neuroscientist, are resting-state fluctuations in task paradigms uninteresting noise or meaningful signals (e.g. Donner, *JNeurosci*, 2013)?
- Amusingly, FC is just the flip of RSA
  - if $\mathbf{X}$ is voxels x stimuli, RSA ≈ $\mathbf{X}^T\mathbf{X}$ and FC ≈ $\mathbf{X}\mathbf{X}^T$
- There are attempts to merge approaches, e.g. "connective fields" in vision (Haak, *NeuroImage*, 2013)

9