

INC Summer Neuroimaging Bootcamp, 2022

Resting State Functional Imaging

Joel Bruss (Tranel & Boes Labs)

May 25, 2022

Outline

- What Is Resting State?
- A Brief History Of Resting State
 - The Default Mode Network
 - Motor Network And Time-Series Correlations
- Accounting For Nuisance Signals
 - Motion
 - Magnetic Field Inhomogeneity
 - Confound Signals (WM, CSF, Global Signal)
 - Smoothing And Filtering
- Post-Processed Data

What Is Resting State?

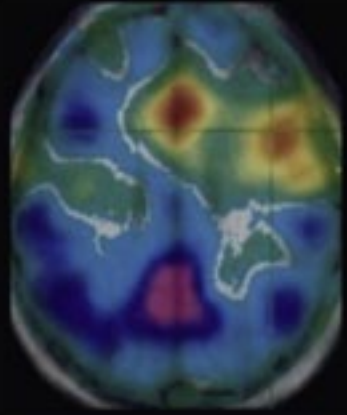
Resting State

- A boring, passive task
 - Lay still in a scanner for 6+ minutes, asked to clear your mind of thoughts, try not to think of anything in particular, don't fall asleep
 - Either eyes closed, eyes open staring at a fixation cross, passive movie viewing
- Low frequency fluctuations, typically around 0.01 to 0.1 Hz
 - Compared to EEG (~4-30 Hz range)
- Correlated fluctuations between functionally “connected” regions
- BOLD signal as a proxy for neuronal activity
- Really just a series of grayscale voxels, measured over time

A Brief History Of Resting State

Default Mode Network

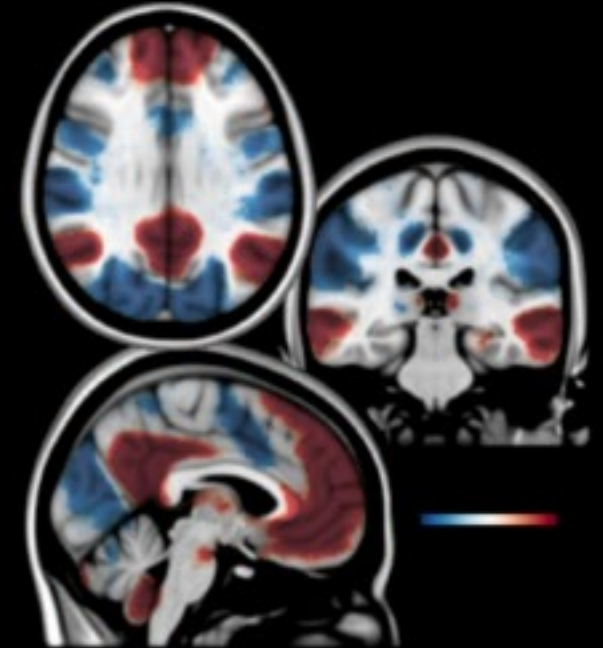
The Default Mode Network



Andreasen et. al.
"REST" network; PET passive - task
activation compared to episodic
memory



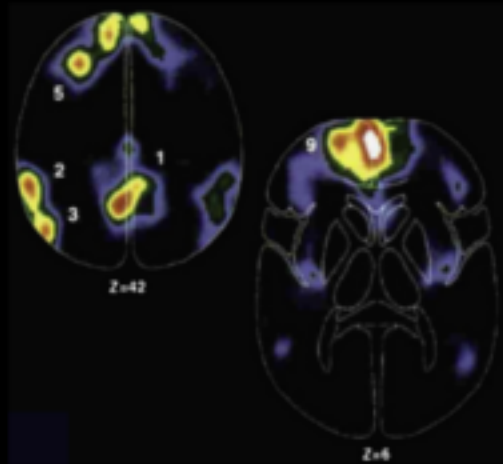
Buckner et. al.
Task fMRI passive (fixation)
compared to word generation



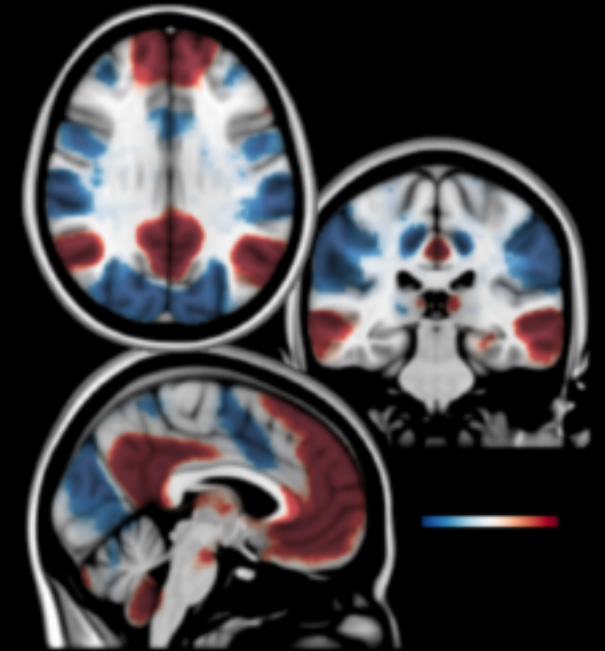
Example DMN

1995

The Default Mode Network



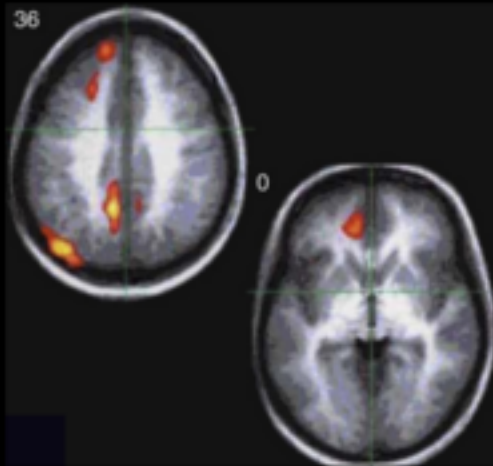
Shulman et. al.
Meta analysis across 10 studies,
regions active during passive
task states



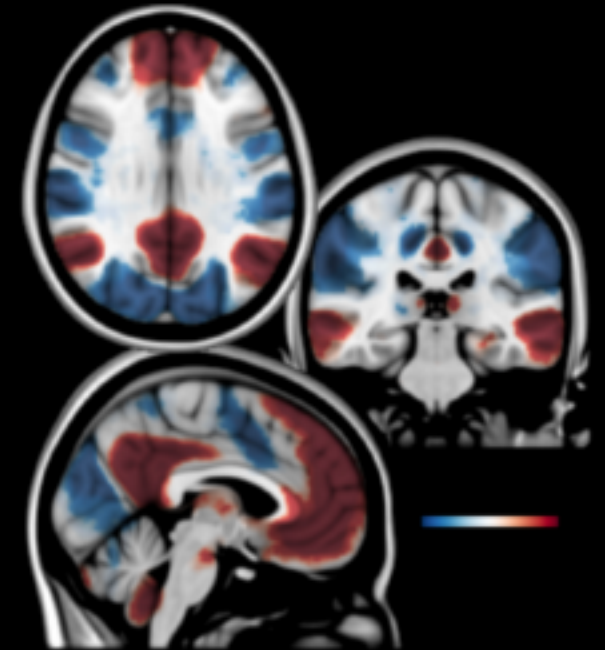
Example DMN

1997

The Default Mode Network



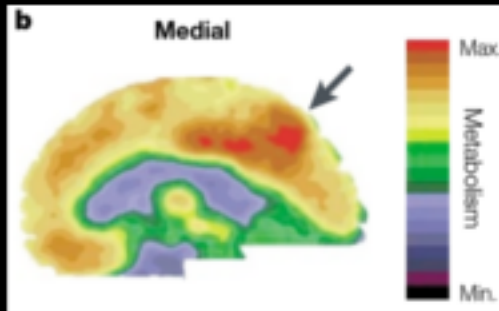
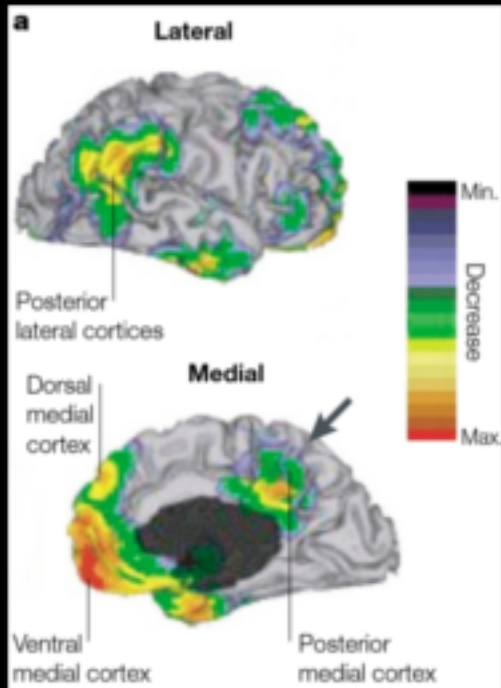
Binder et. al.
Task fMRI (Rest - tones);
perceptual task disruption of
rest activity, first targeted DMN study



Example DMN

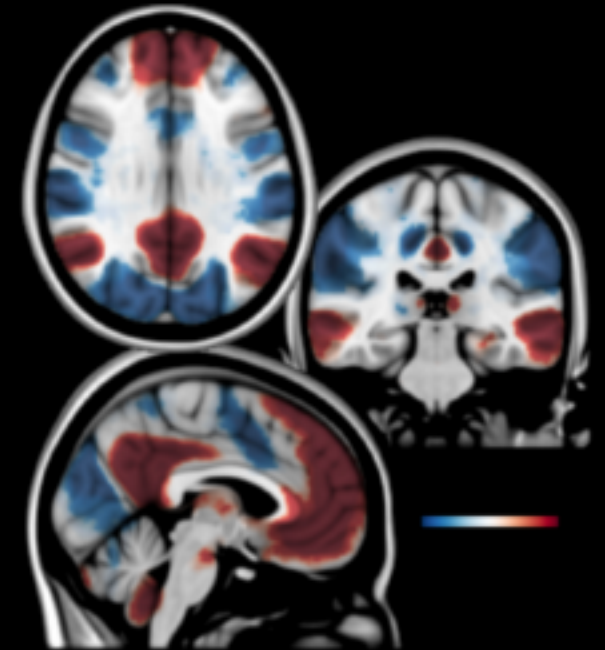
1999

The Default Mode Network



Gusnard & Raichle
Re-examination of Shulman et. al. (1997)
PET de-activation vs. PET resting
metabolism

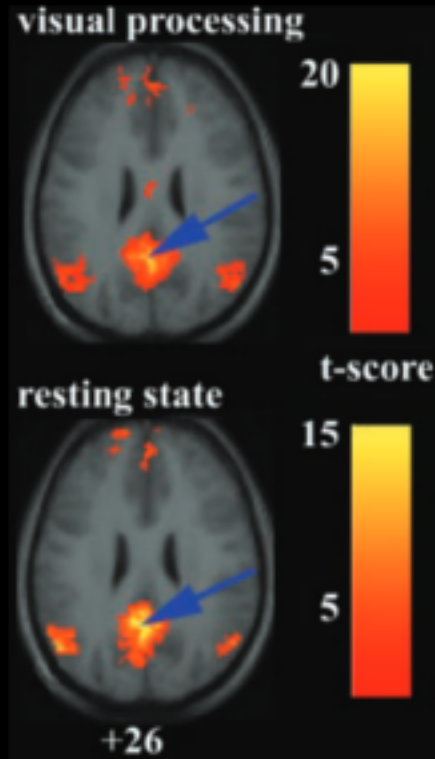
Raichle et. al.
"A **Default Mode** of Brain Function"



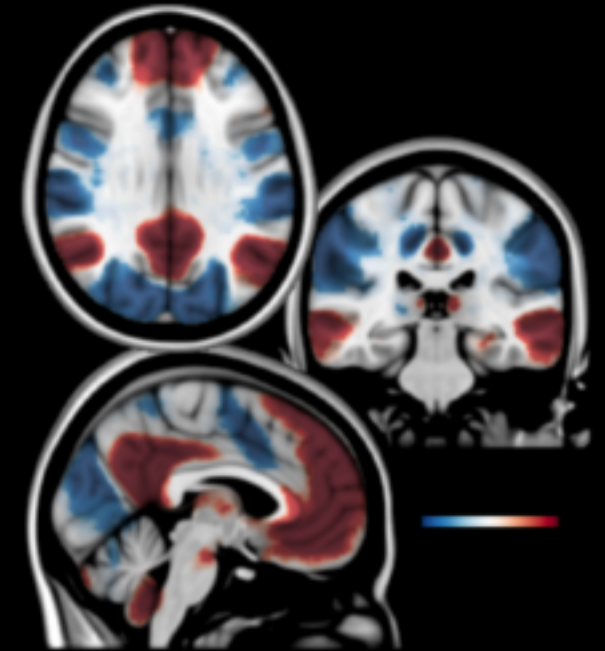
Example DMN

2001

The Default Mode Network



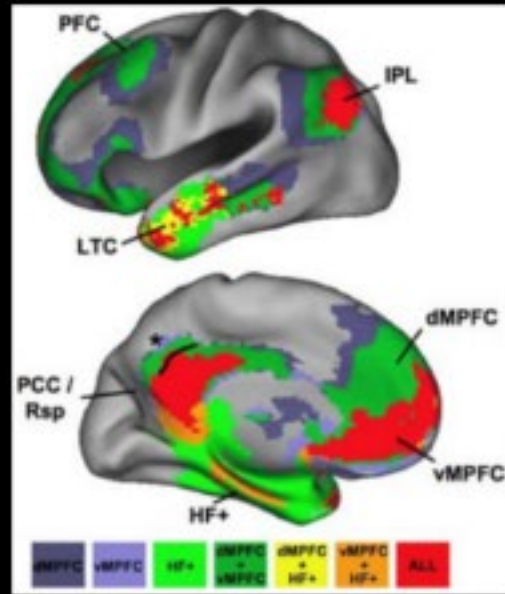
Greicius et. al.
Working memory task derived
ROIs (e.g. PCC) used for functional
connectivity, compared to a visual
processing task



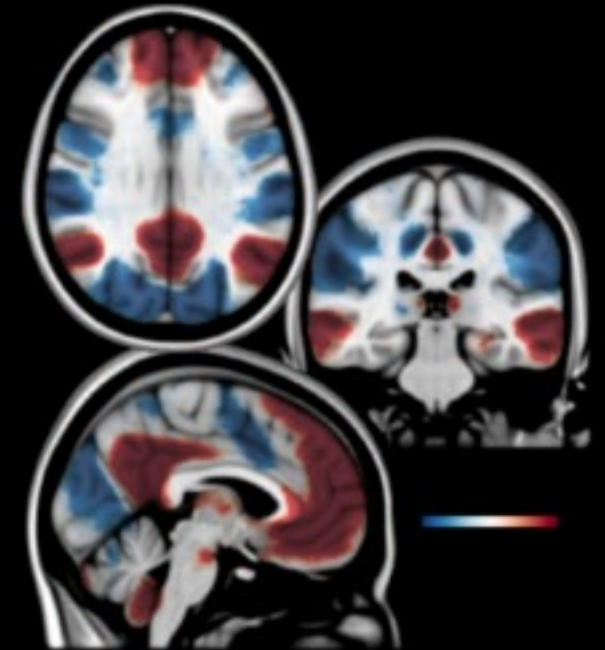
Example DMN

2003

The Default Mode Network



Buckner et. al.
Expansion of DMN into
subsystems



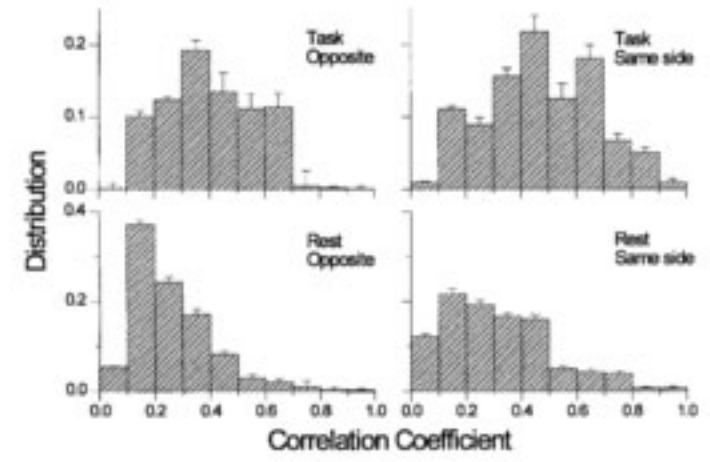
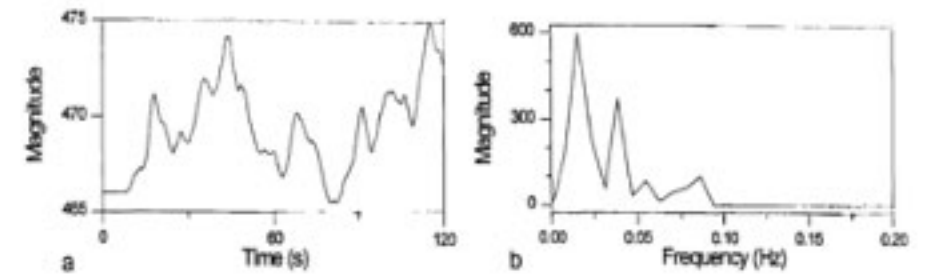
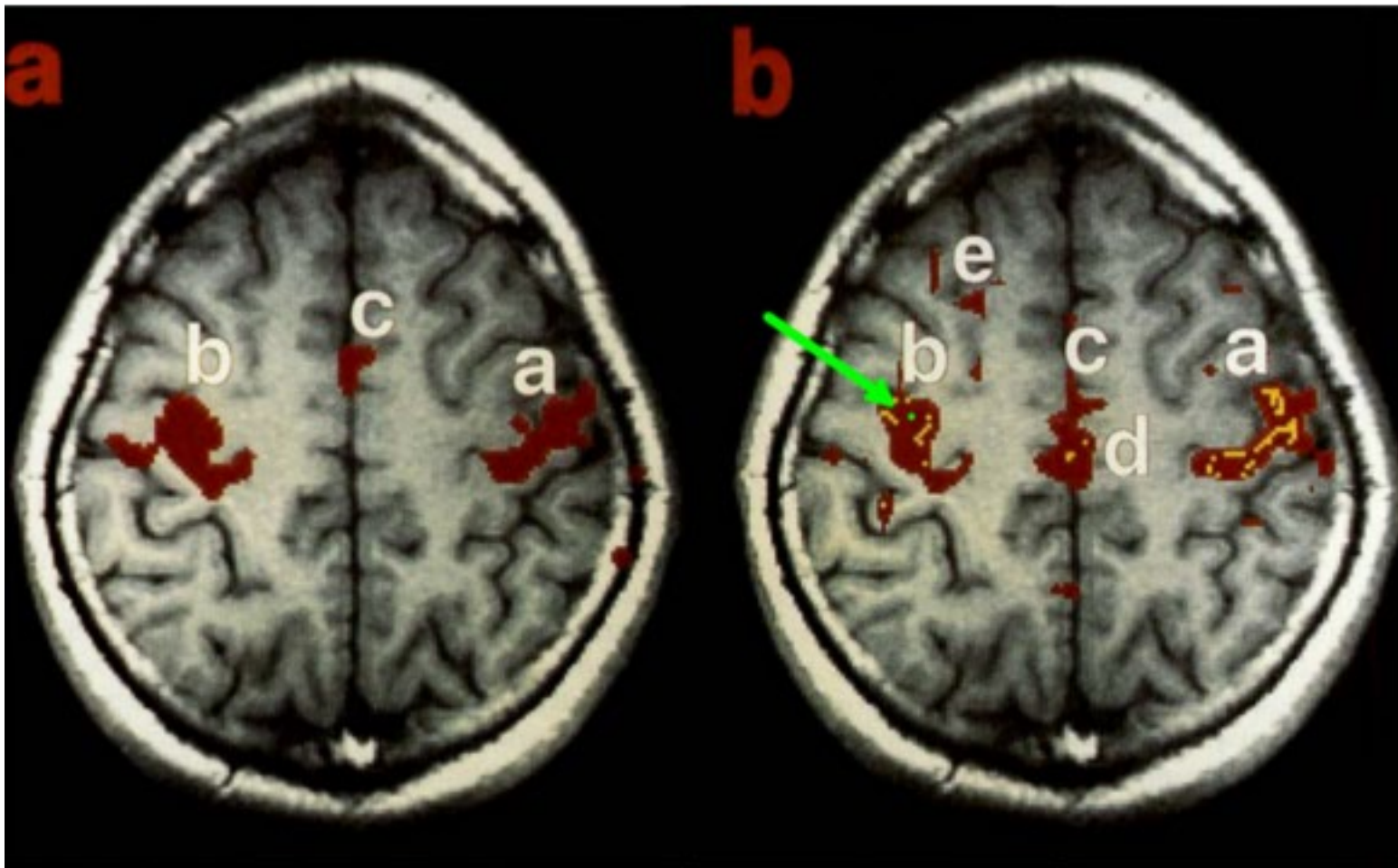
Example DMN

2008

A Brief History Of Resting State

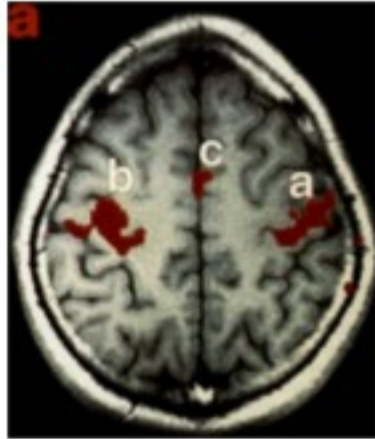
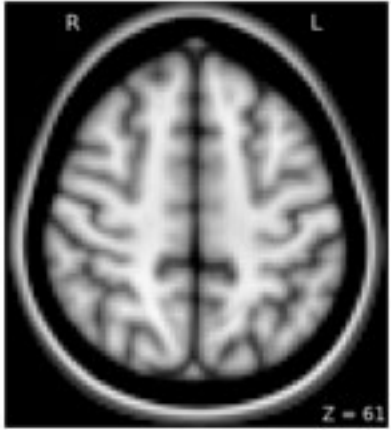
Motor Network And Time-Series Correlations

The Motor Network

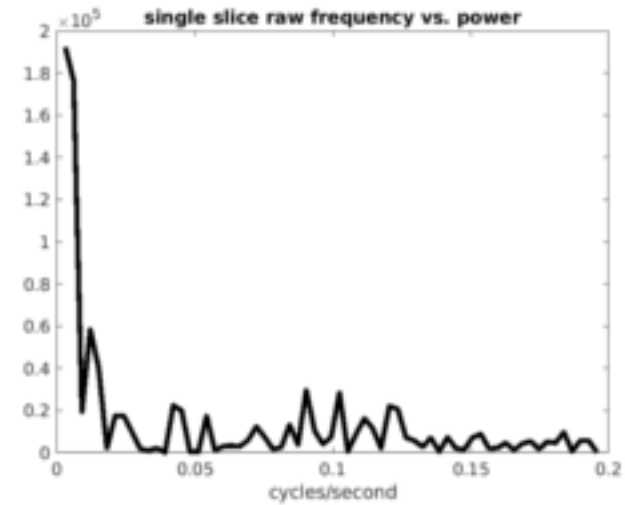
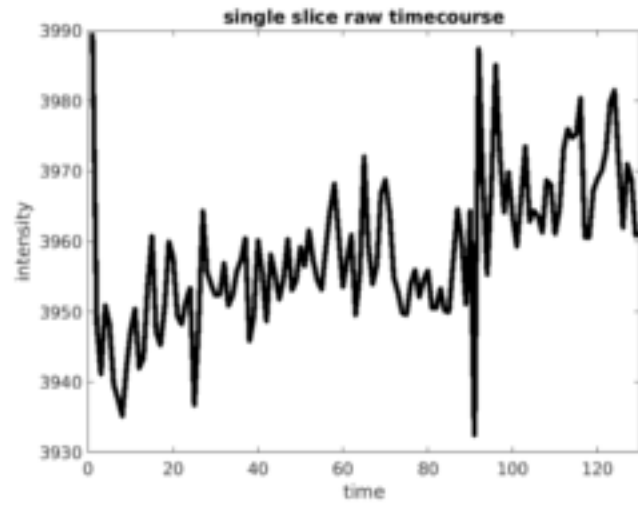
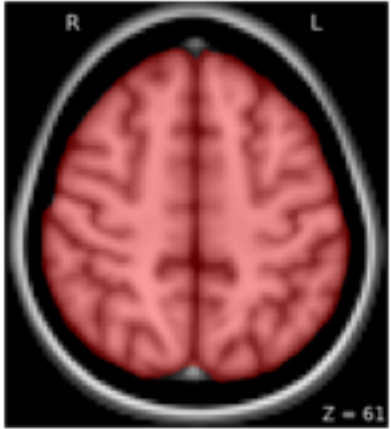


Biswal et. al., 1995

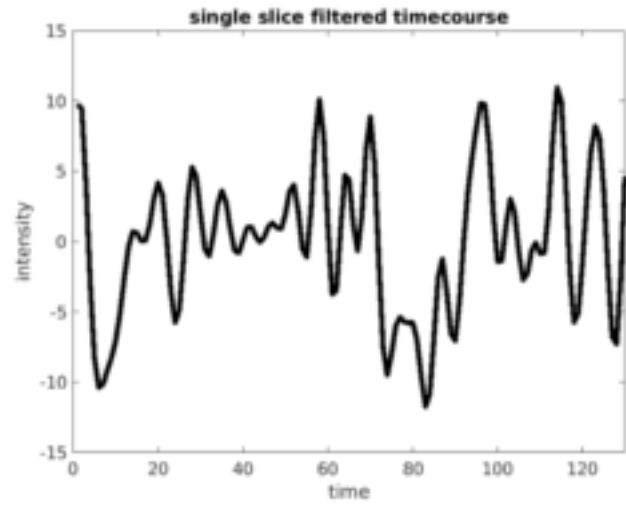
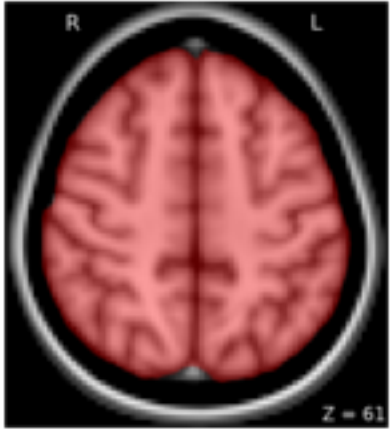
Raw To Filtered Data



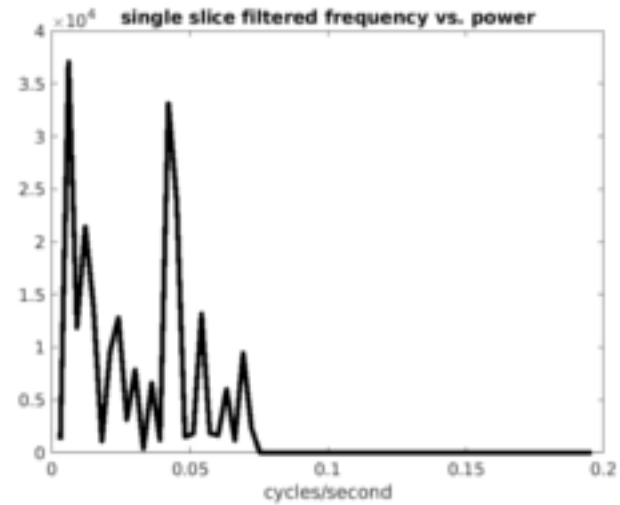
Raw To Filtered Data



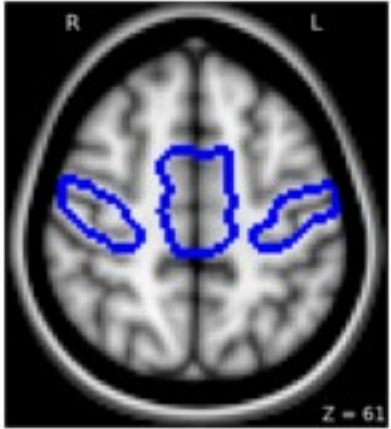
Raw To Filtered Data



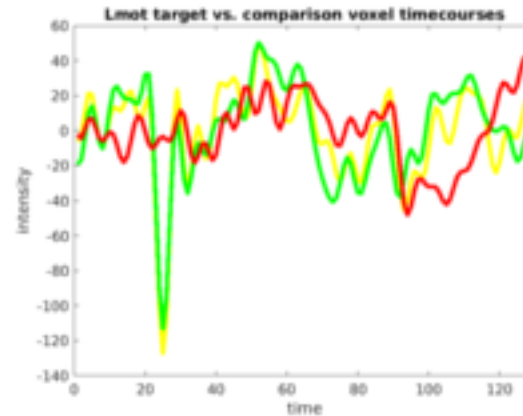
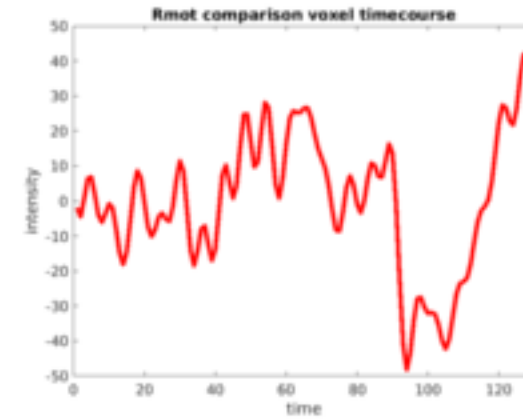
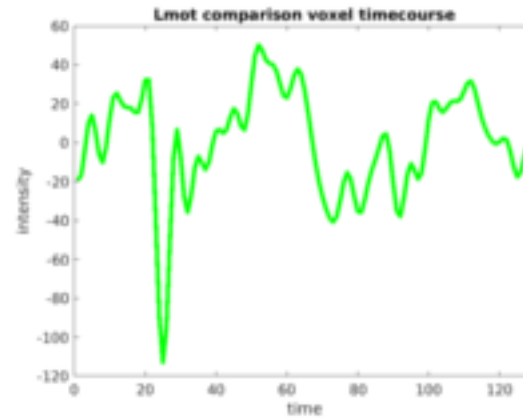
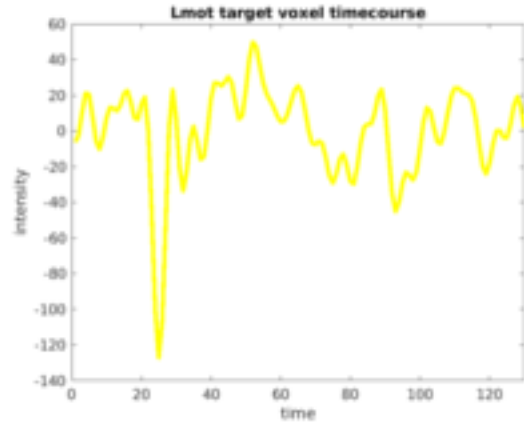
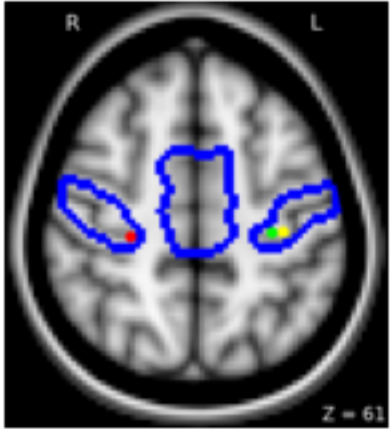
Lowpass filter, 0.08 Hz



Motor Hand And Midline Masks

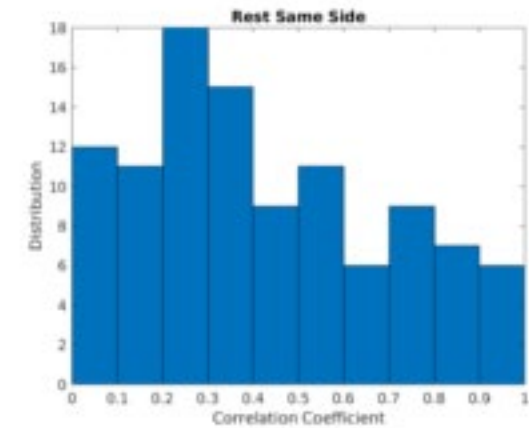
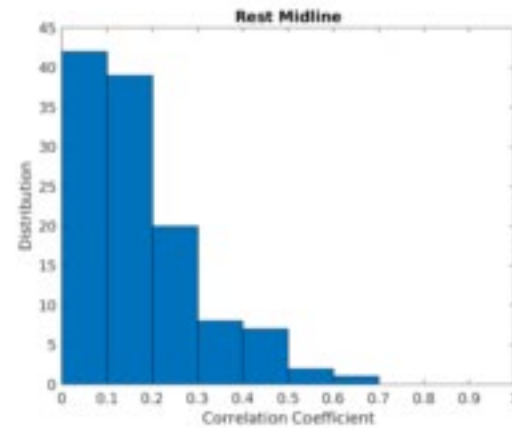
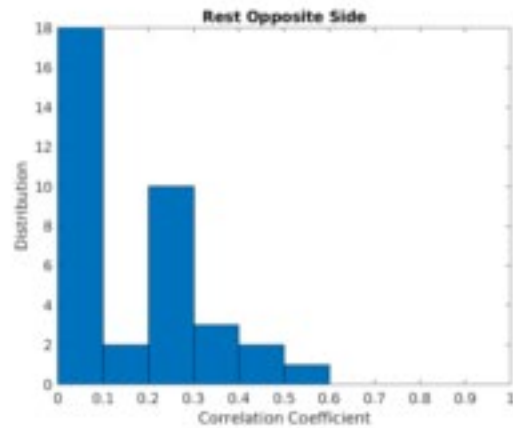
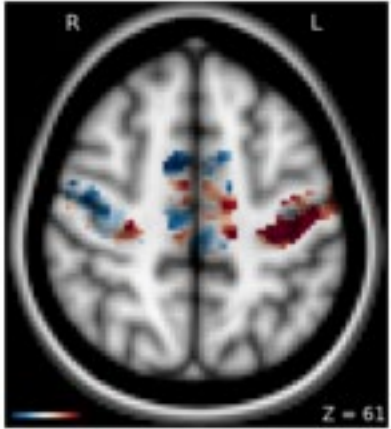


Voxelwise Time-Series Correlations



Correlations
target to Lmot comp = 0.8659
target to Rmot comp = 0.2904

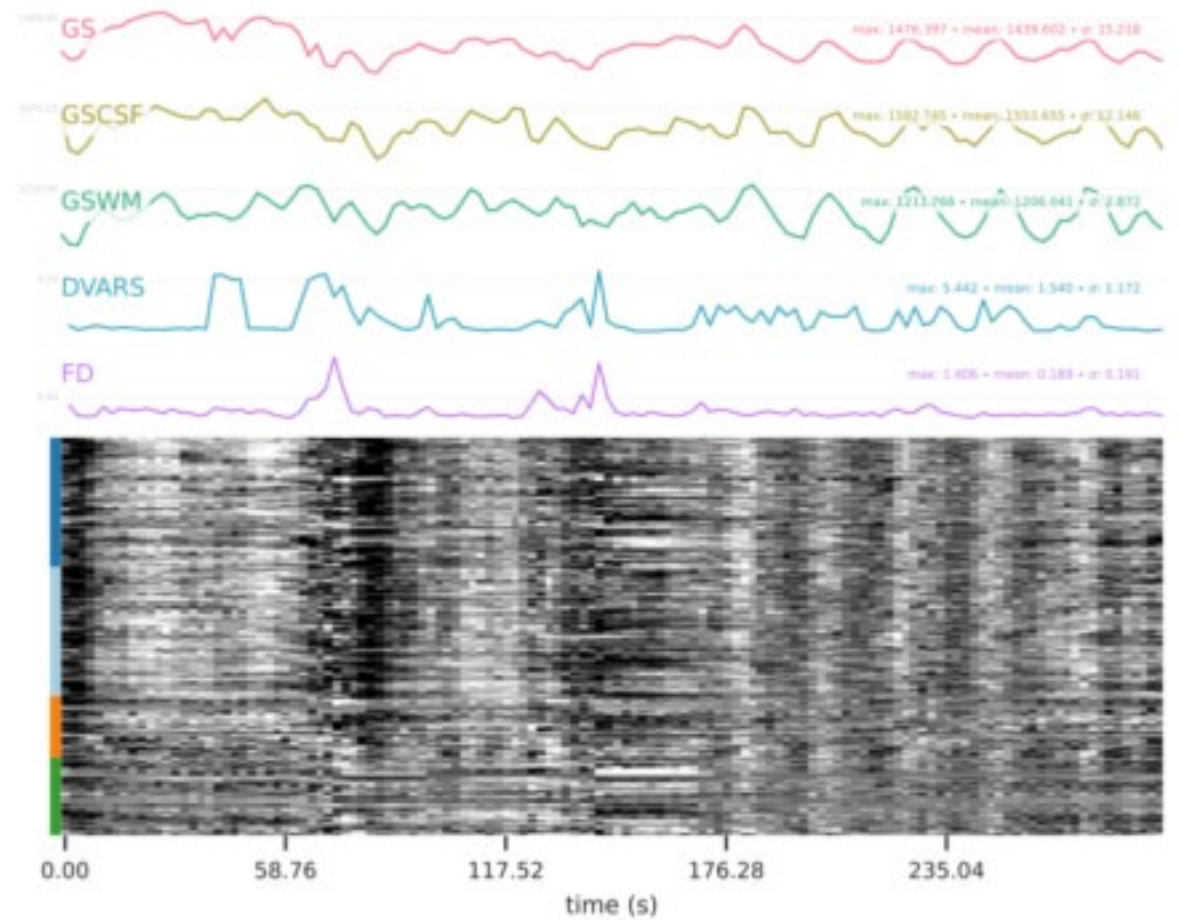
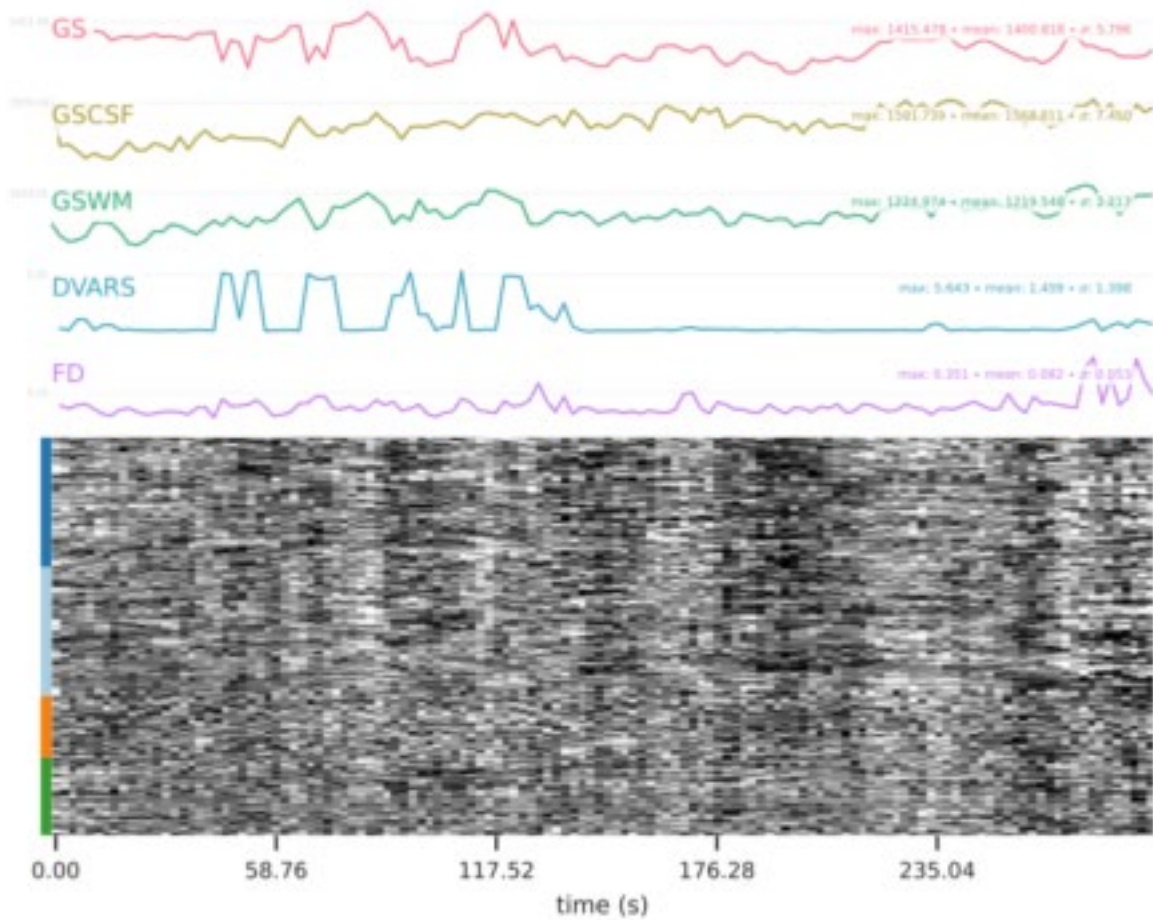
Voxelwise Time-Series Correlations



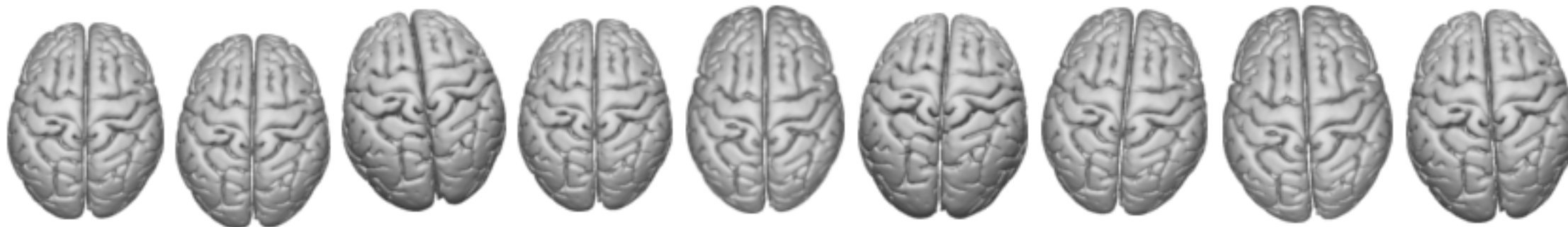
Accounting For Nuisance Signals

Motion

Two Runs With Different Motion



Motion Correction

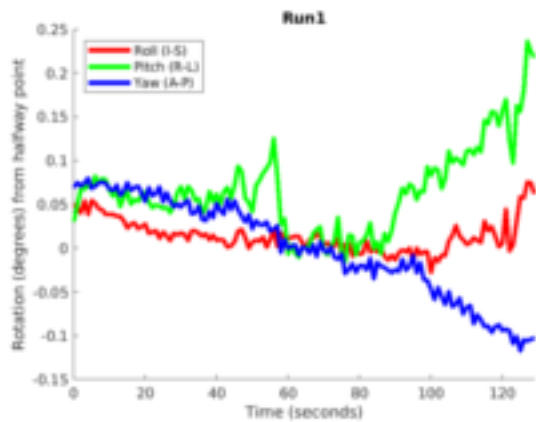


Time

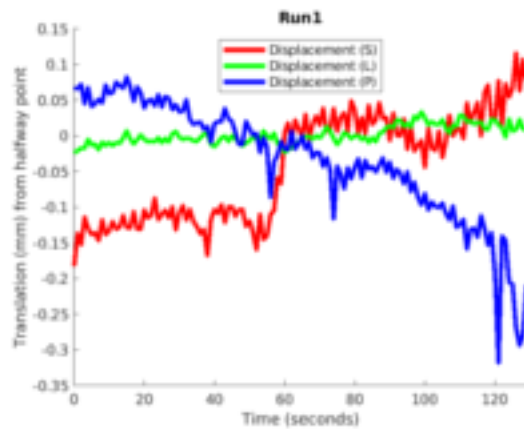


Calculate the rotations (roll, pitch & yaw (degrees)) and translations (displacement (mm)) to adjust each frame to match the target frame

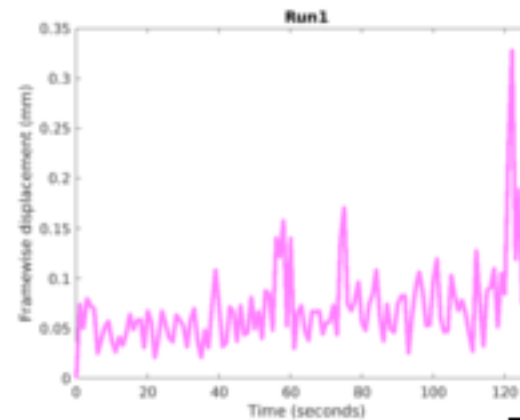
Motion Correction, Visualized



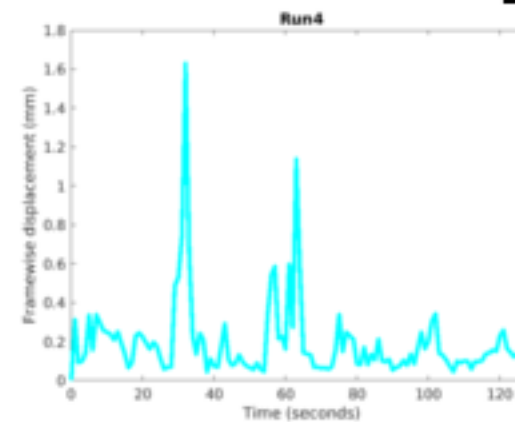
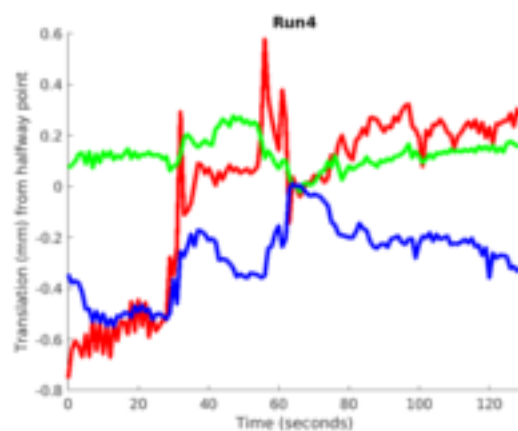
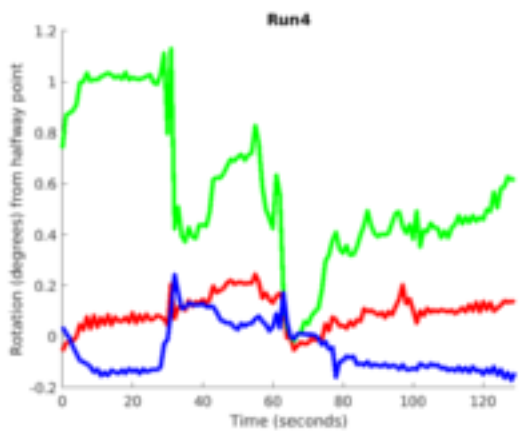
Rotations



Translations



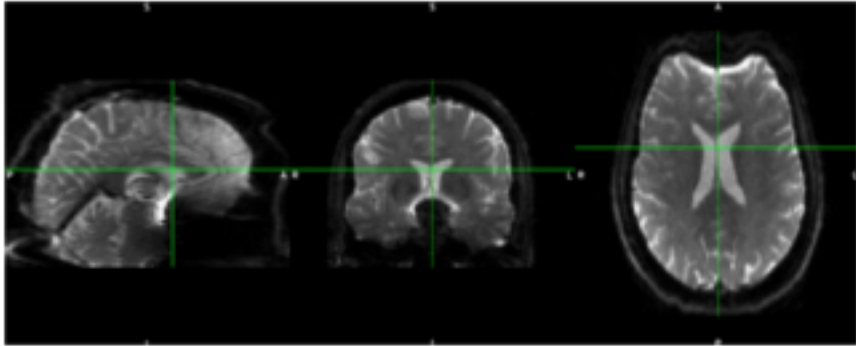
Framewise Displacement



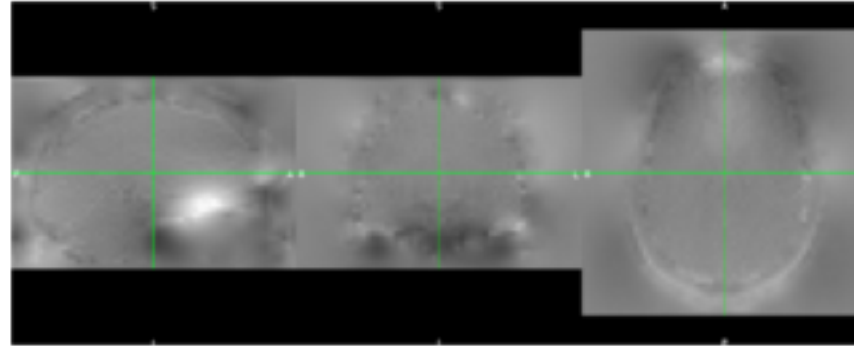
Accounting For Nuisance Signals

Magnetic Field Inhomogeneity

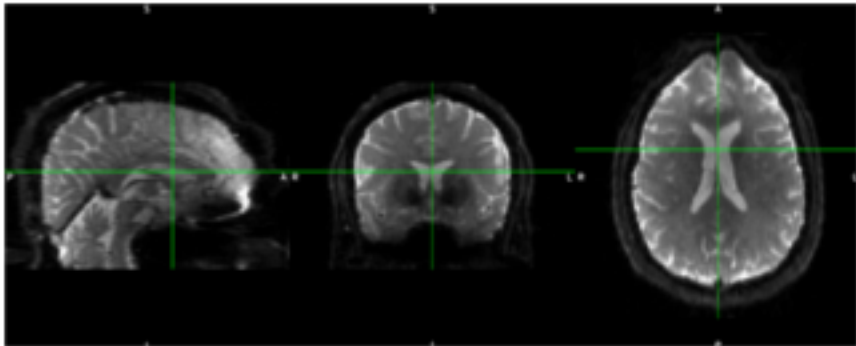
blip-up-blip-down via TOPUP



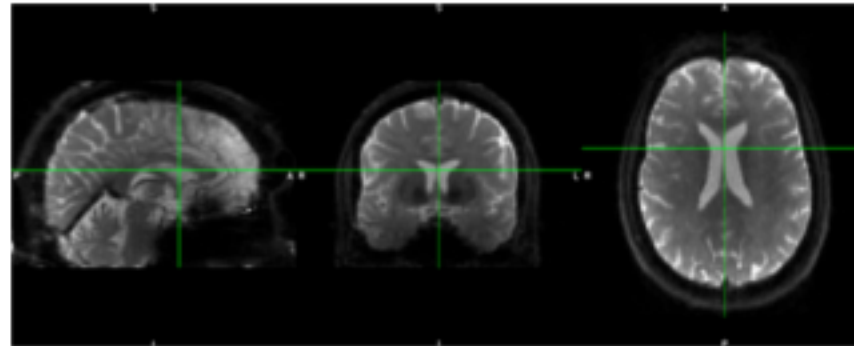
AP Distortion



B0 Field



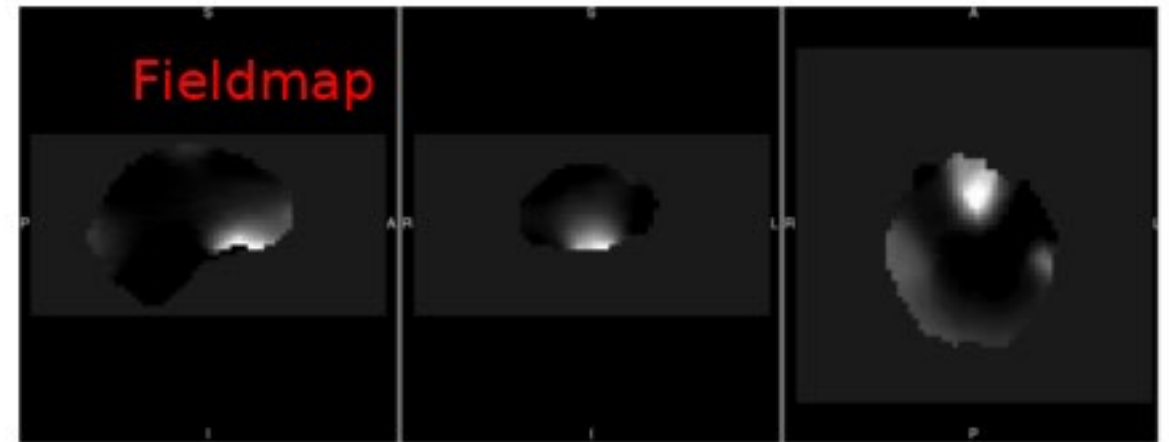
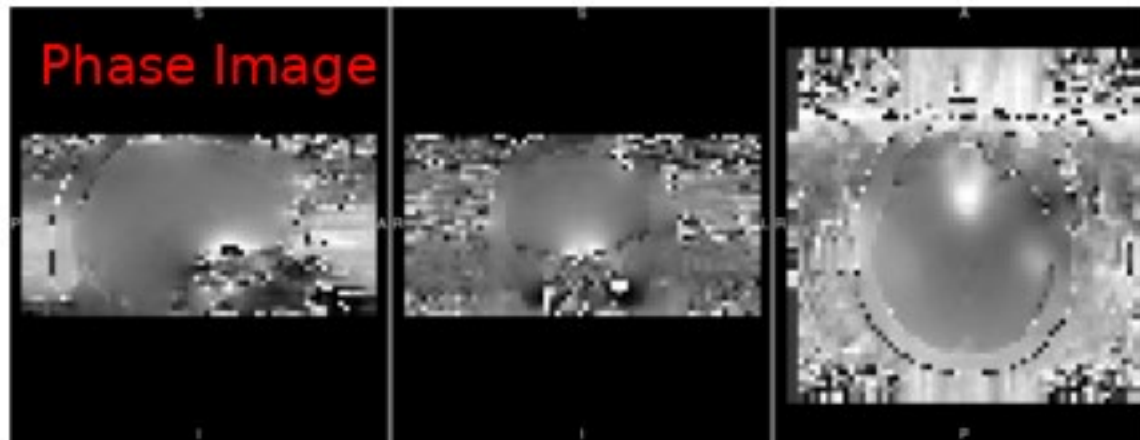
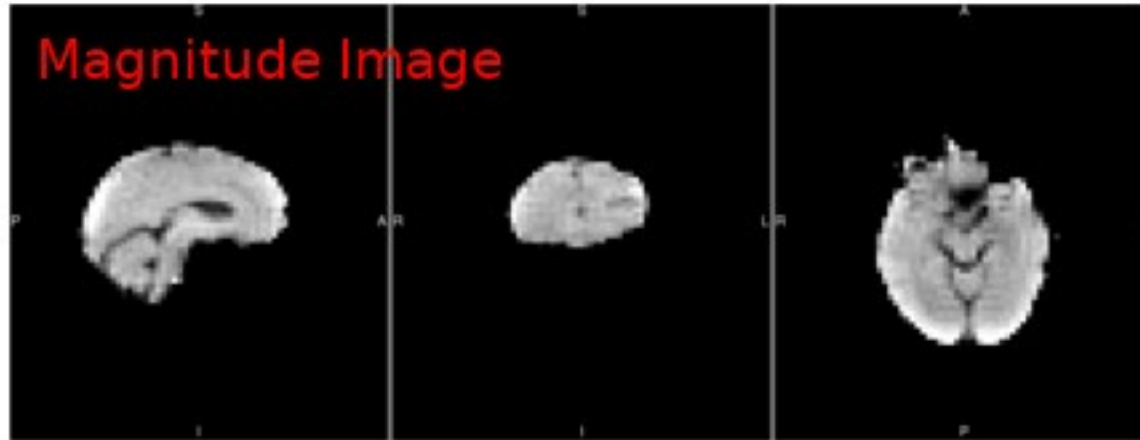
PA Distortion



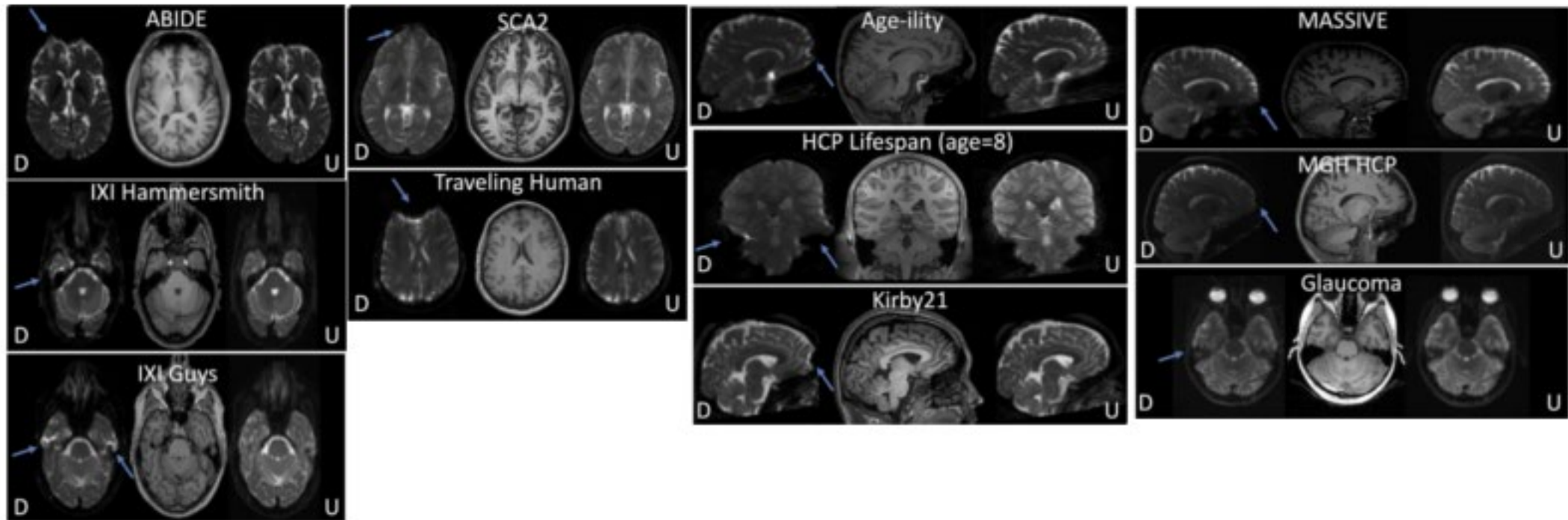
Corrected Image

https://www.fmrib.ox.ac.uk/primers/intro_primer/ExBox20/IntroBox20.html

Fieldmap Correction



Infinite B0

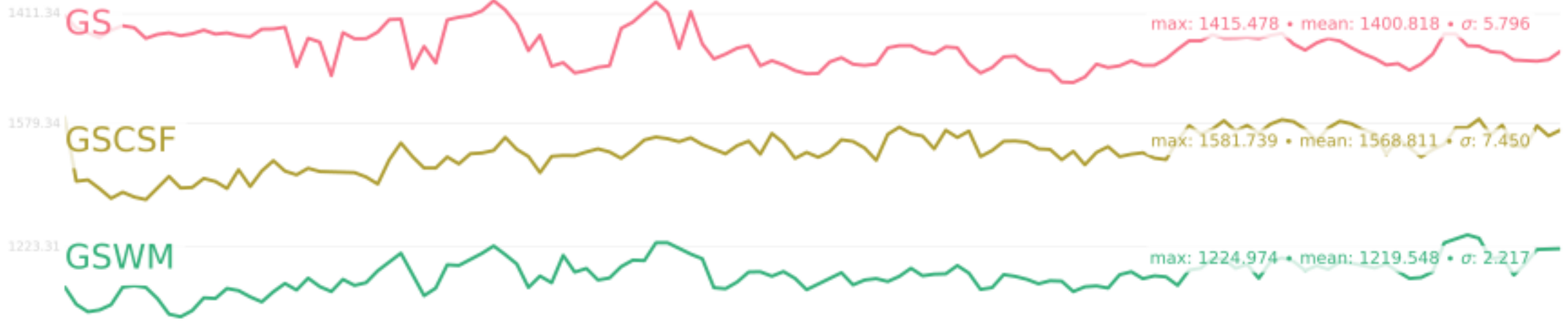


Schilling et. al., 2020

Accounting For Nuisance Signals

Confound signals (WM, CSF, Global signal)

Confound Signals

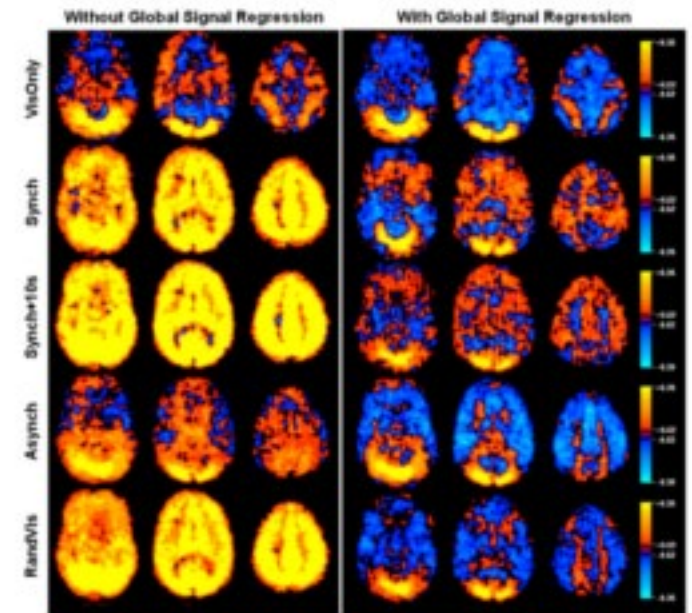
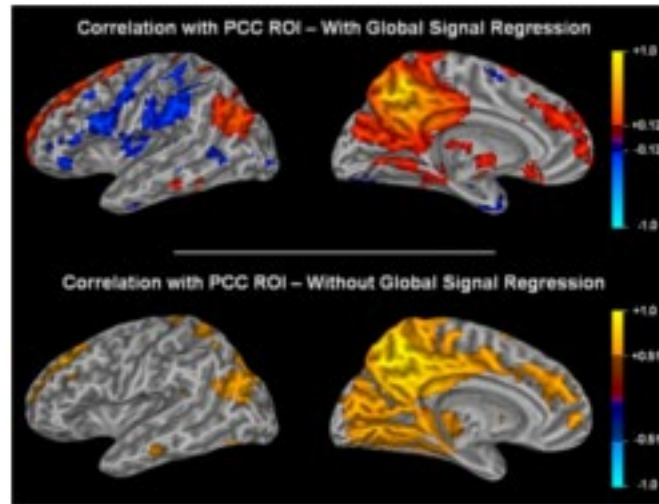
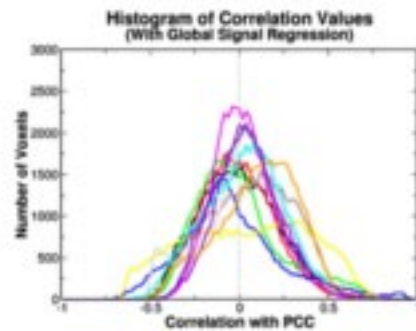
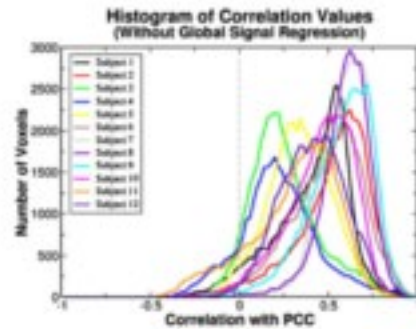


Global Signal



CSF and WM

The Effects Of GSR

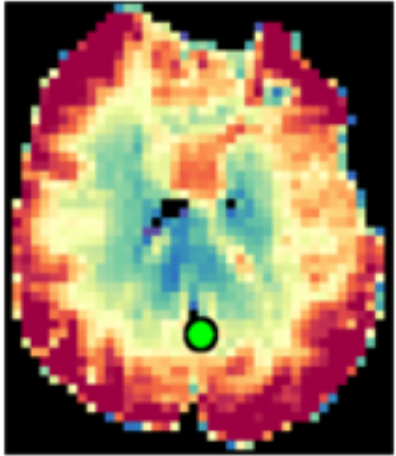


Murphy et. al., 2009

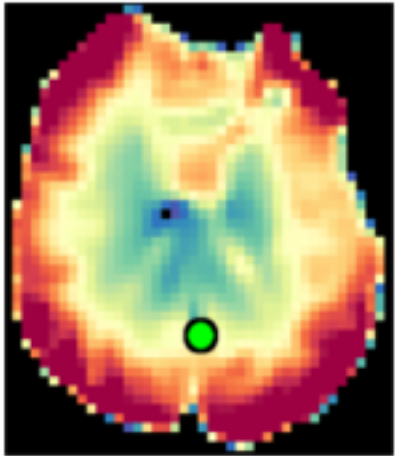
Accounting For Nuisance Signals

Smoothing And filtering

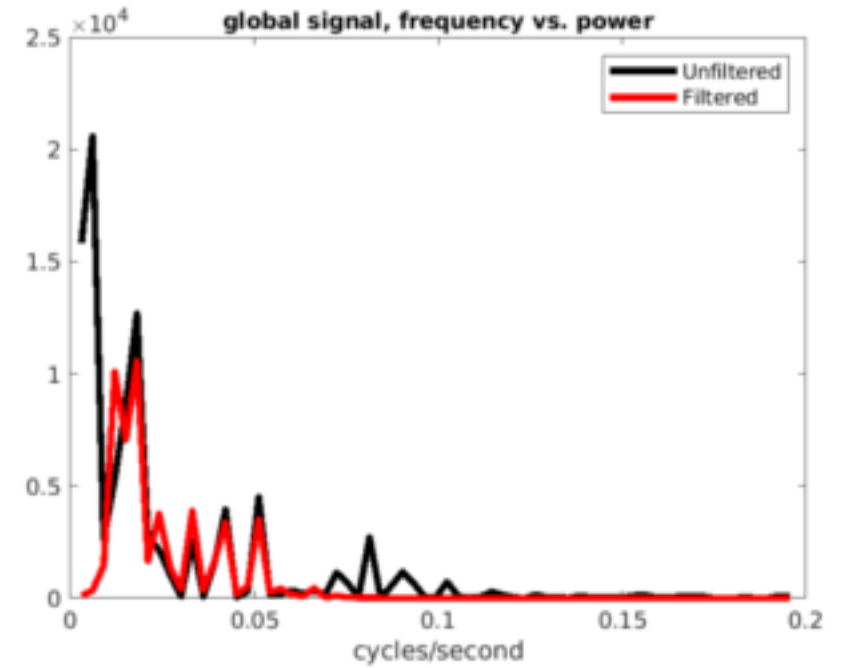
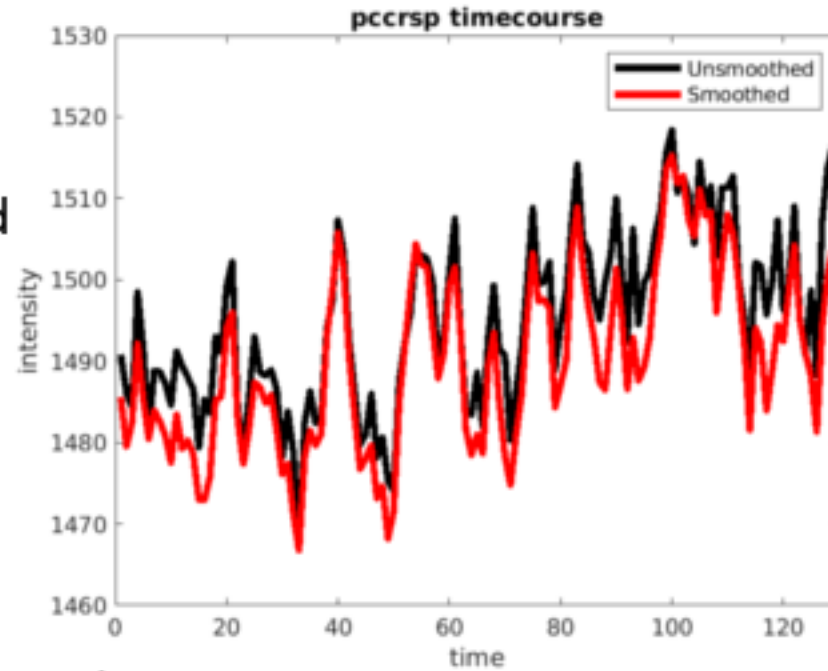
Smoothing And Filtering



Unsmoothed



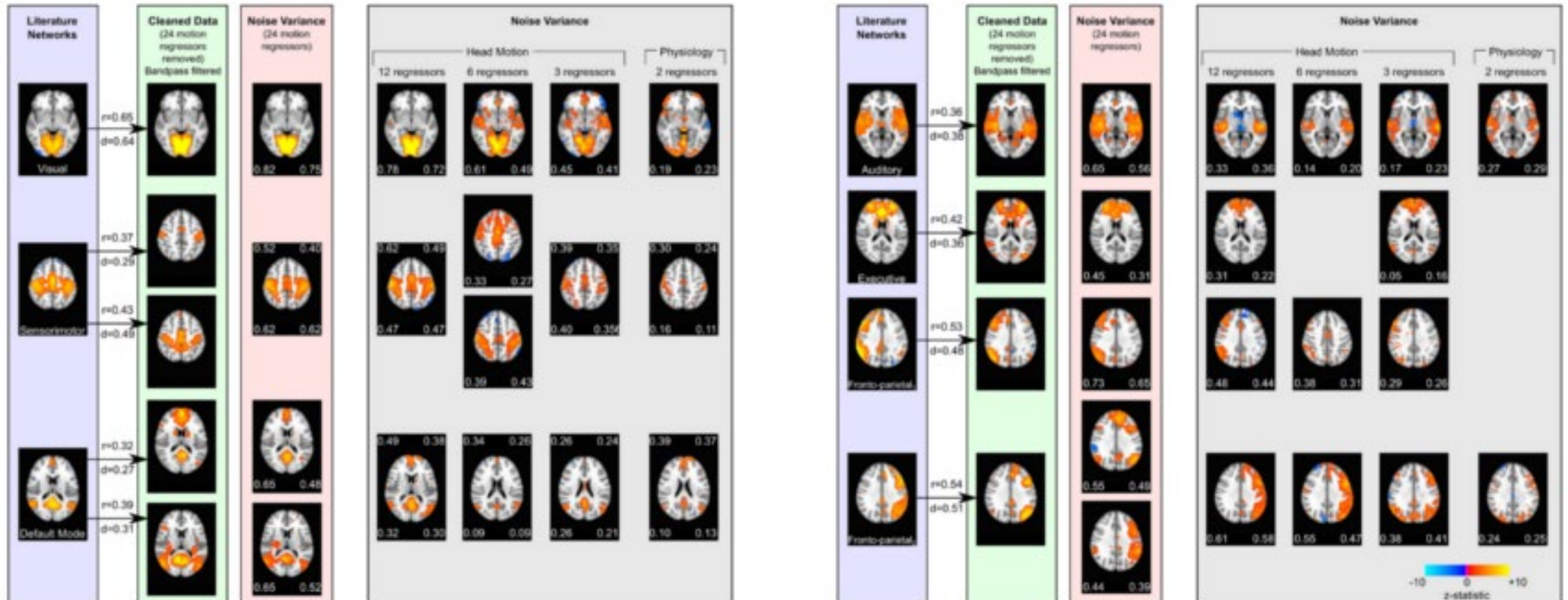
6mm FWHM
Gaussian Smooth



Accounting For Nuisance Signals

But Wait...

Is Noise Really Noise?

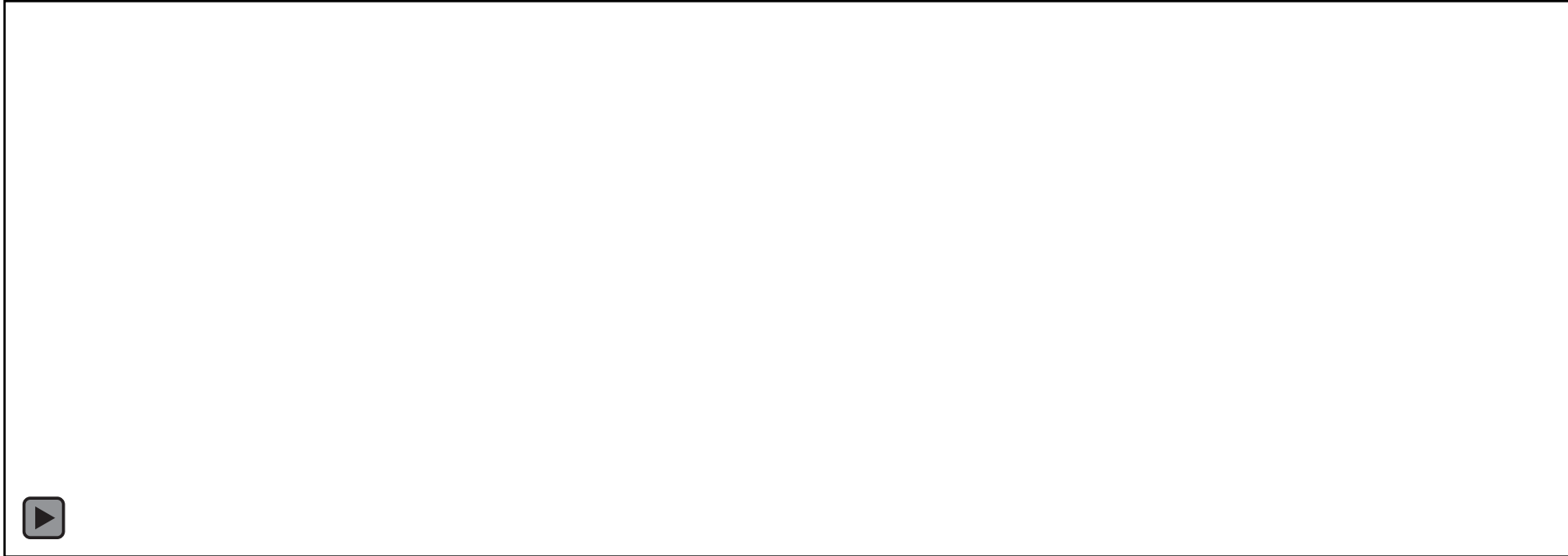


Bright et. al., 2015

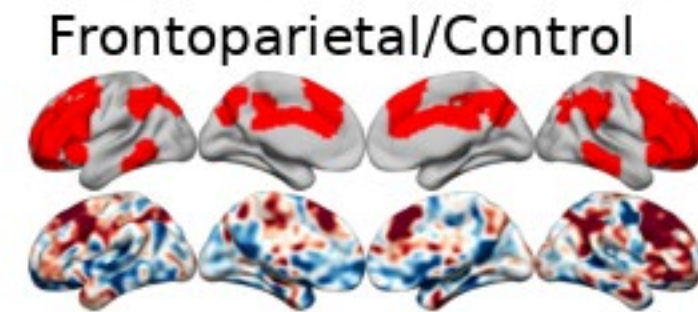
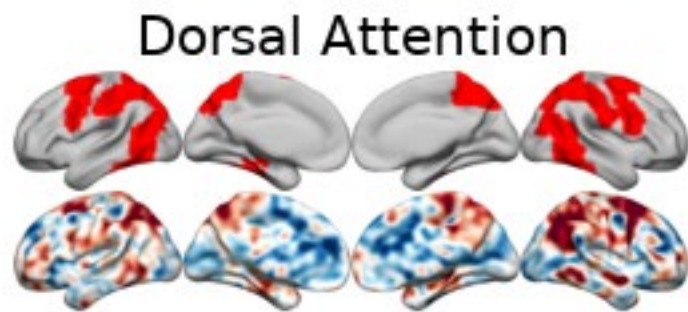
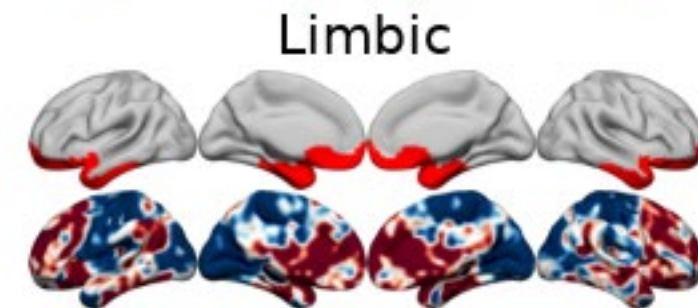
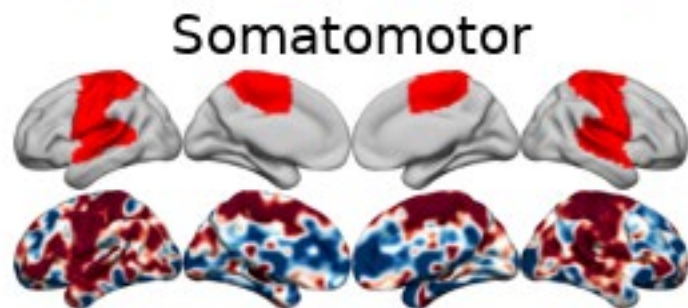
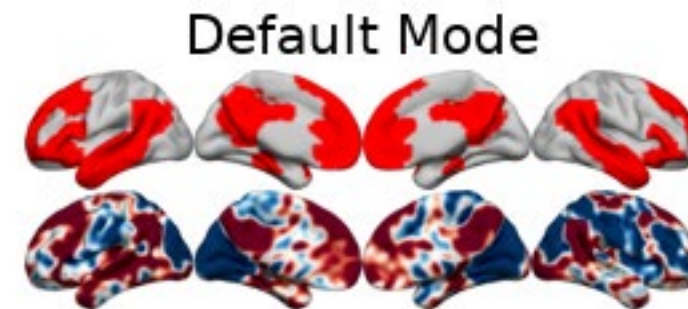
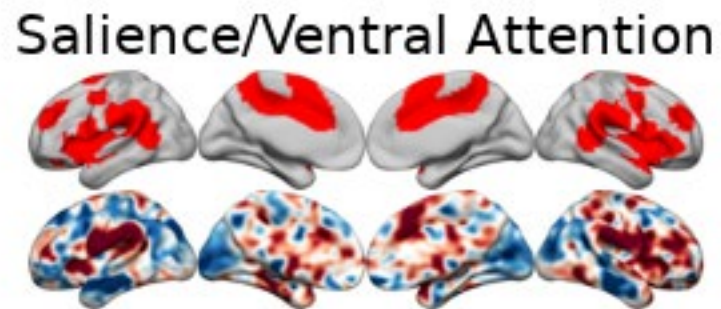
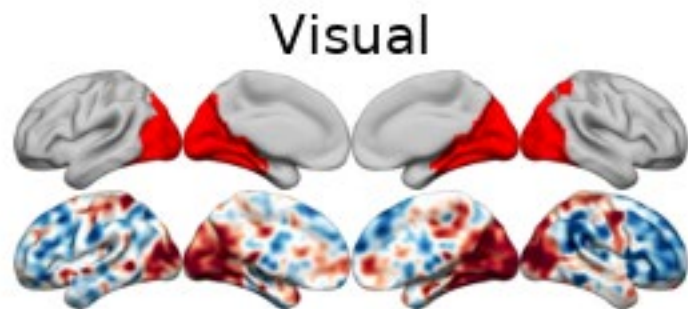
Post-Processed Data

From Raw To Final

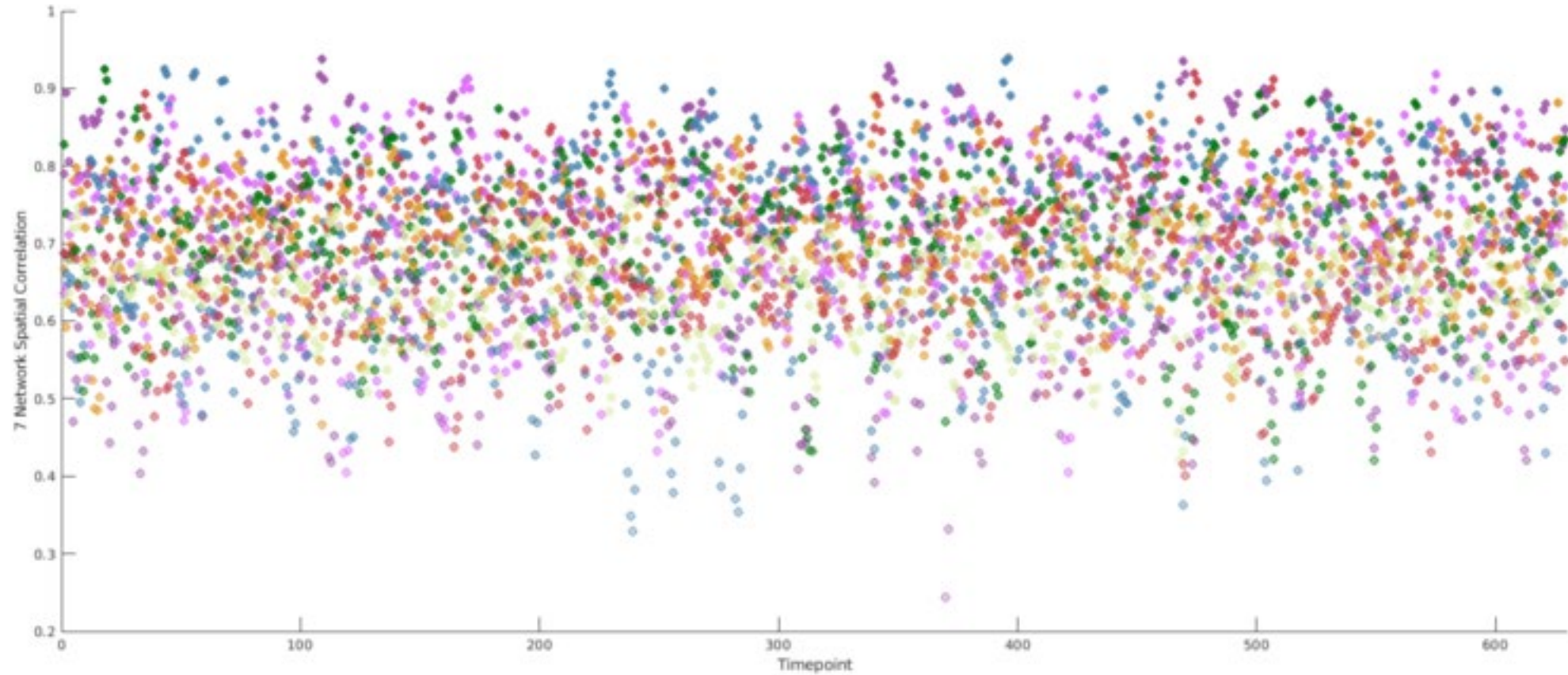
Raw Vs. Processed Data



Network Snapshots



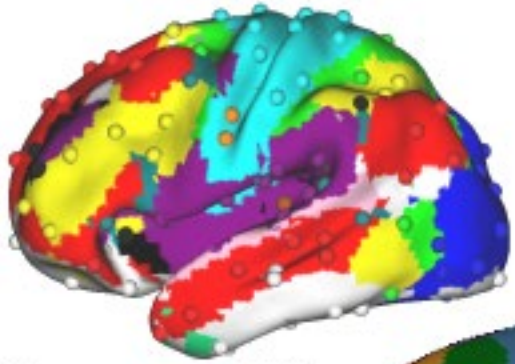
Network Snapshots



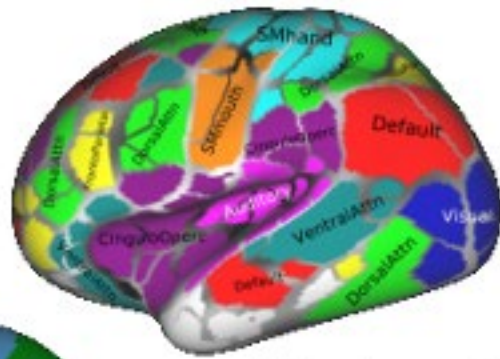
Post-Processed Data

Networks And ROI Correlations

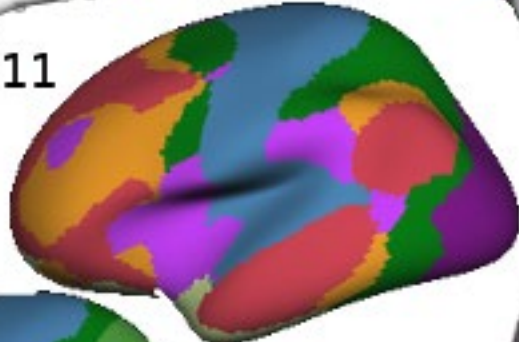
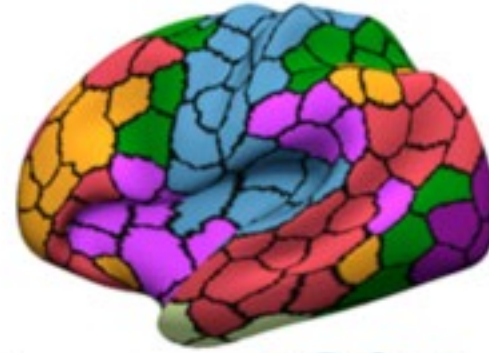
Atlases and ROI-ROI Correlations



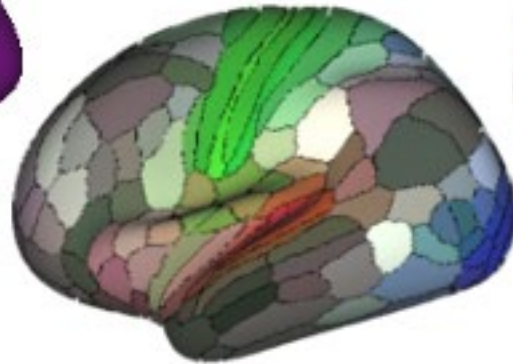
Powers, 2011



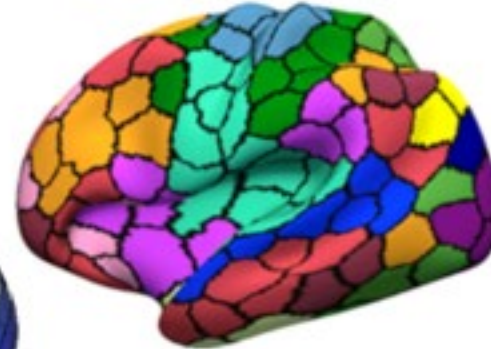
Gordon, 2016



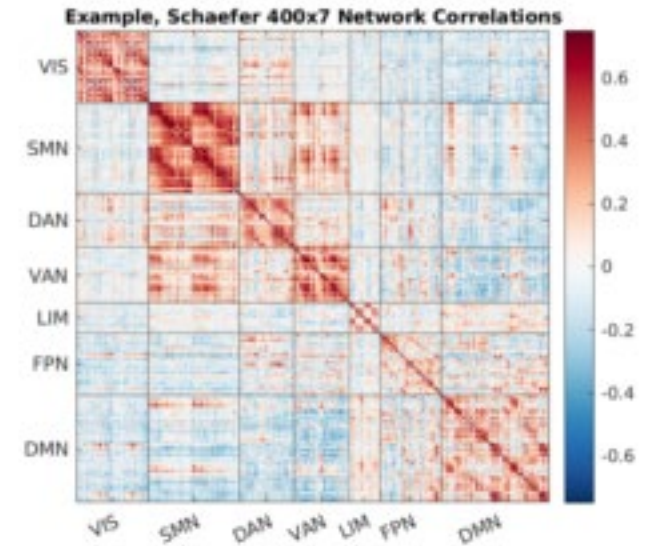
Yeo, 2011



MMP1, 2017



Schaefer, 2018



IOWA

INC Summer Bootcamp, 2022

Thank you

Joel Bruss
Resting State Functional Imaging
Neurology (Tranel & Boes Labs)

