THE UNIVERSITY OF SYDNEY

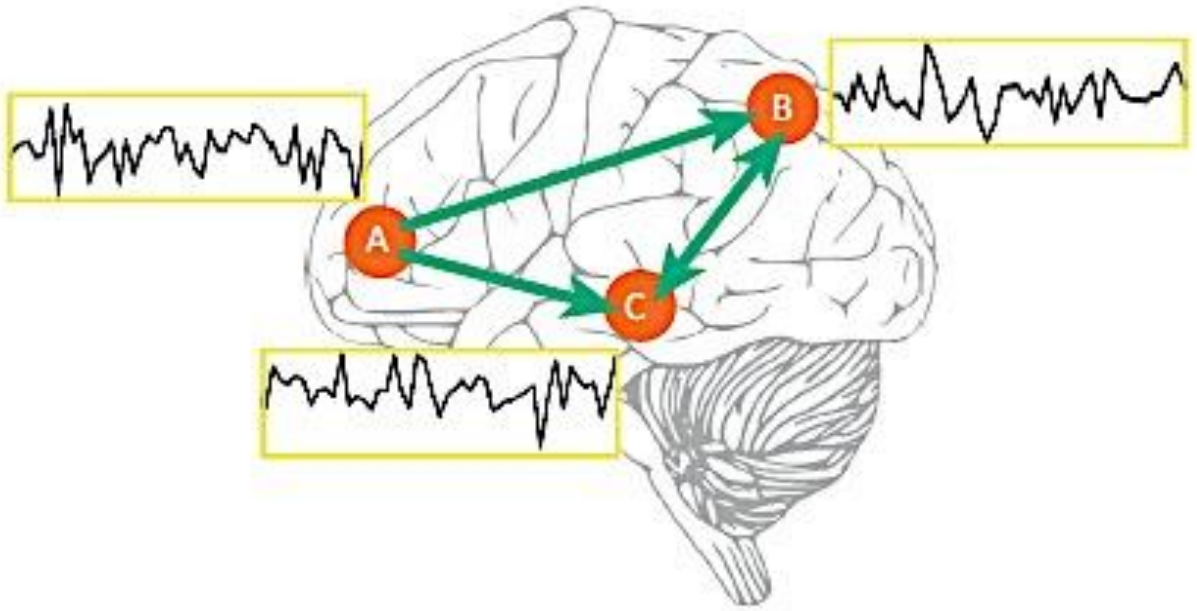
BRAIN AND MIND RESEARCH INSTITUTE

ESTIMATING LARGE-SCALE *NETWORK CONVERGENCE* IN THE FUNCTIONAL CONNECTOME

BELL P.T., SHINE J.M.

RESTING-STATE fMRI

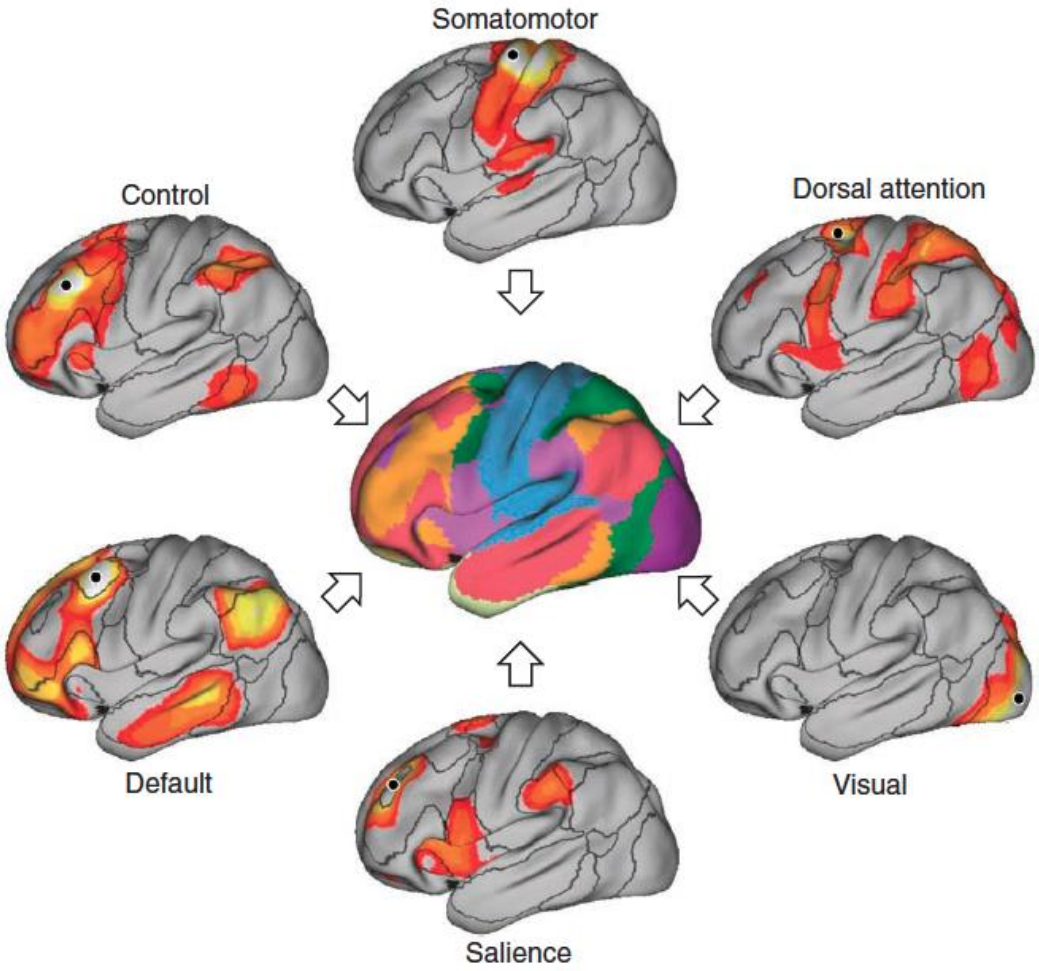
Temporal correlations of spontaneous fluctuations in the BOLD signal can be used to study **functional brain networks**



Smith *et al.*, (2013)

LARGE-SCALE NETWORKS

Large-scale networks of temporally correlated patterns in the 'resting' brain



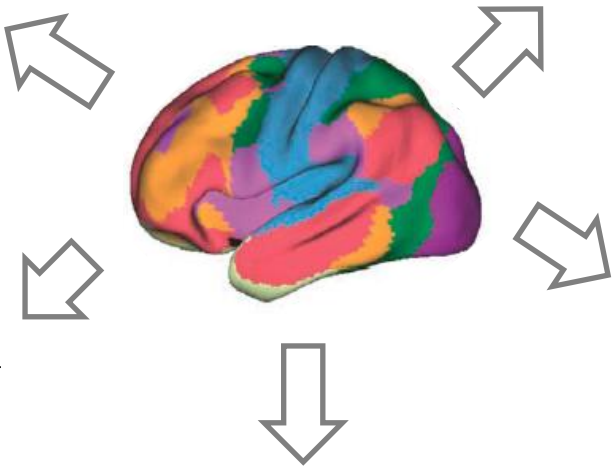
Yeo et al., 2011

LARGE-SCALE NETWORKS

Large-scale networks of temporally correlated patterns in the 'resting' brain

Persist during sleep & under anaesthesia

Present across individual subjects

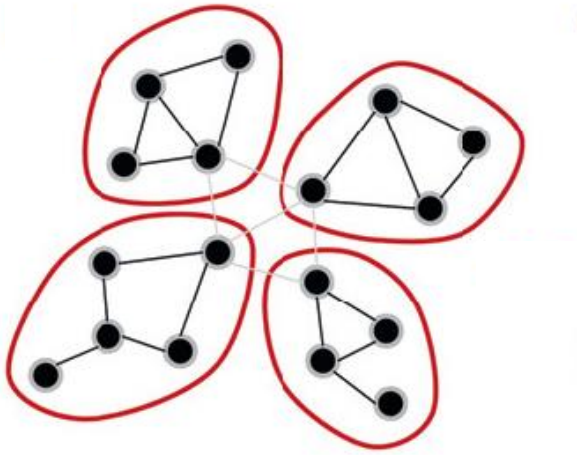


Related to structural connectivity

Present during task

Disrupted by disease

INTEGRATION AND SEGREGATION

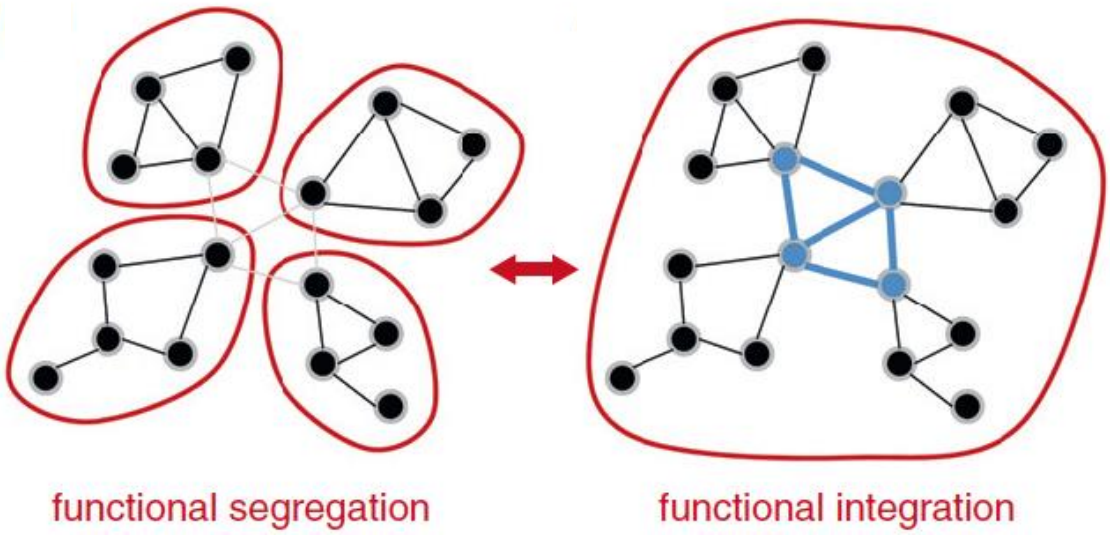


functional segregation

Sporns 2013

INTEGRATION AND SEGREGATION

Few studies have investigated how resting-state networks are related to one another

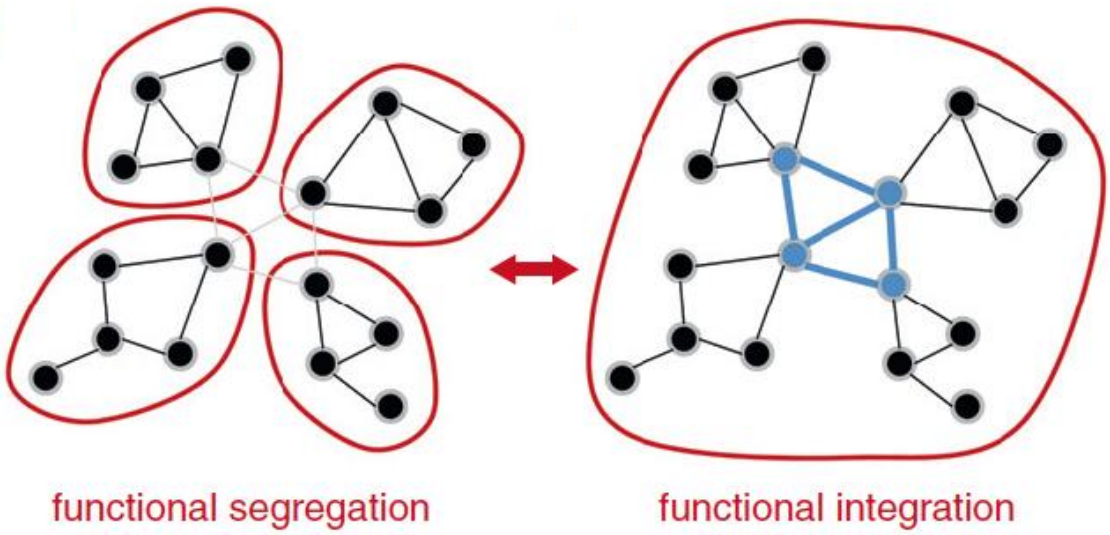


Sporns 2013

INTEGRATION AND SEGREGATION

Many previous studies have assumed that neural regions belong to a single resting-state network

(e.g. PCC *"belongs"* to DMN)



Sporns 2013

RESTING-STATE NETWORK CONVERGENCE

Goals:

- Estimate topography of resting-state network convergence across the cortex and subcortex

RESTING-STATE NETWORK CONVERGENCE

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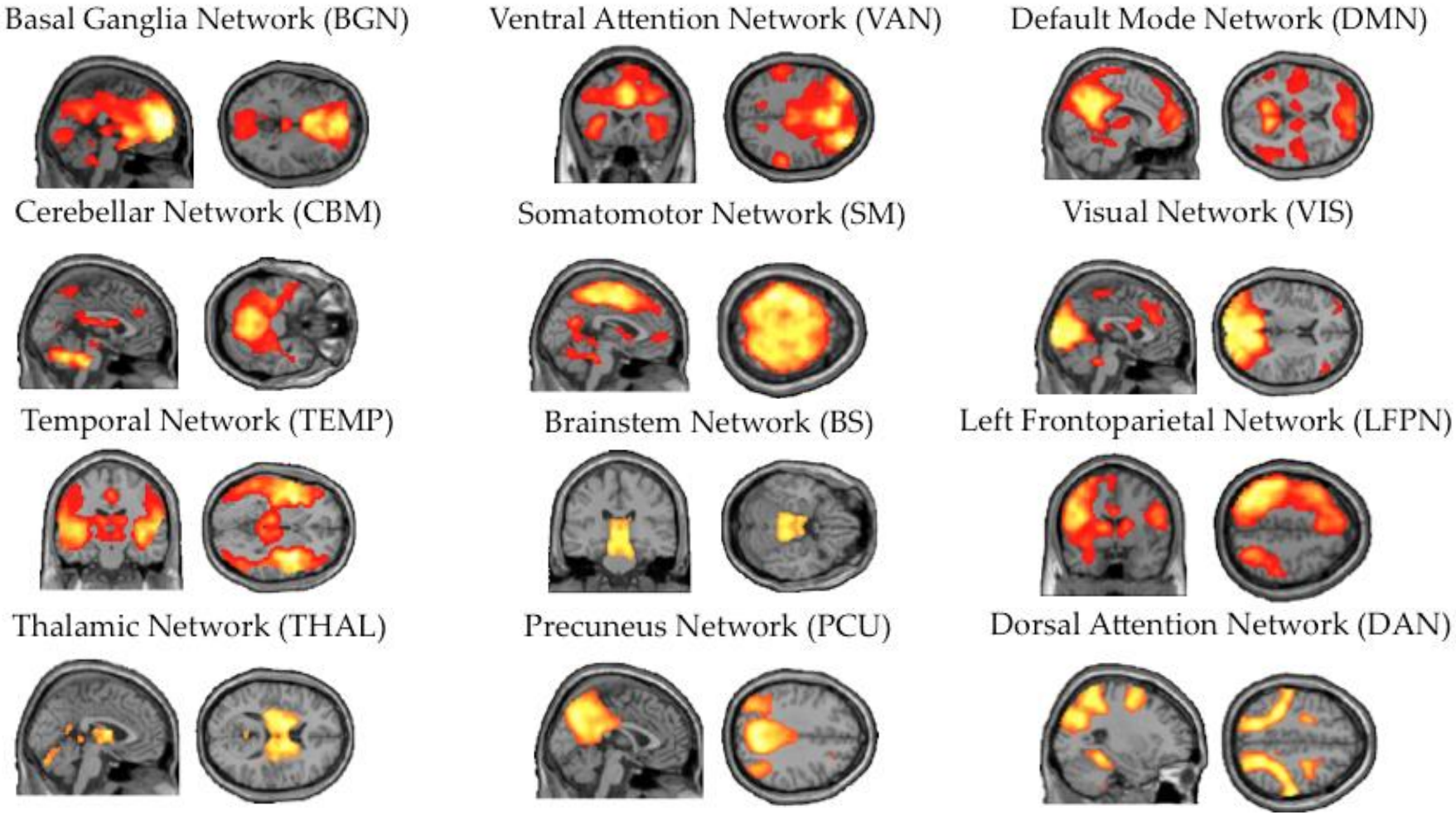
- Estimate topography of resting-state network convergence across the cortex and subcortex

Resting-state Data:

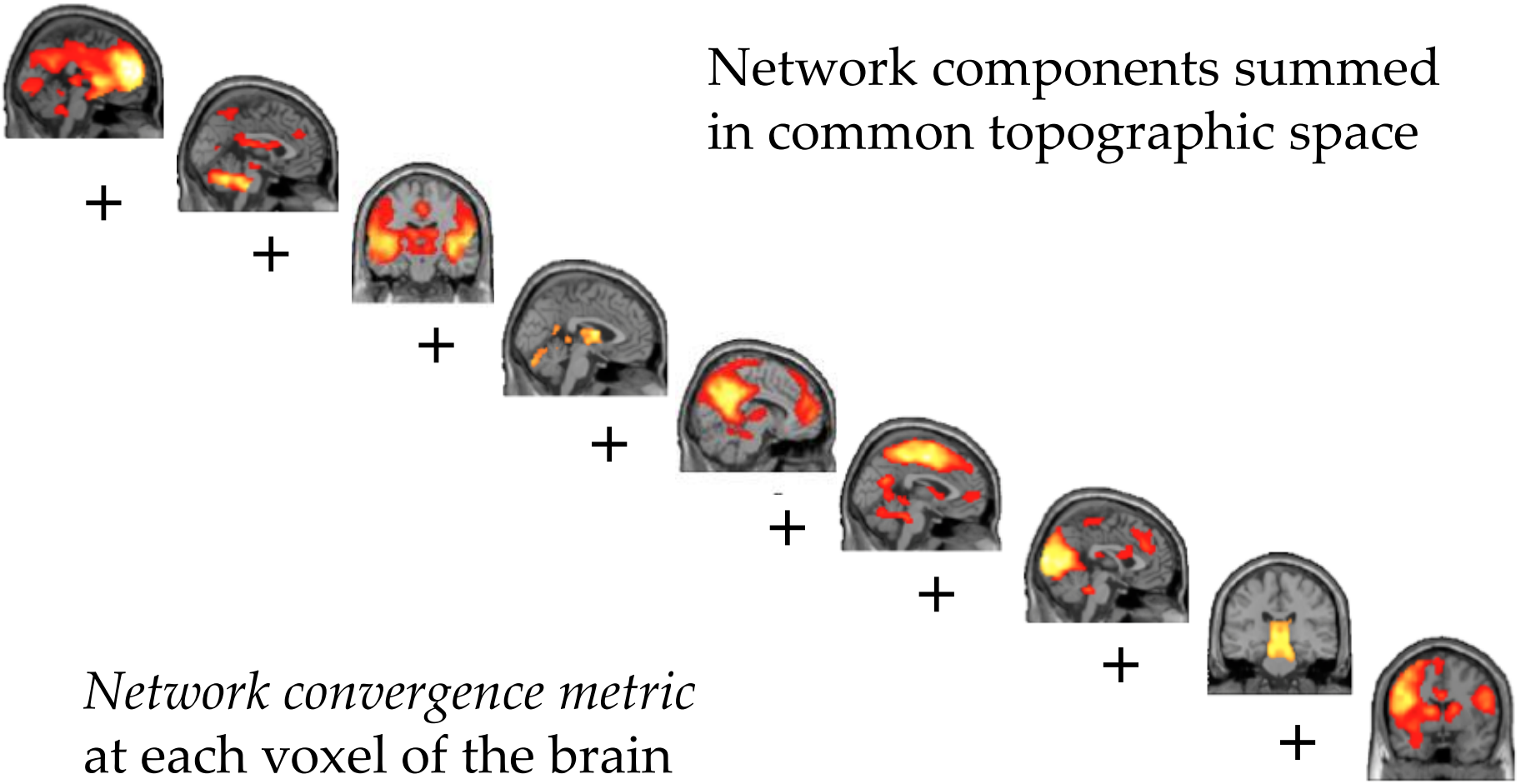
- 100 healthy controls Cambridge cohort from 1000 Functional Connectomes Project
- Discovery sample (n = 50), Replication sample (n = 50)

sICA NETWORK DEFINITION



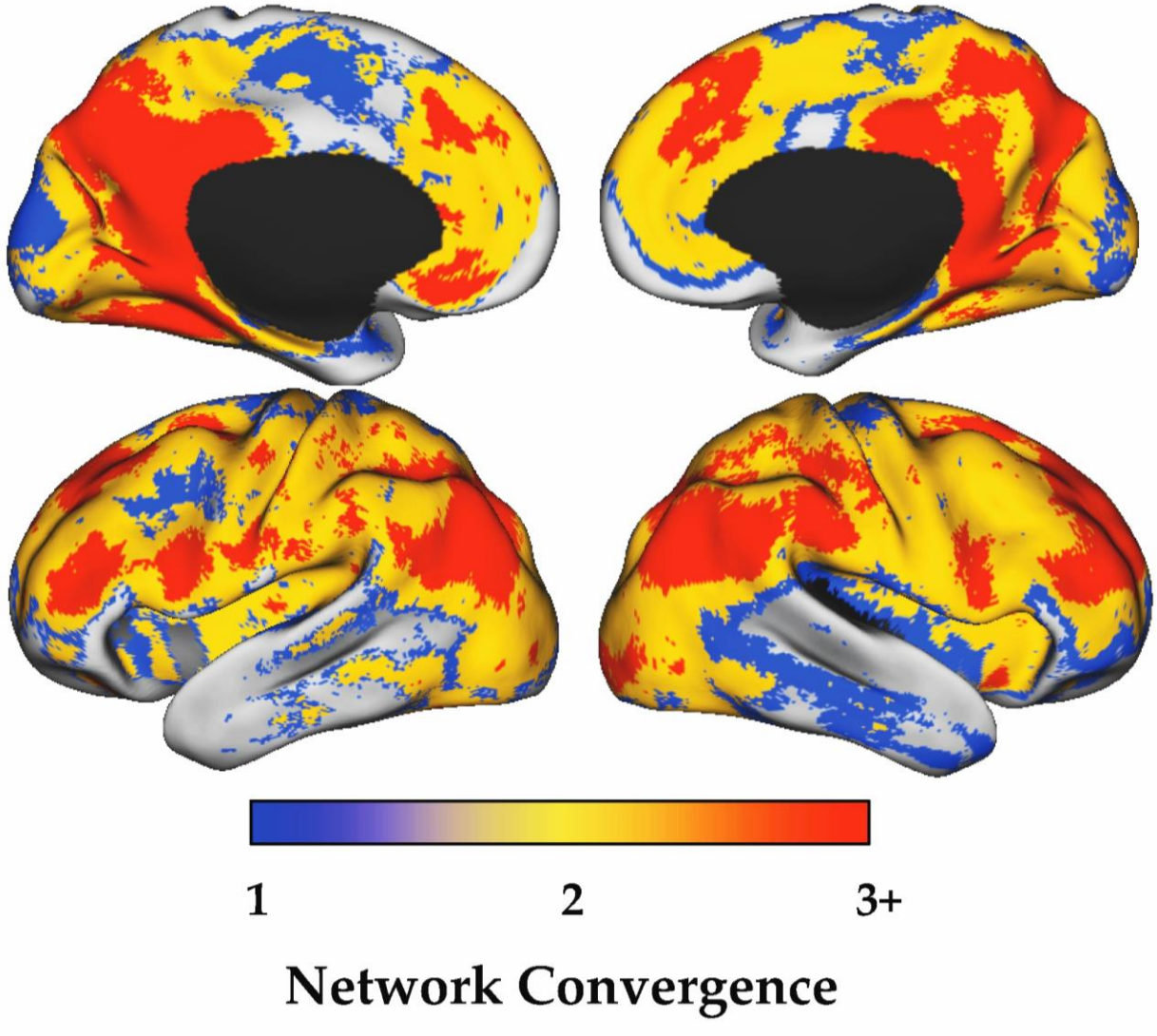
Components thresholded at: p = 0.001, FDR = 0.01

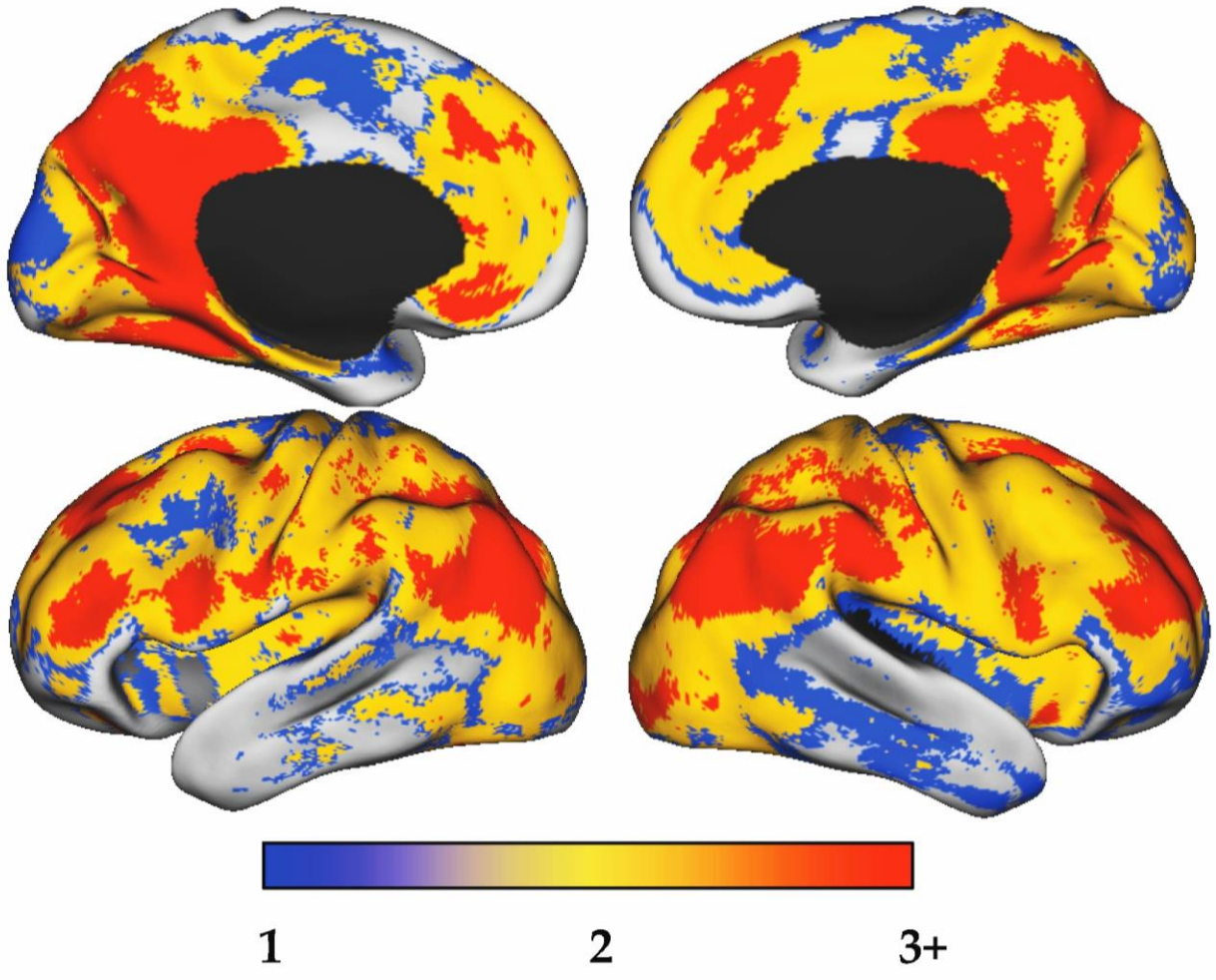
NETWORK CONVERGENCE MAPS



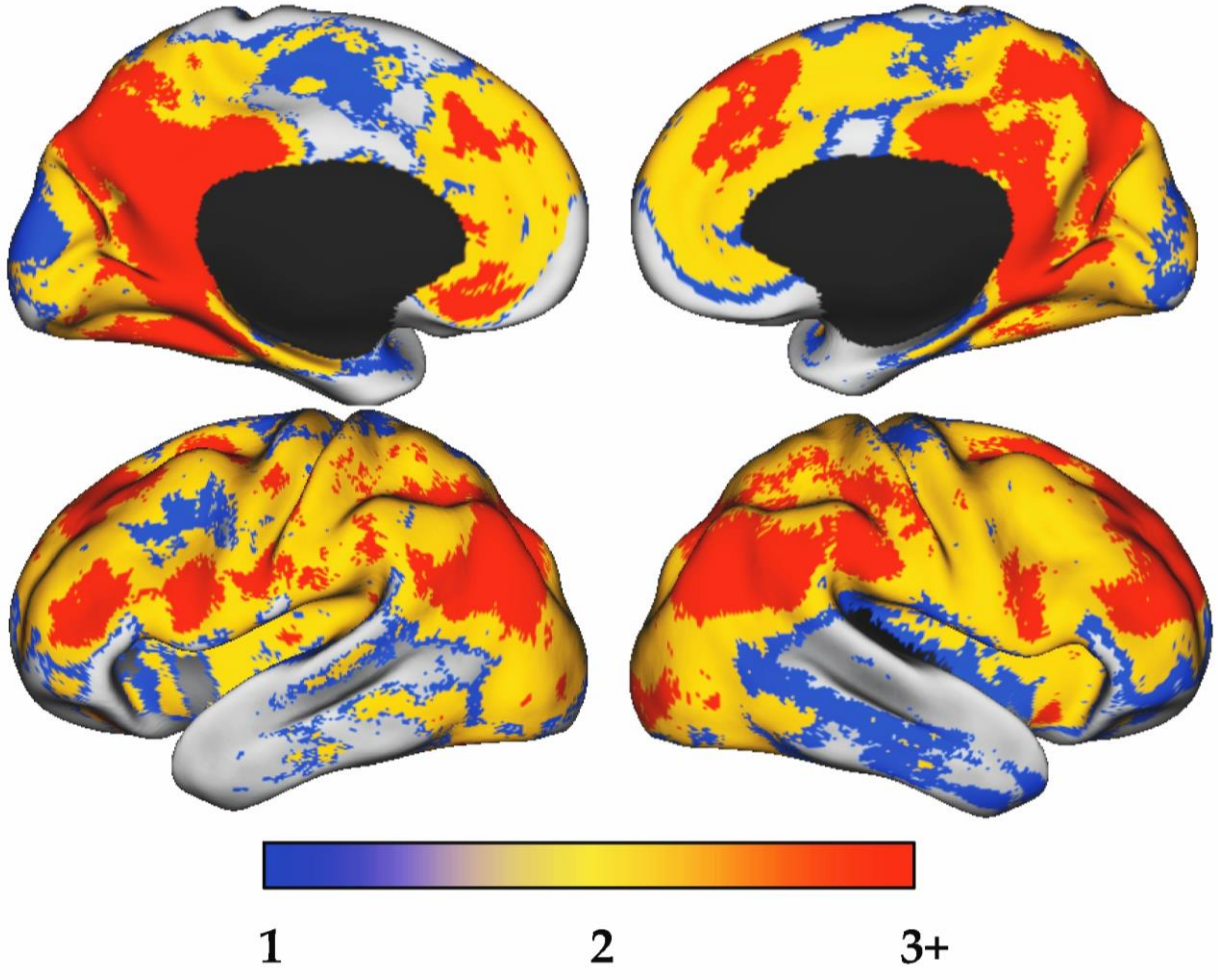
Network components summed in common topographic space

Network convergence metric at each voxel of the brain

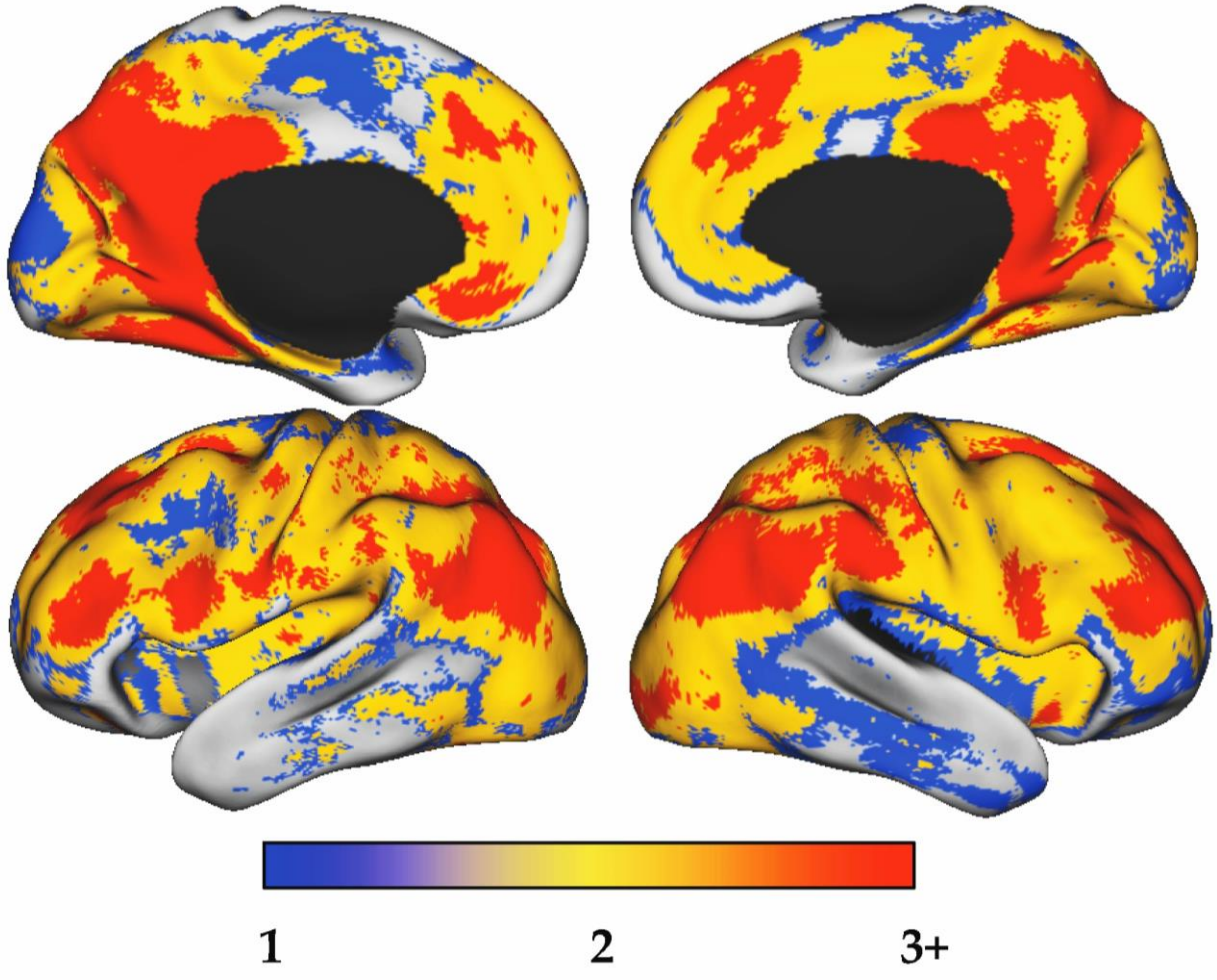

1
2
3+
Network Convergence



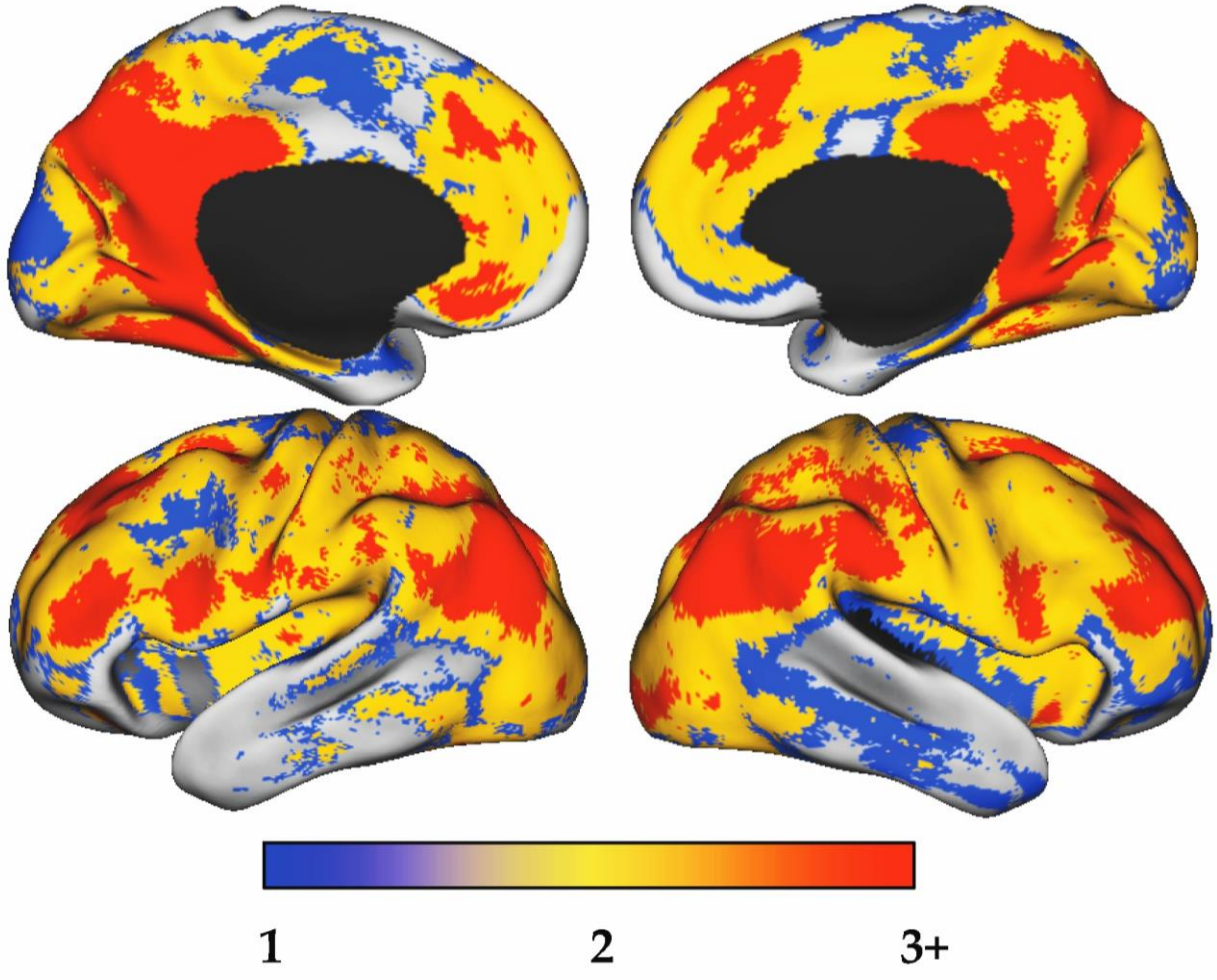
1. **Reproducible in an independent cohort (rho = 0.801, p < 0.001)**



1. Reproducible in an independent cohort (rho = 0.801, $p < 0.001$)
2. **Robust to the method used to extract the networks (rho = 0.747, $p < 0.001$)**



1. Reproducible in an independent cohort (rho = 0.801, $p < 0.001$)
2. Robust to the method used to extract the networks (rho = 0.747, $p < 0.001$)
3. **Reproducible at the individual subject level**



1. Reproducible in an independent cohort (rho = 0.801, $p < 0.001$)
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3. Reproducible at the individual subject level
4. **Robust to variable number of components defined**

Robust to variable statistical thresholds used to define networks

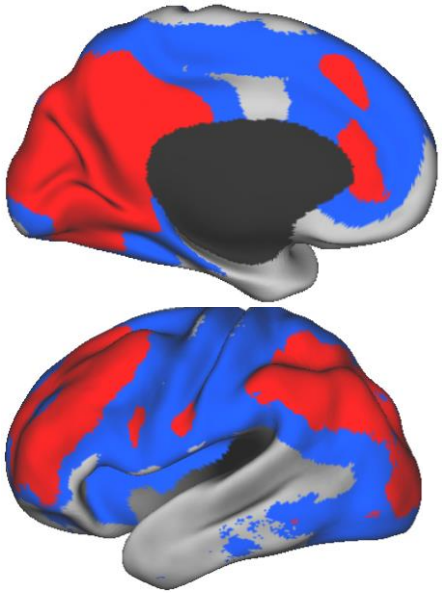
Defined a series of network convergence maps across a wide range of thresholds

For each statistical threshold, the network convergence metric at each voxel was normalized

Normalized Z-scores at each voxel were then averaged across all thresholds

Degree to which a given voxel supports network convergence relative to all other voxels across a range of statistical thresholds

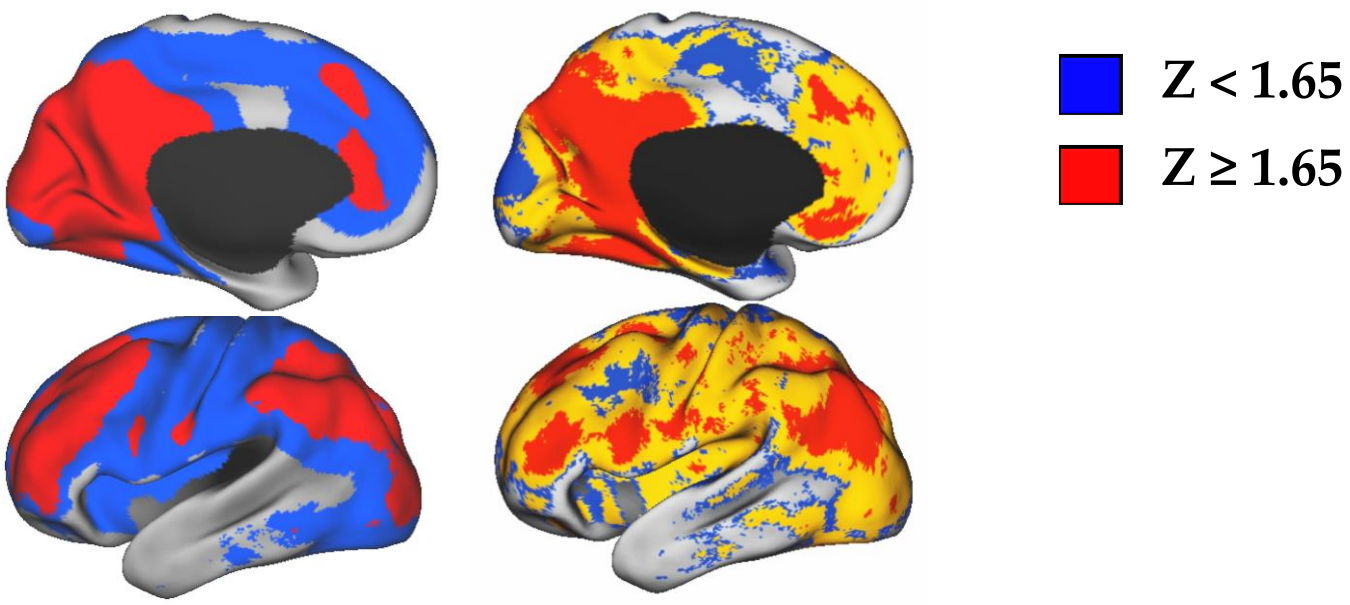
Robust to variable statistical thresholds used to define networks



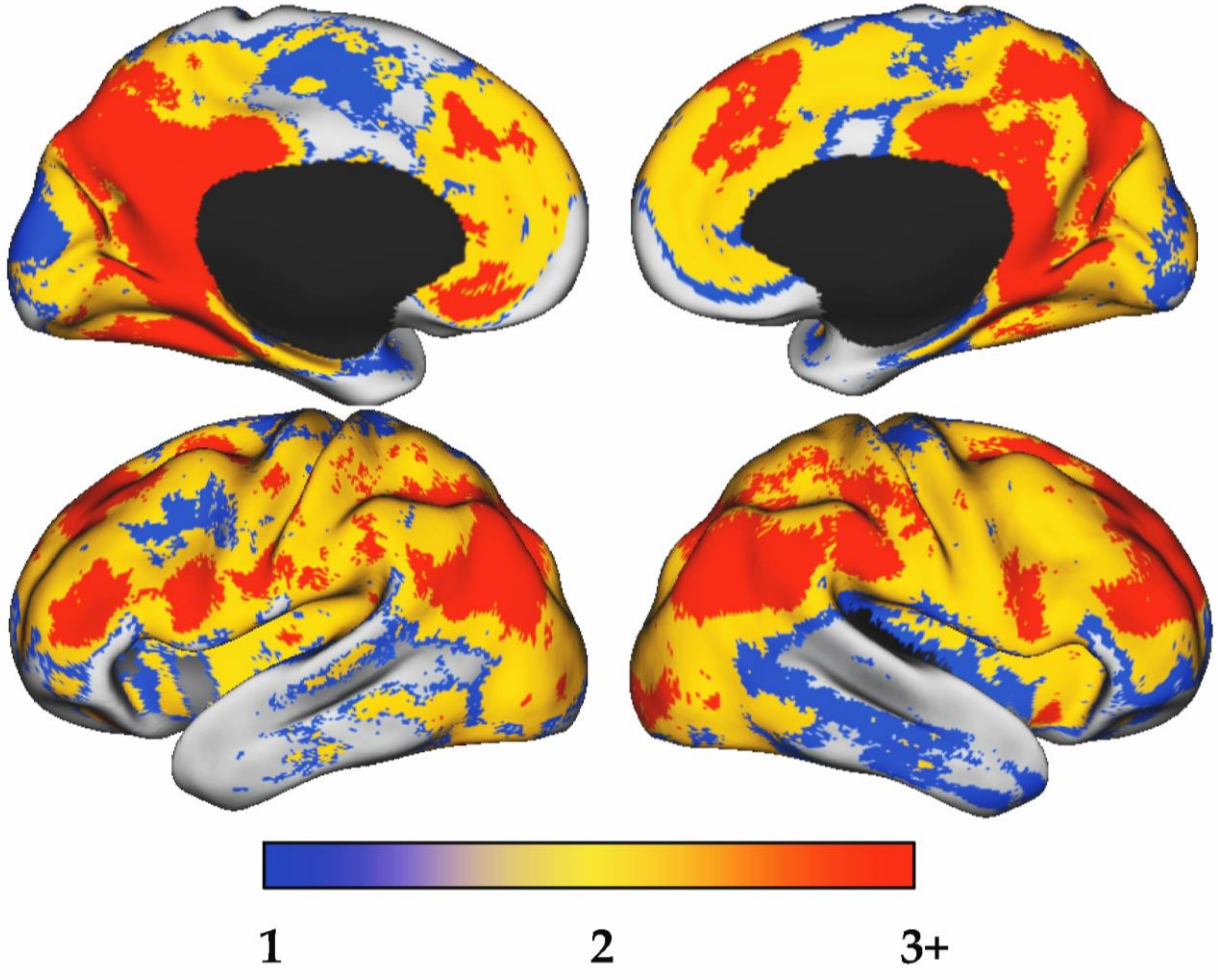
Z < 1.65

Z ≥ 1.65

Robust to variable statistical thresholds used to define networks

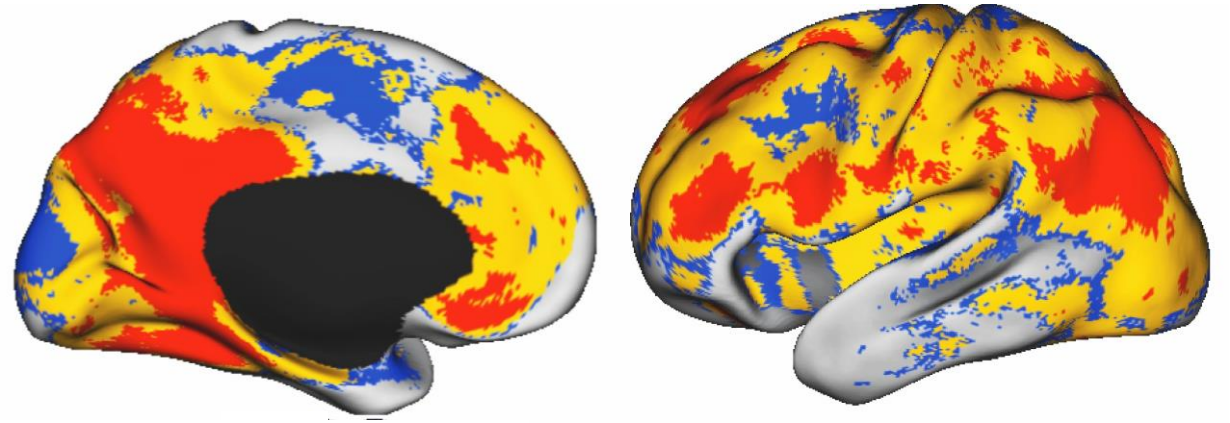


rho = 0.791, p < 0.001



1. Reproducible in an independent cohort (rho = 0.801, p < 0.001)
2. Robust to the method used to extract the networks (rho = 0.747, p < 0.001)
3. Reproducible at the individual subject level
4. Robust to variable number of components defined
5. **Robust to variable thresholds to define networks (rho = 0.791, p < 0.001)**

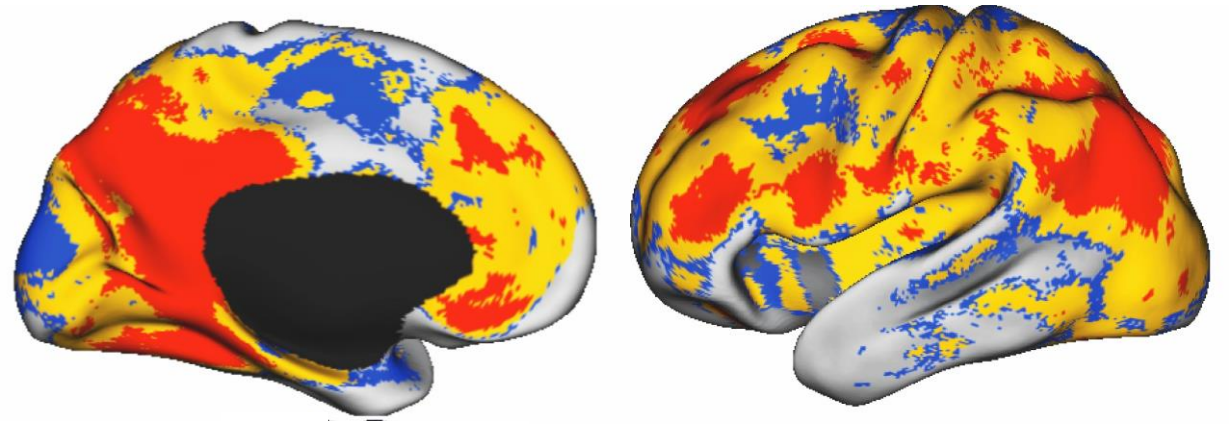
CORTICAL CONVERGENCE SYSTEM



Segregation **Integration**

1 2 3+

CORTICAL CONVERGENCE SYSTEM

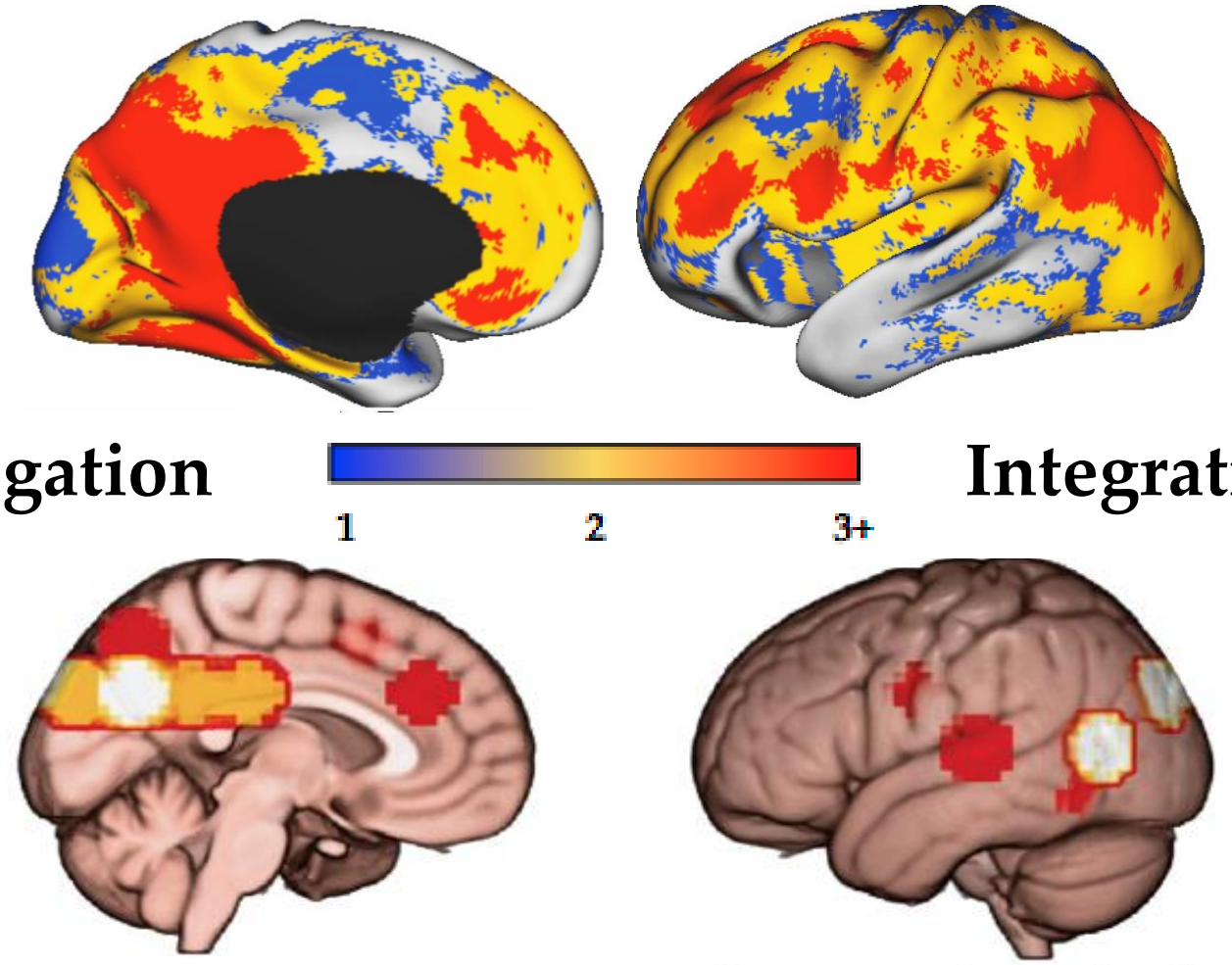


Segregation **Integration**

1 2 3+

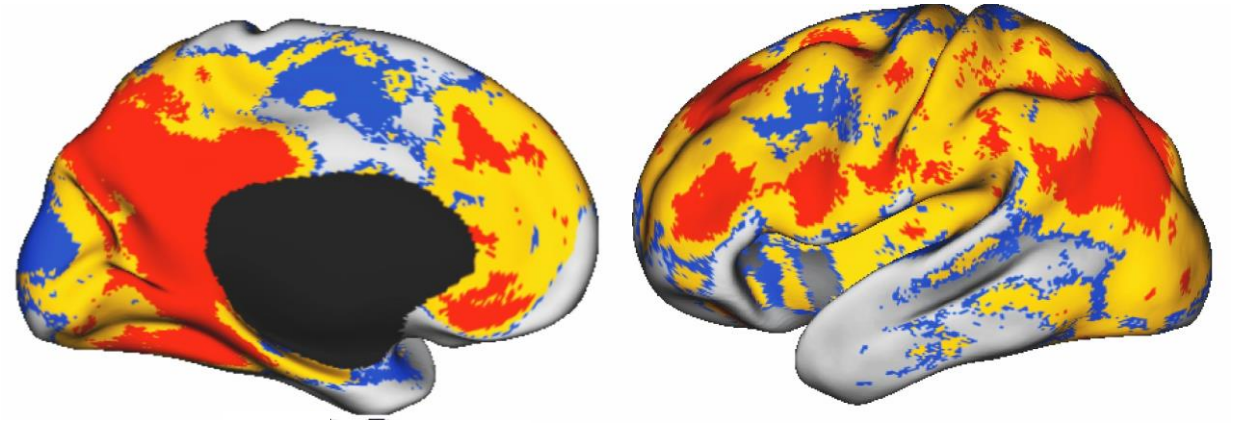
- Prominent *cortical convergence system*
  - PCC/ precuneus
  - Posterior parietal cortex
  - mPFC
  - Rostral ACC
  - Frontal cortical regions
- Consistent with hubs in the graph analytic literature

CORTICAL CONVERGENCE SYSTEM



Braga *et al.,* 2013 used a novel searchlight method to estimate "echoes" of multiple resting-state networks

CORTICAL CONVERGENCE SYSTEM

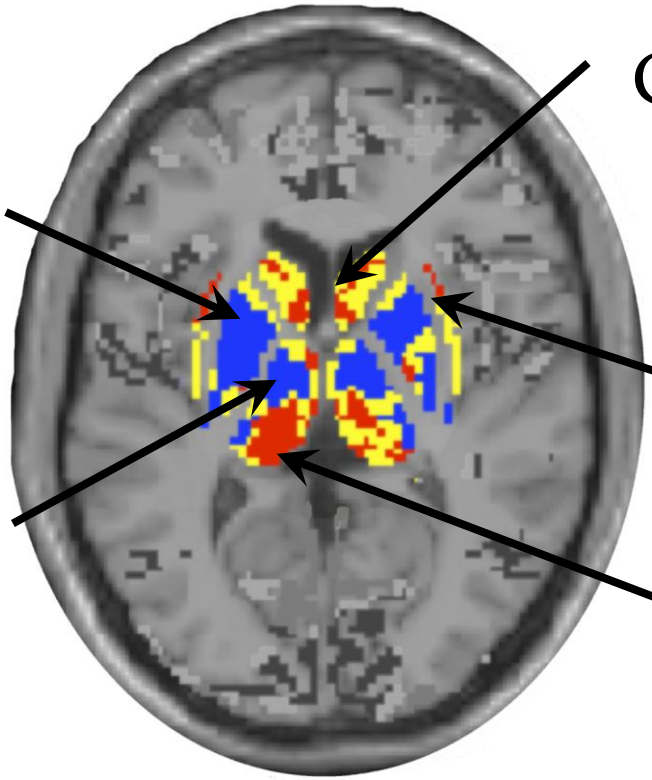


Segregation **Integration**

1 2 3+

The PCC does not *"belong"* to the DMN

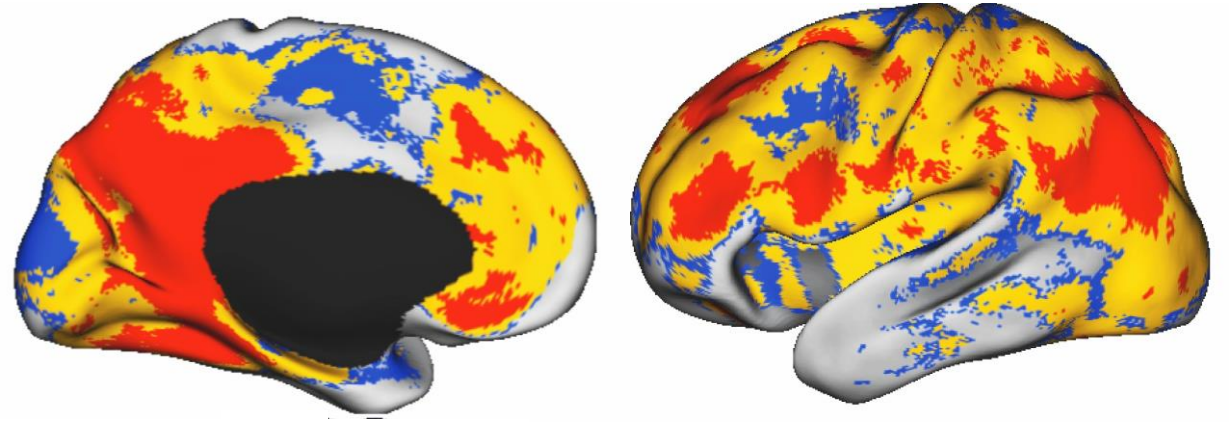
SUBCORTICAL CONVERGENCE SYSTEM



GLOBAL CONNECTIVITY

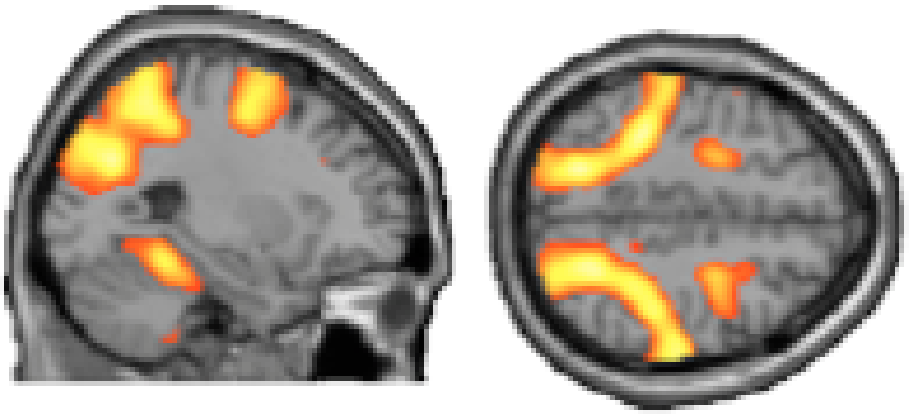
Network convergence is positively correlated with global connectivity

(Spearman's rho = 0.543 , $p < 0.0001$)



Intrinsic connectivity contrast (Martuzzi *et al.*, 2011)

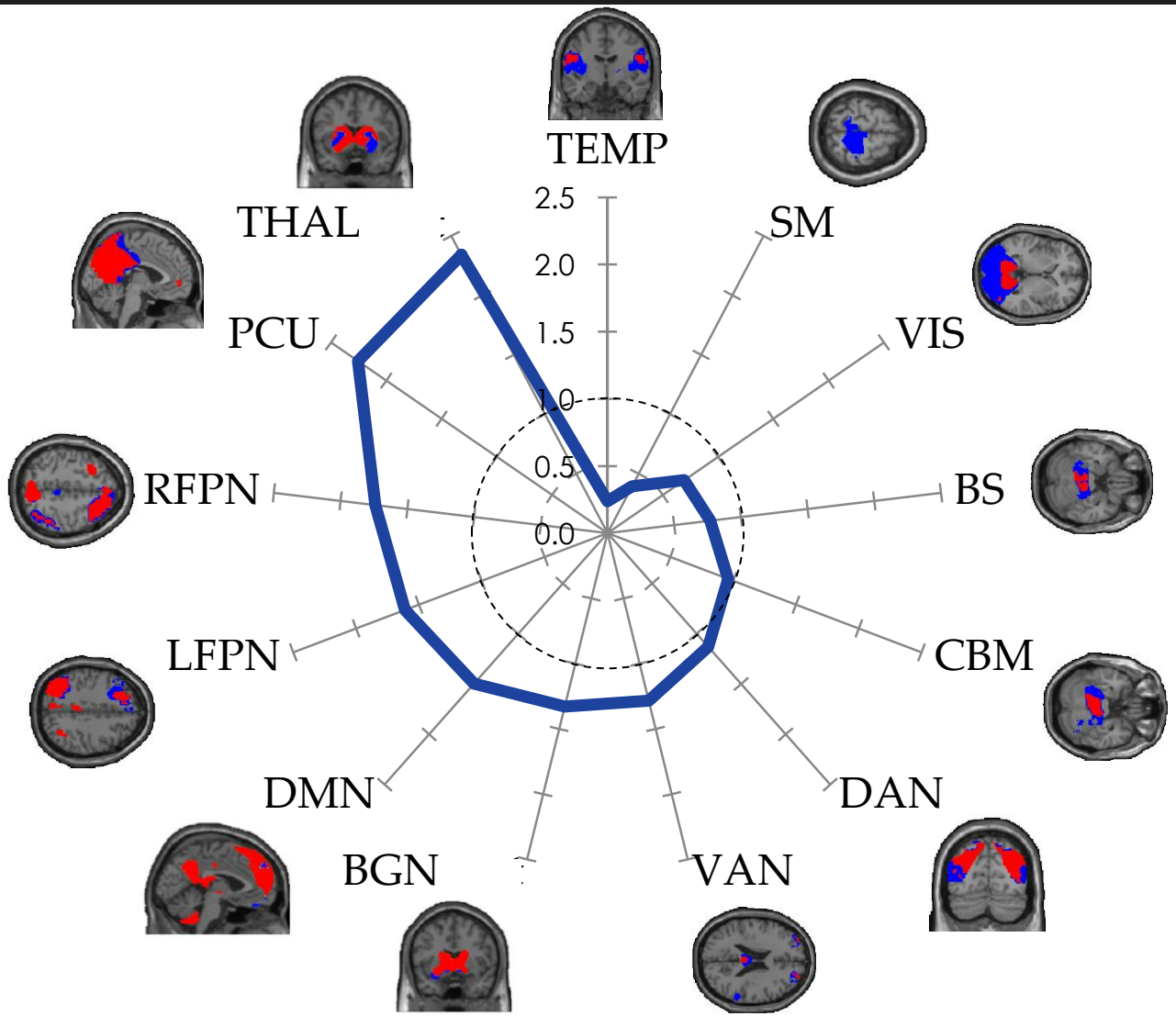
HETEROGENEITY OF CONVERGENCE *Within* NETWORKS

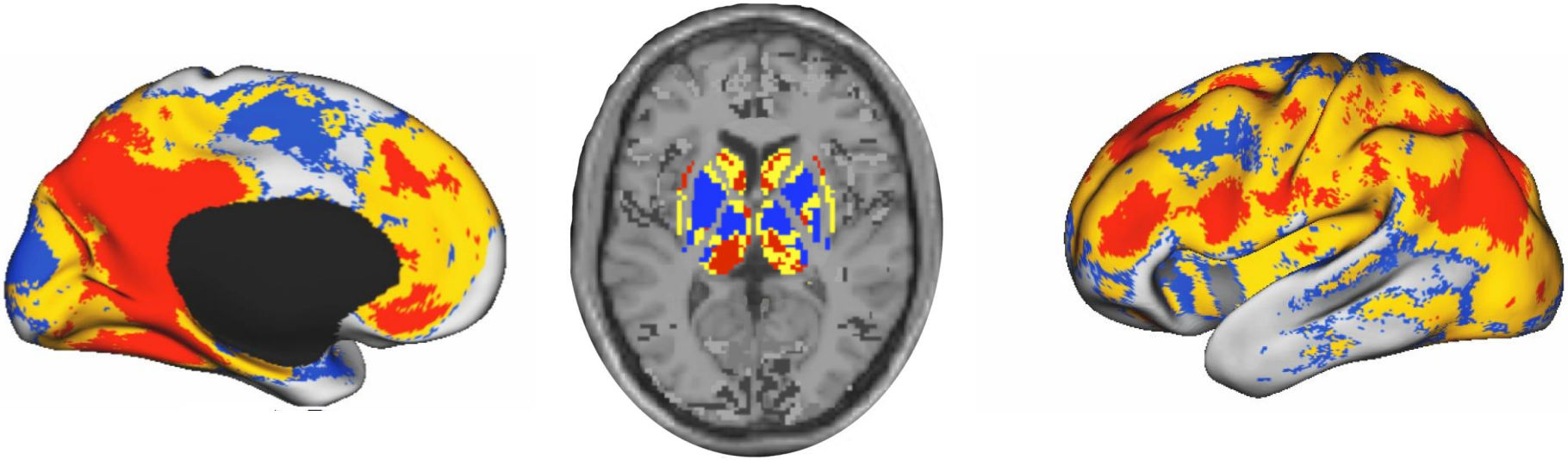


Proportion of voxels within each of the large-scale network masks that was implicated high-level network convergence

(>2 standard deviations above the mean in threshold-adjusted convergence maps)

HETEROGENEITY OF CONVERGENCE *Within* NETWORKS



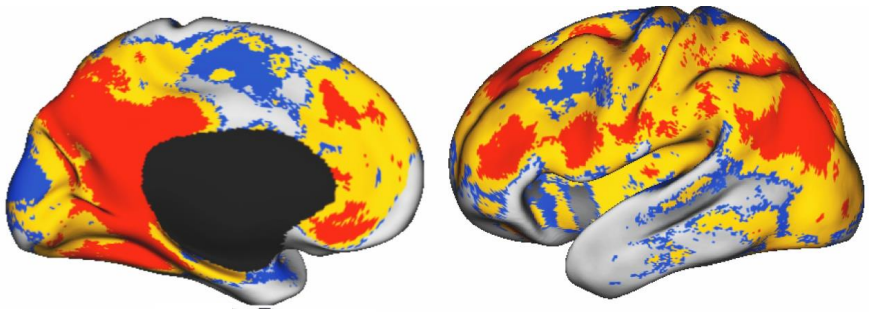


Large-Scale Network Convergence In the Functional Connectome

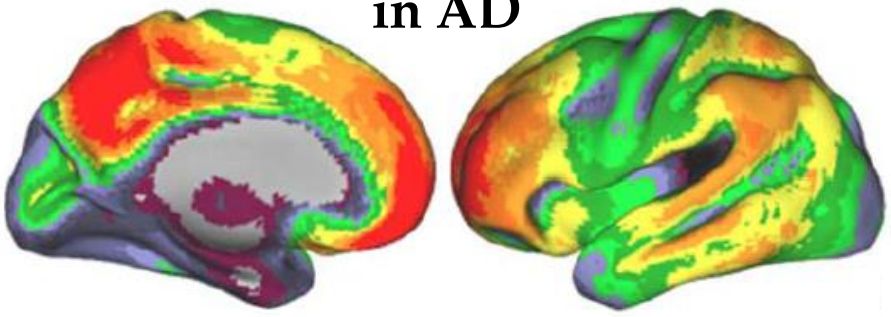
FUTURE DIRECTIONS

- *How do large-scale networks dynamically interact over time?*
- *Does the topography of network convergence change with task- based demands?*
- *Does neurological and neuropsychiatric disease impair integration across networks?*

Network Convergence



Amyloid beta deposition in AD



Buckner *et al.*, 2009

ACKNOWLEDGEMENTS

- James “Mac” Shine
- Michael Hornberger
- Claire O'Callaghan
- Moran Gilat
- 1000 Functional Connectomes Project