Day 5- Probing the Normal and Abnormal human connectome

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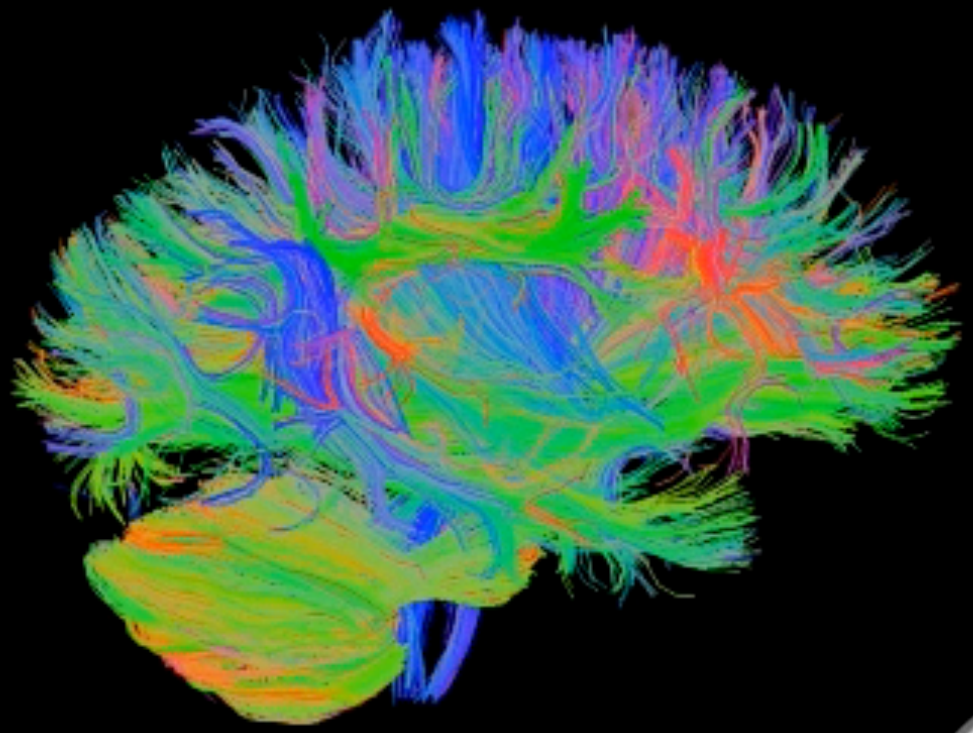
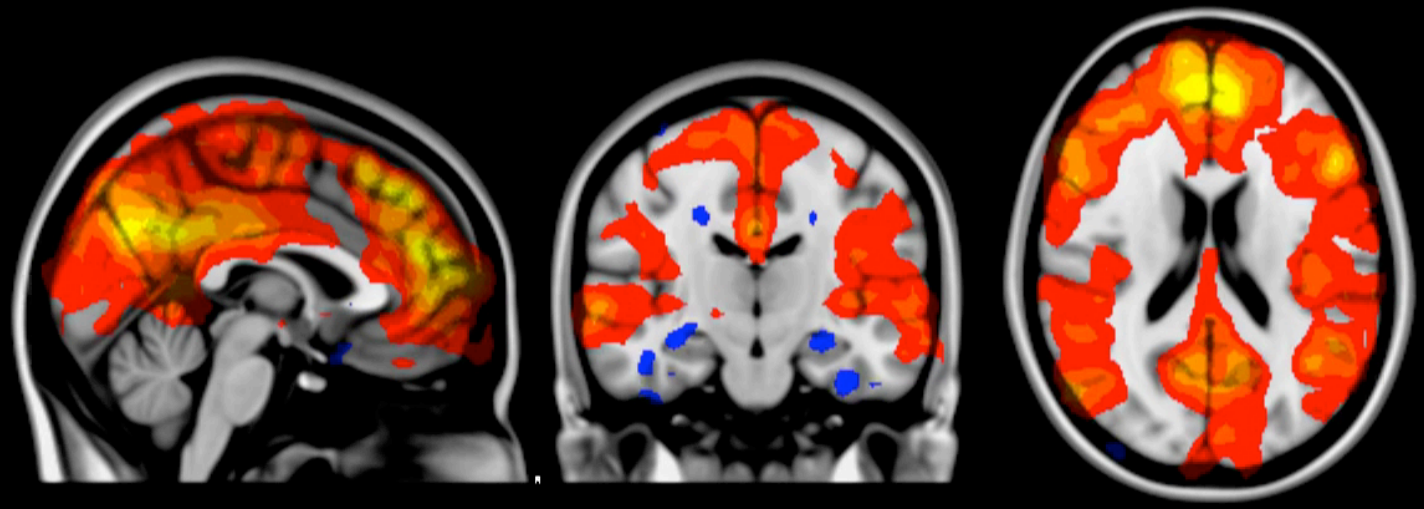
•How does brain network structure constrain function?
•What are the organizational principles of brain networks?
•How do these affect / effect disorder?

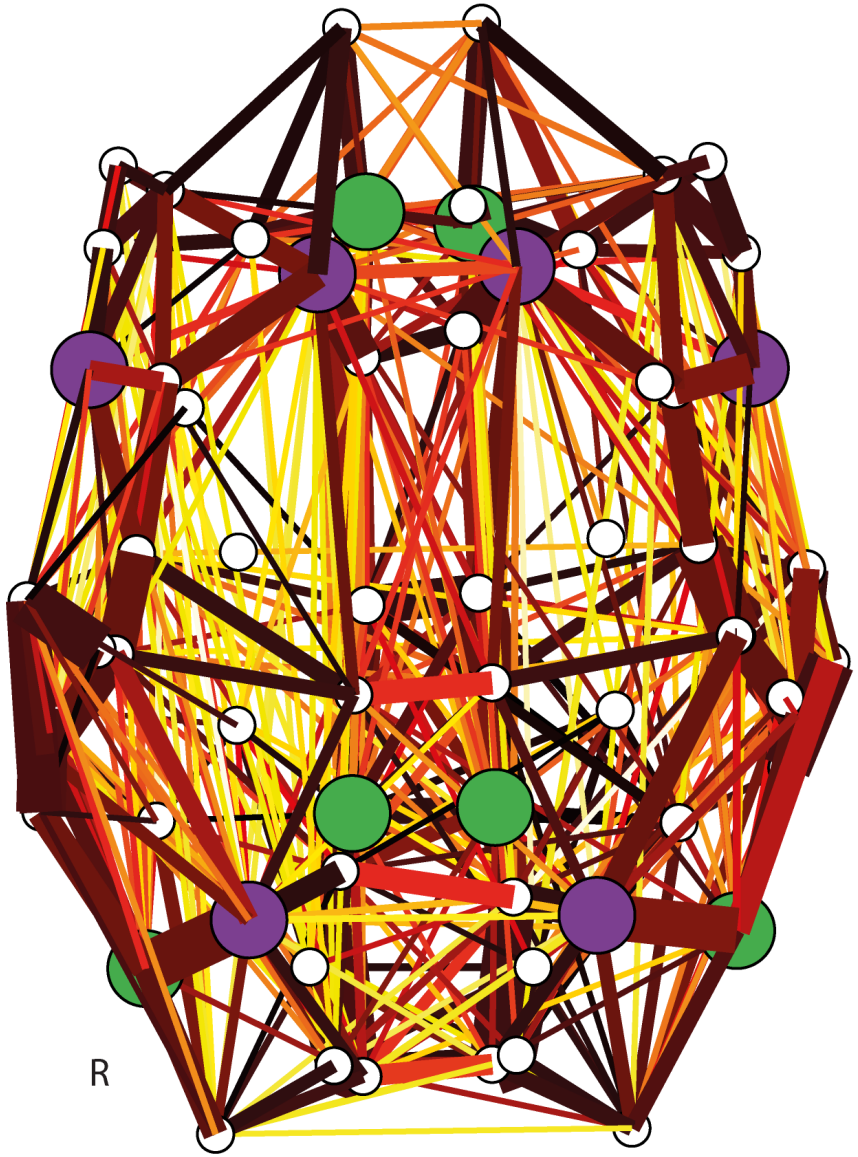


Building a Model to

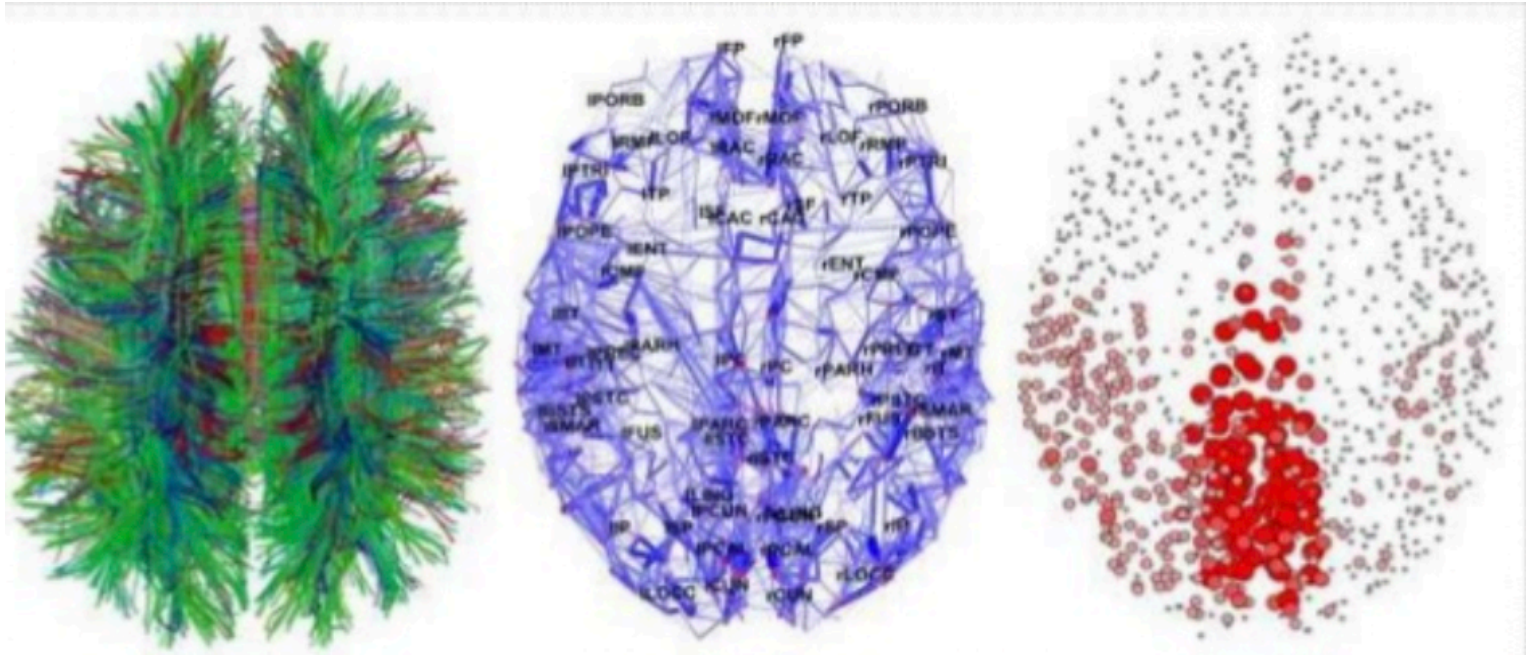
Trade **complexity**, with

interpretability

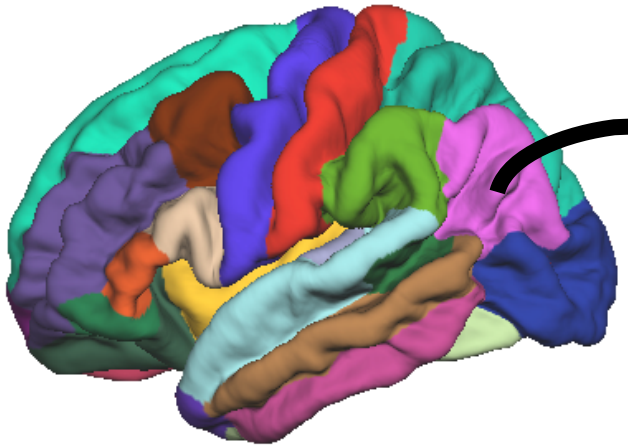


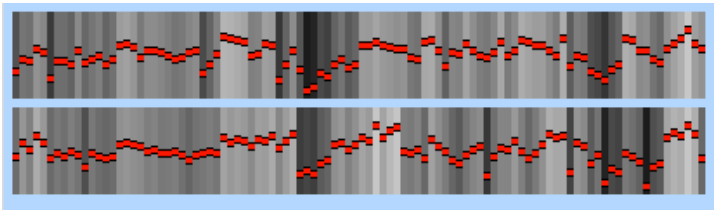


The "Connectome"



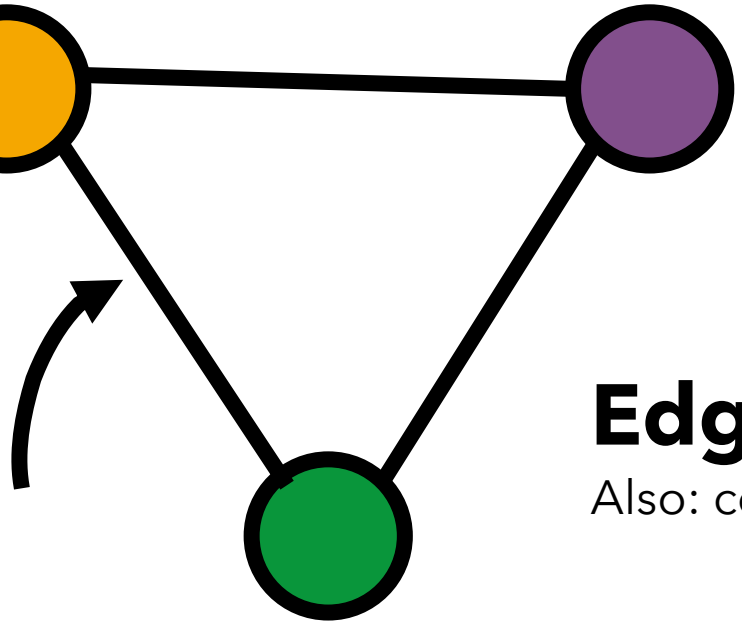
Graphs describe the topology of the relationships between discrete objects





Correlation

Strength of structural connection



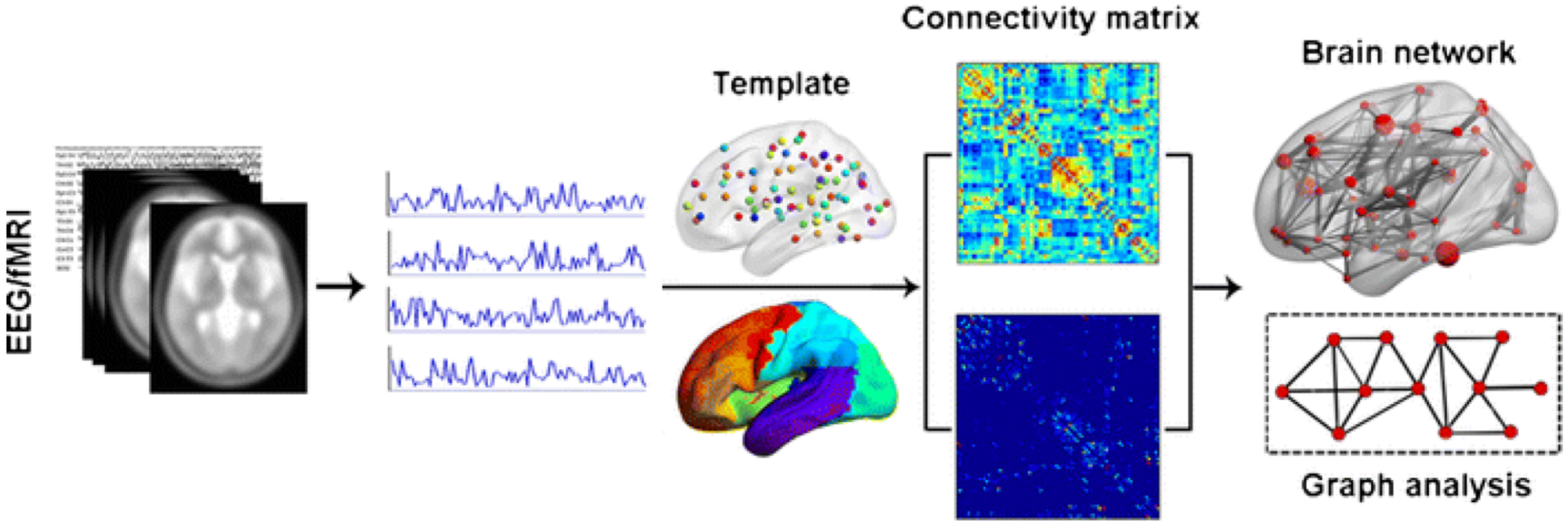
Vertex

Also: node, point

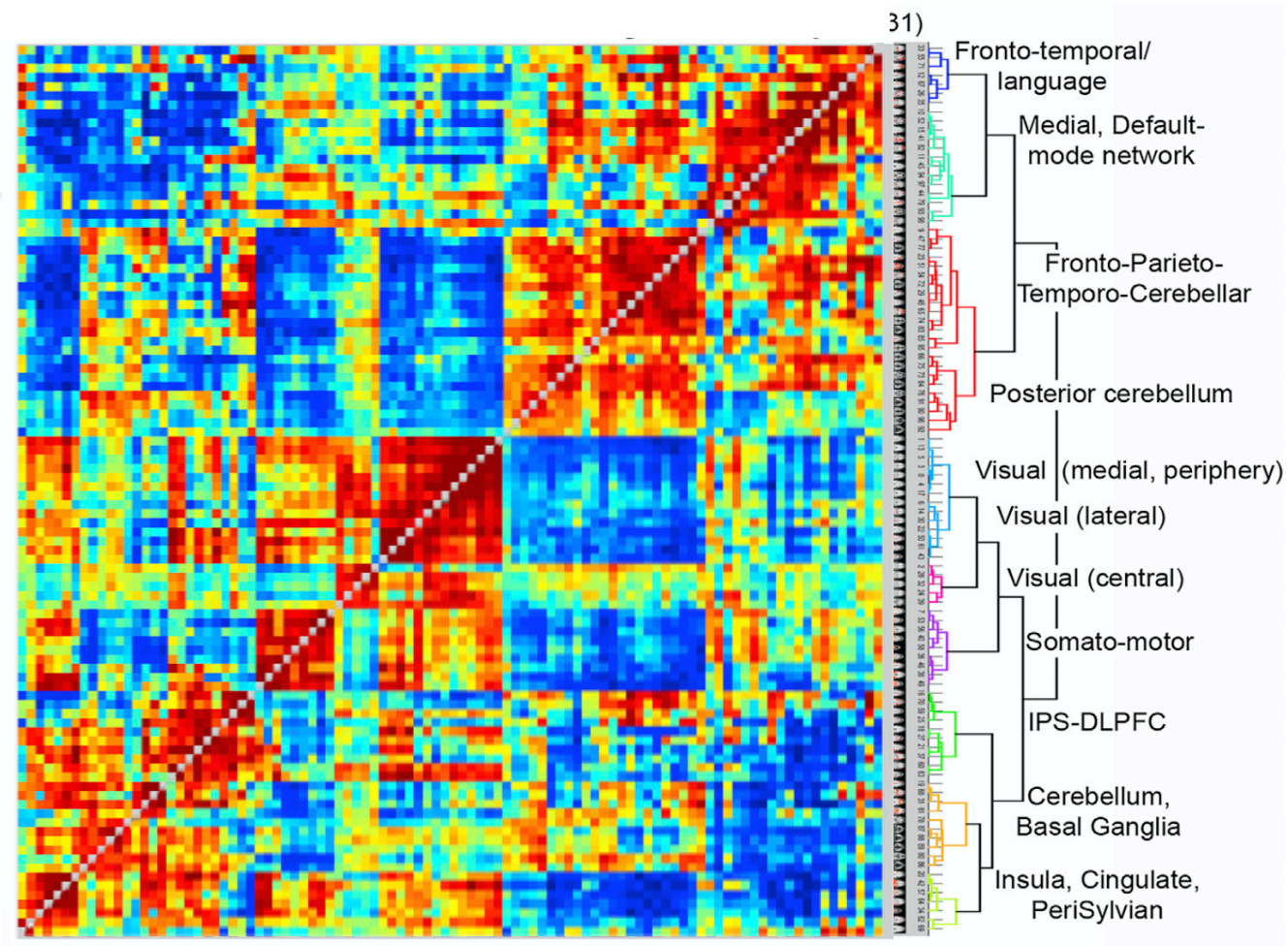
Edge

Also: connection, link, line

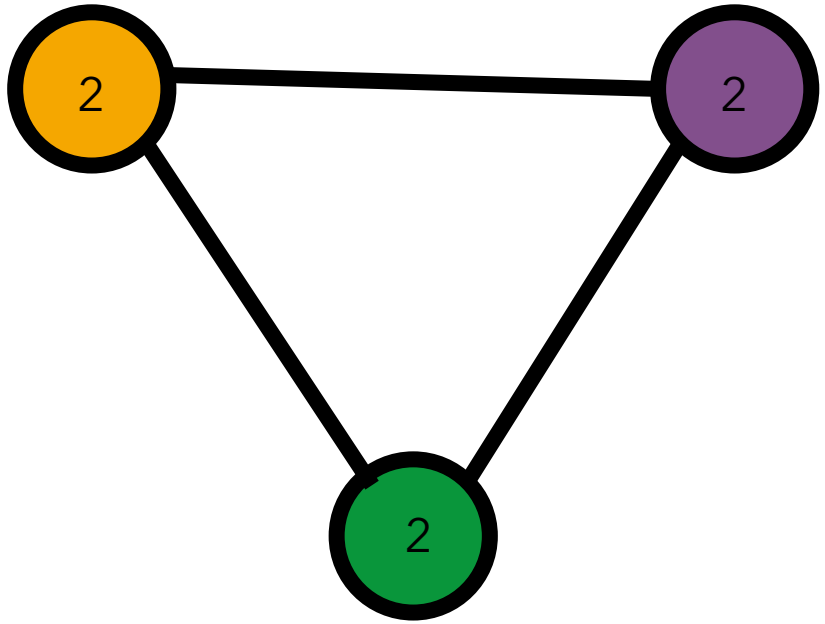
Graphs describe the topology of the relationships between discrete objects



Adapted from Cao et al, Molecular Neurobiology, 2014

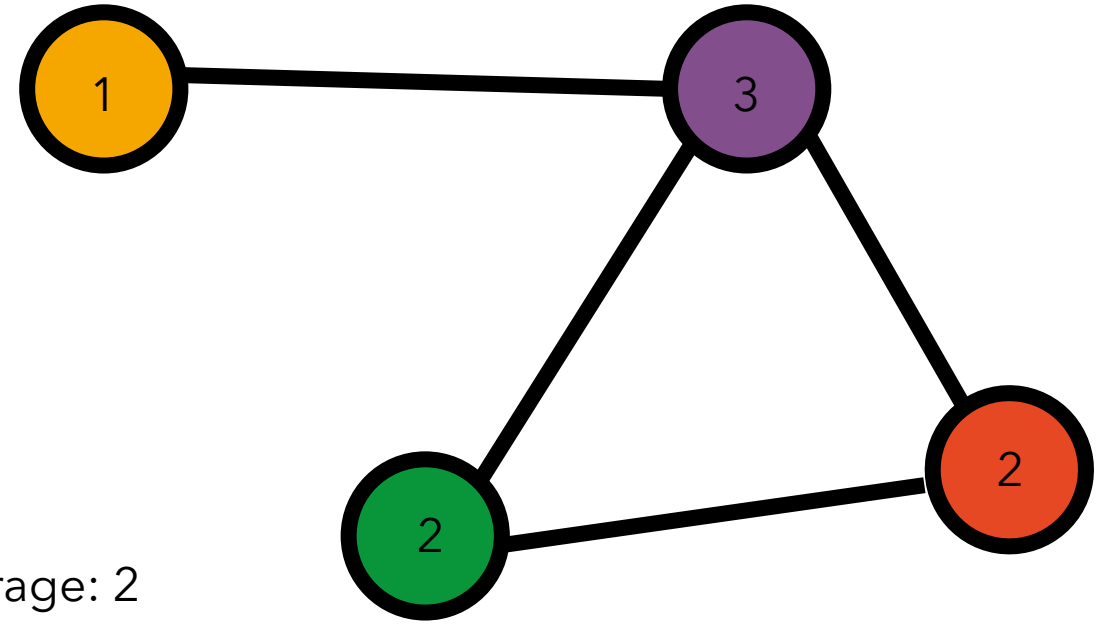

31)
Fronto-temporal/
language
Medial, Default-
mode network
Fronto-Parieto-
Temporo-Cerebellar
Posterior cerebellum
Visual (medial, periphery)
Visual (lateral)
Visual (central)
Somato-motor
IPS-DLPFC
Cerebellum,
Basal Ganglia
Insula, Cingulate,
PeriSylvian

Degree – number of connections an individual node makes



Graphs Theory describes complex relationships between brain regions

Degree – number of connections an individual node makes

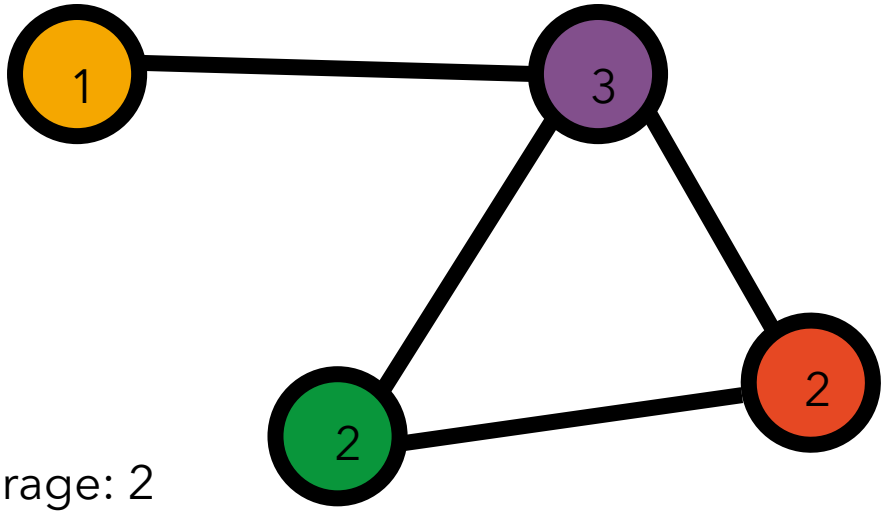


Average: 2
Density ~ 0.6

Graphs Theory describes complex relationships between brain regions

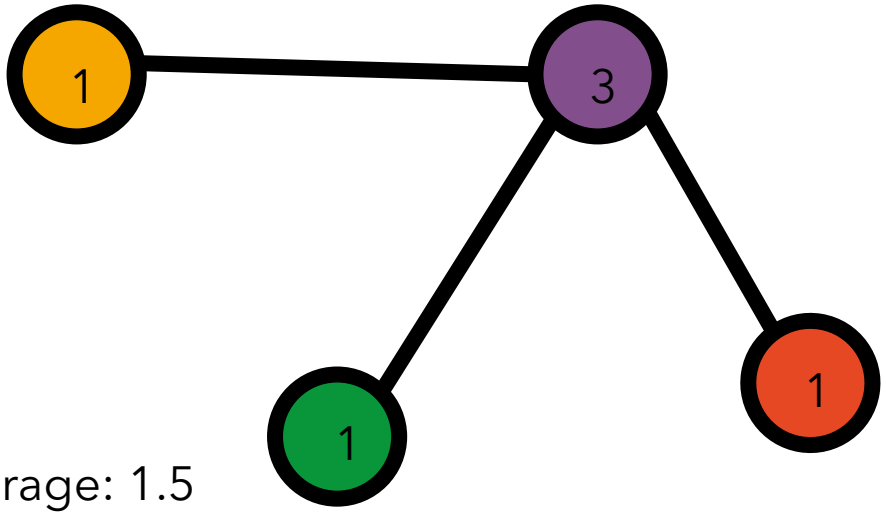
Degree – number of connections an individual node makes

Healthy Controls:



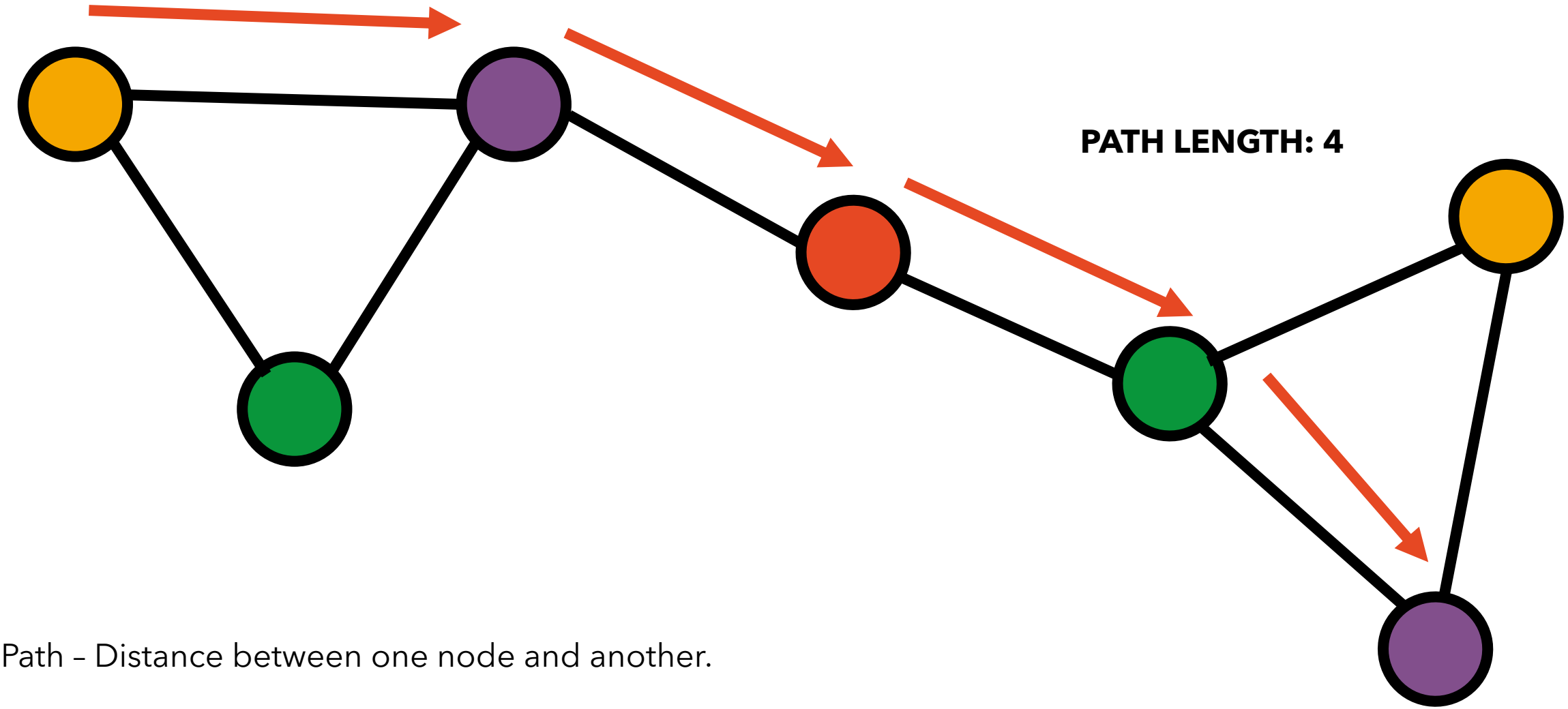
Average: 2
Density ~ 0.3

Traumatic Brain Injury:



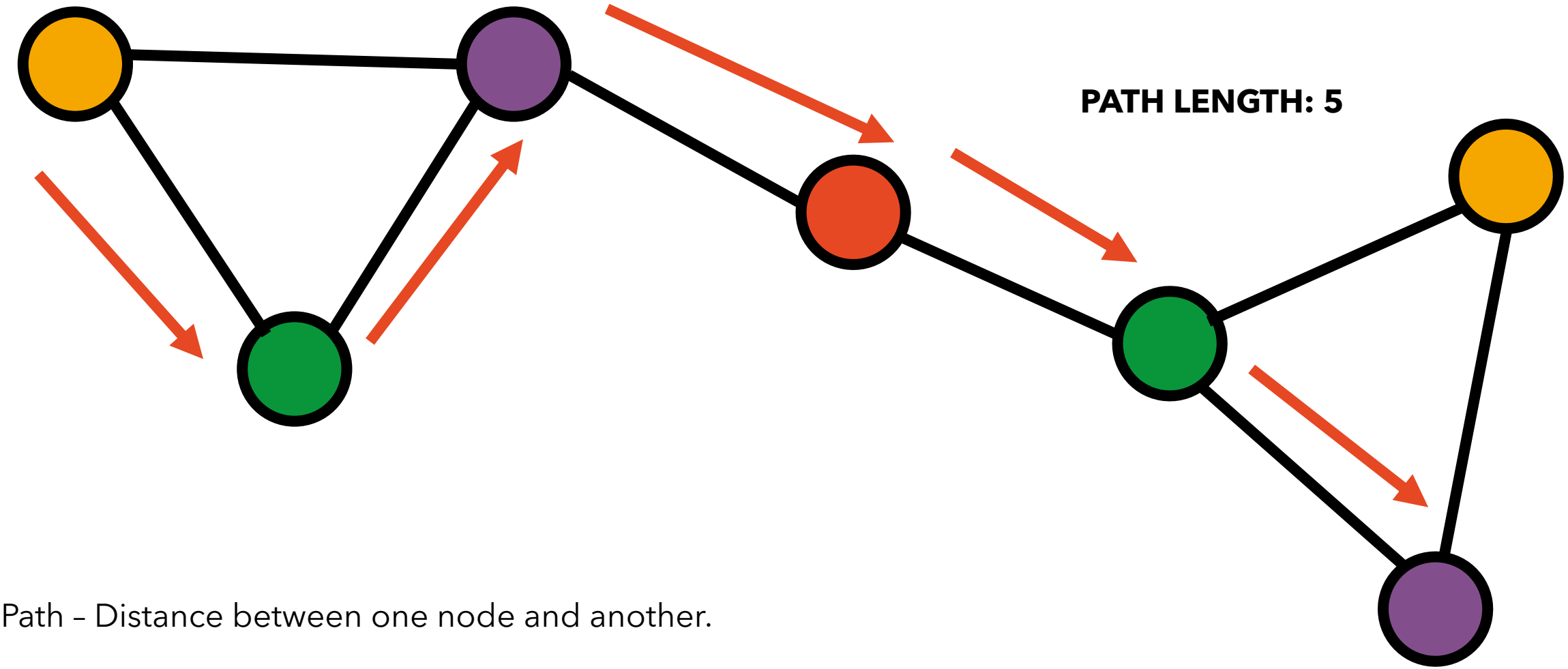
Average: 1.5
Density ~ 0.25

Graphs Theory describes complex relationships between brain regions



Path – Distance between one node and another.

Graphs Theory describes complex relationships between brain regions



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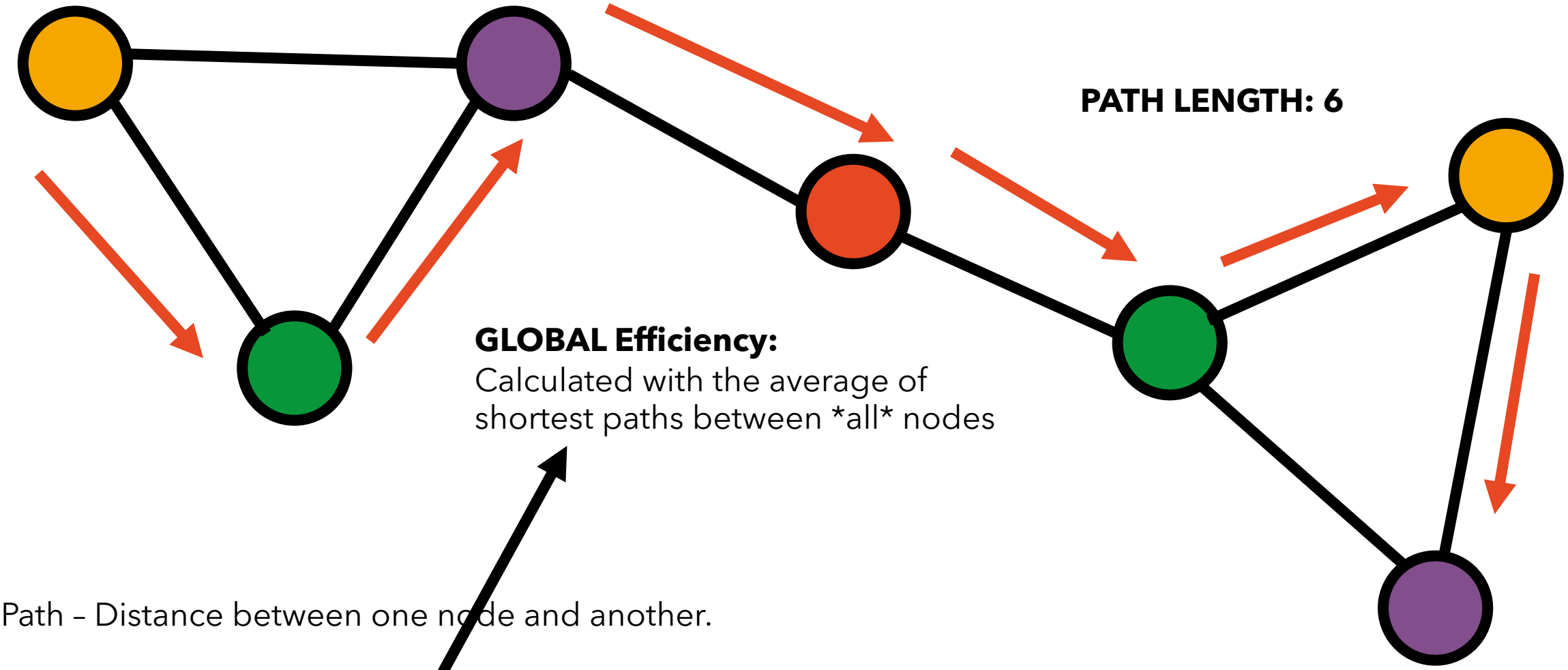


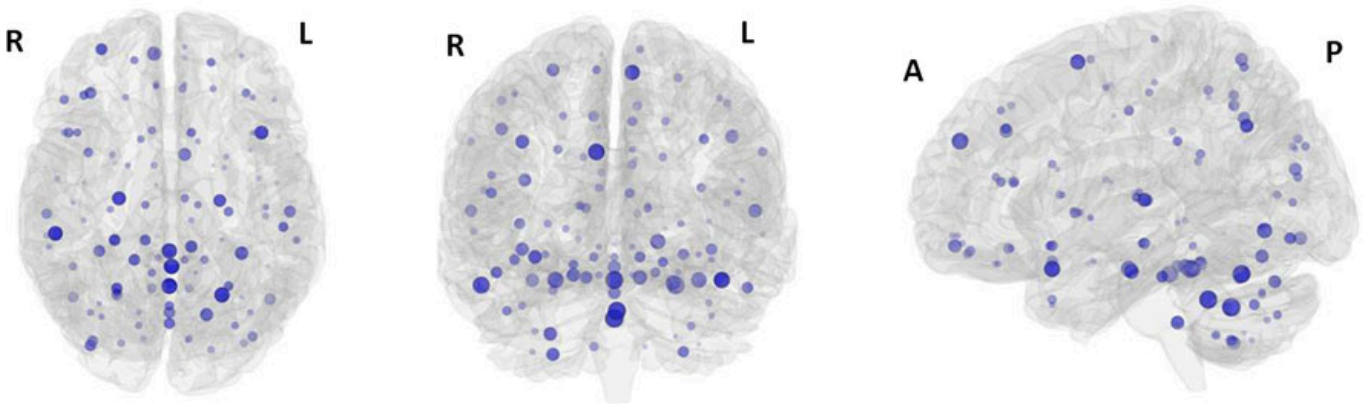
GLOBAL Efficiency:
Calculated with the average of shortest paths between *all* nodes

Path – Distance between one node and another.

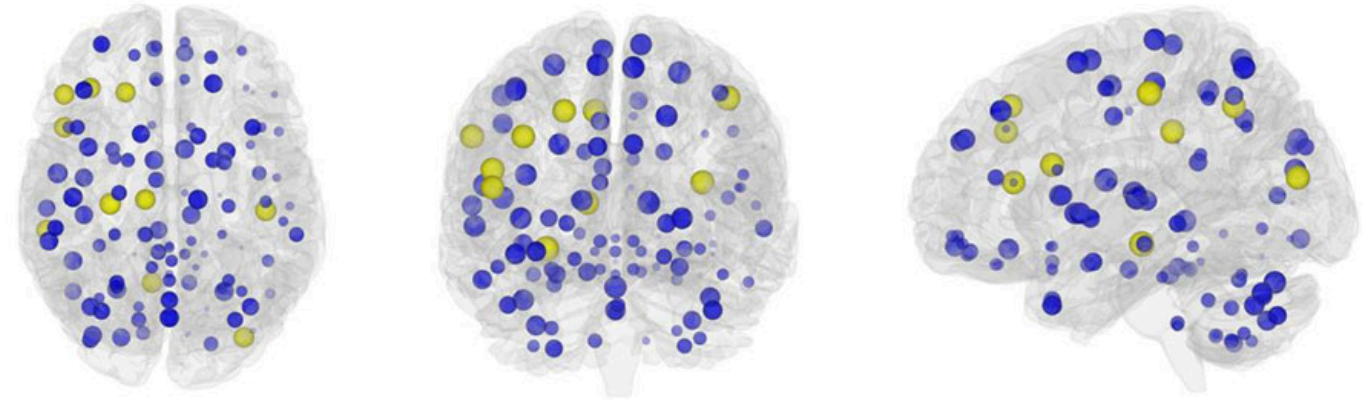
Number of paths: Redundancy in communication.
Shortest Path: Efficiency of connections between regions

Graphs Theory describes complex relationships between brain regions

Controls

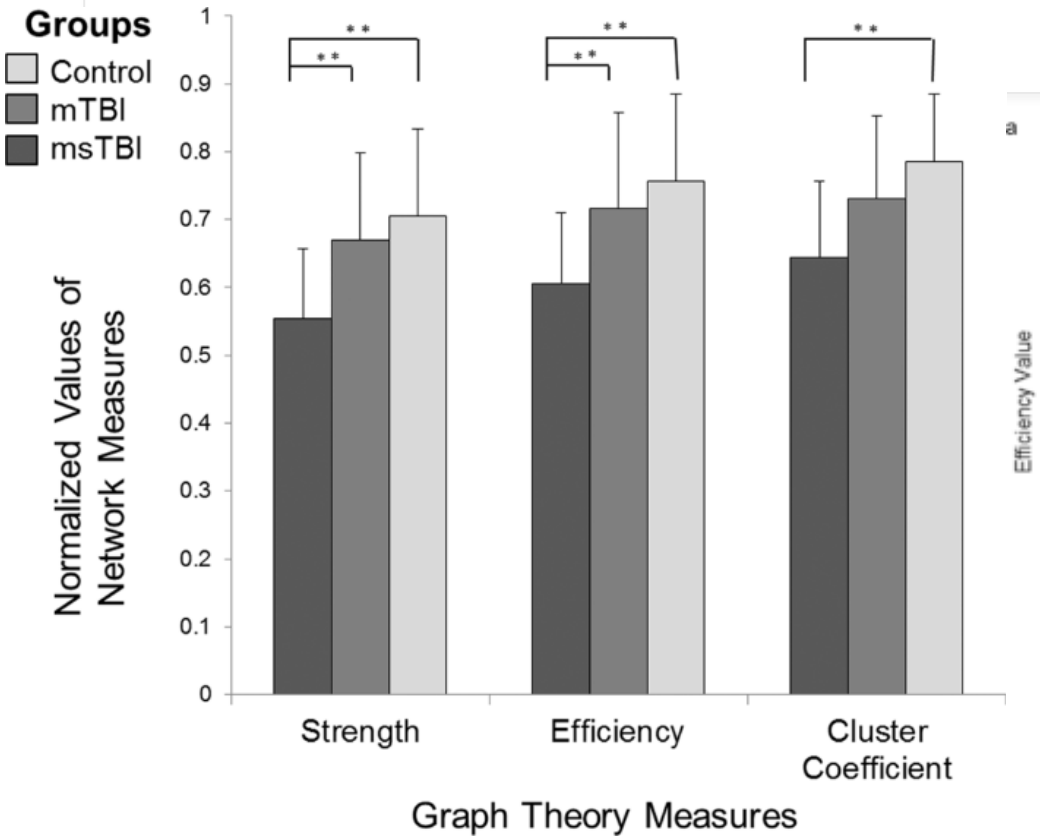


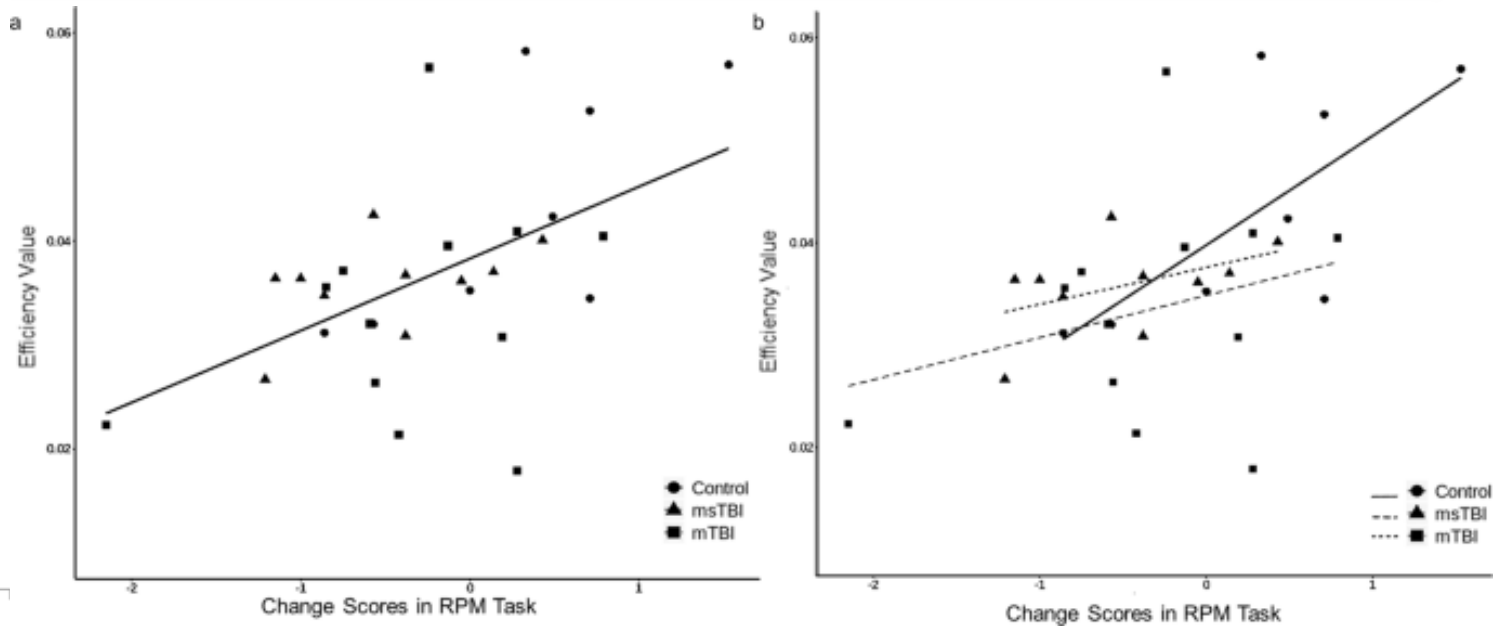
TBI



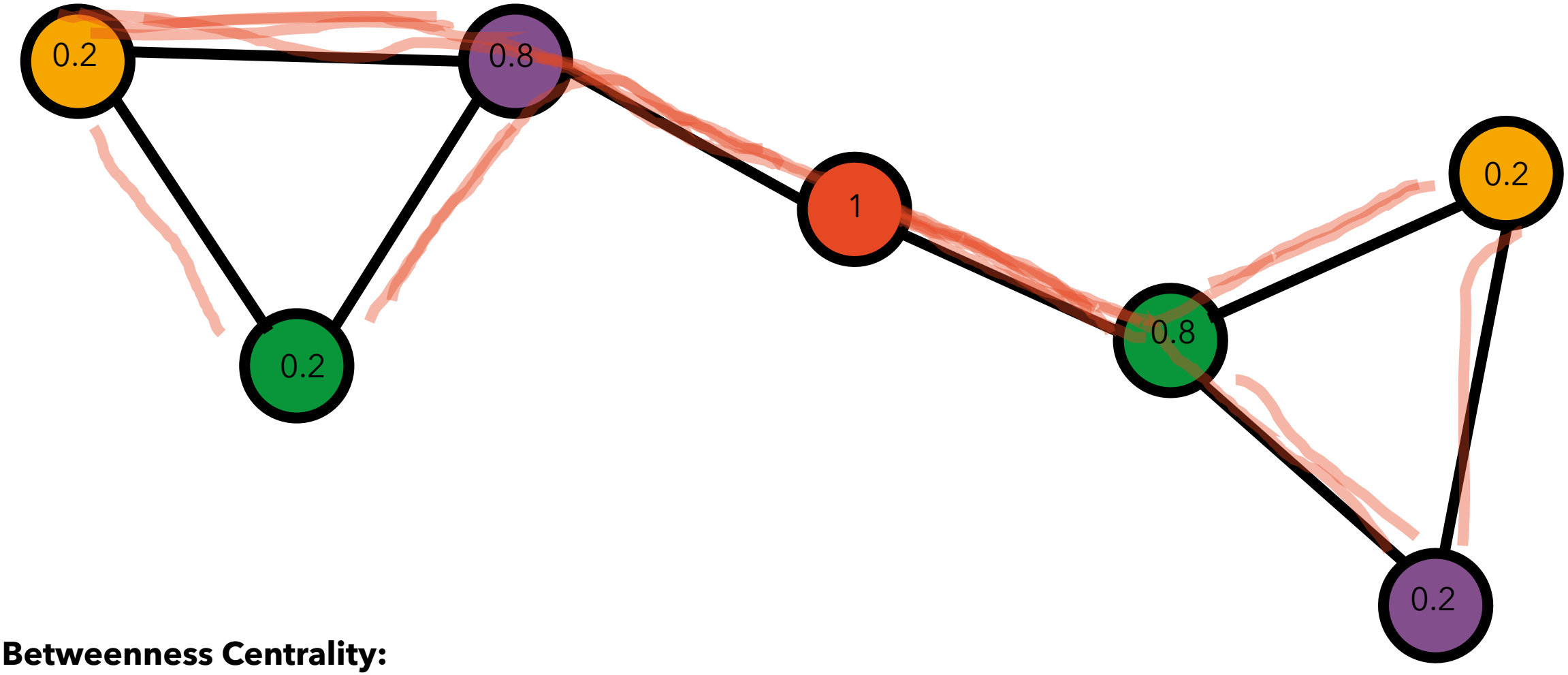
Information processing speed is significantly correlated with local and global efficiency

Caeyenberghs, Karen & Leemans, Alexander & Leunissen, Inge & Gooijers, Jolien & Michiels, Karla & Sunaert, Stefan & Swinnen, Stephan. (2012). Altered structural networks and executive deficits in traumatic brain injury patients. Brain structure & function.



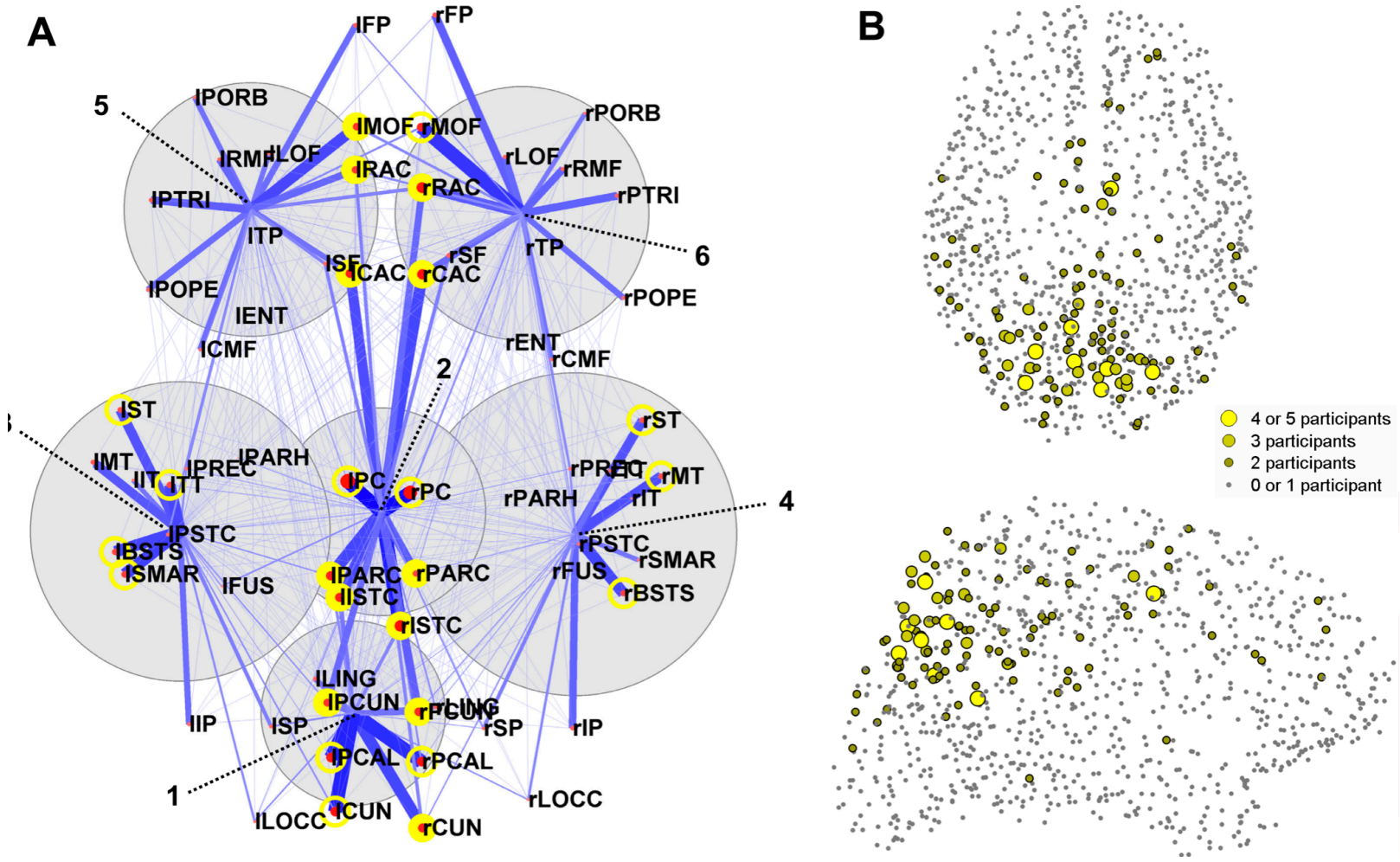


Raitzman (2020) Traumatic Brain Injury Severity in a Network Perspective: A Diffusion MRI Based Connectome Study



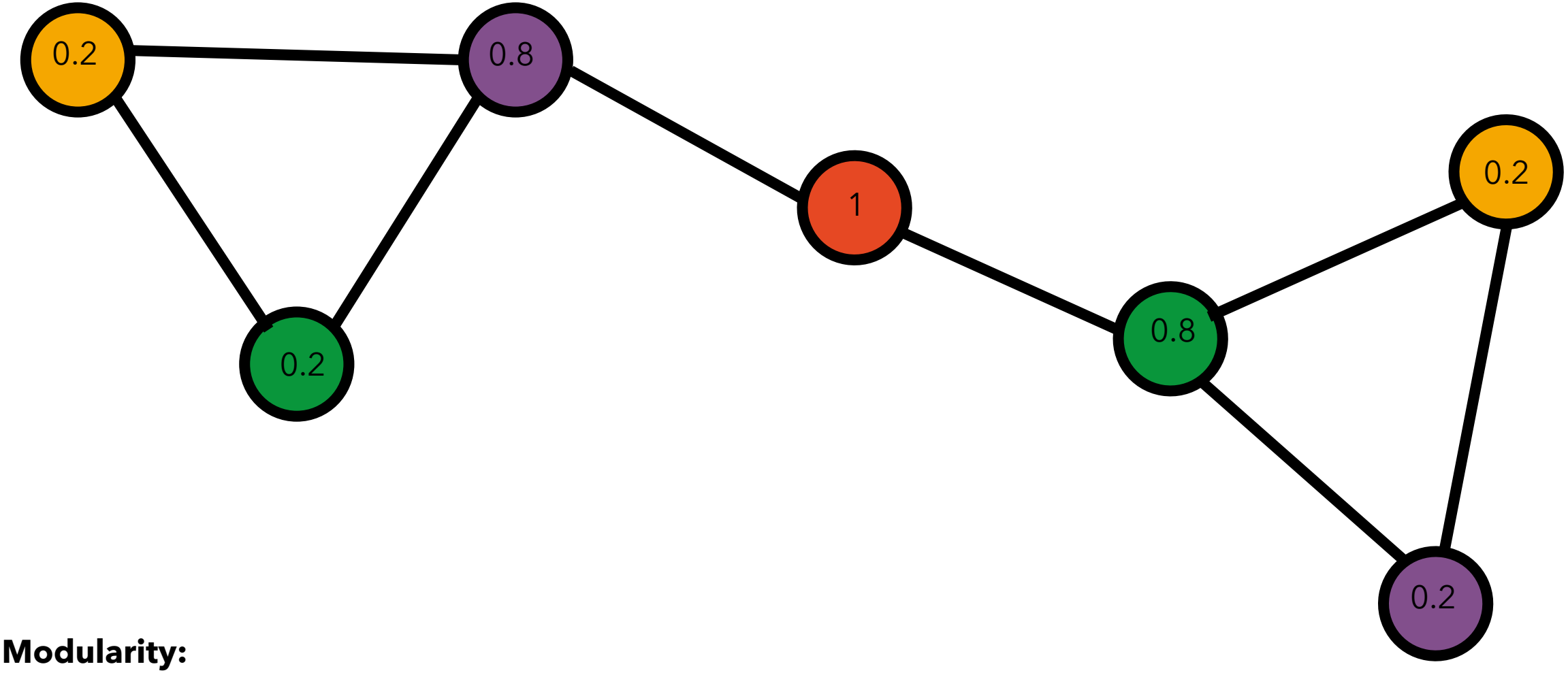
Betweenness Centrality:
How important is each node in forming an efficient network?

Graphs Theory describes complex relationships between brain regions



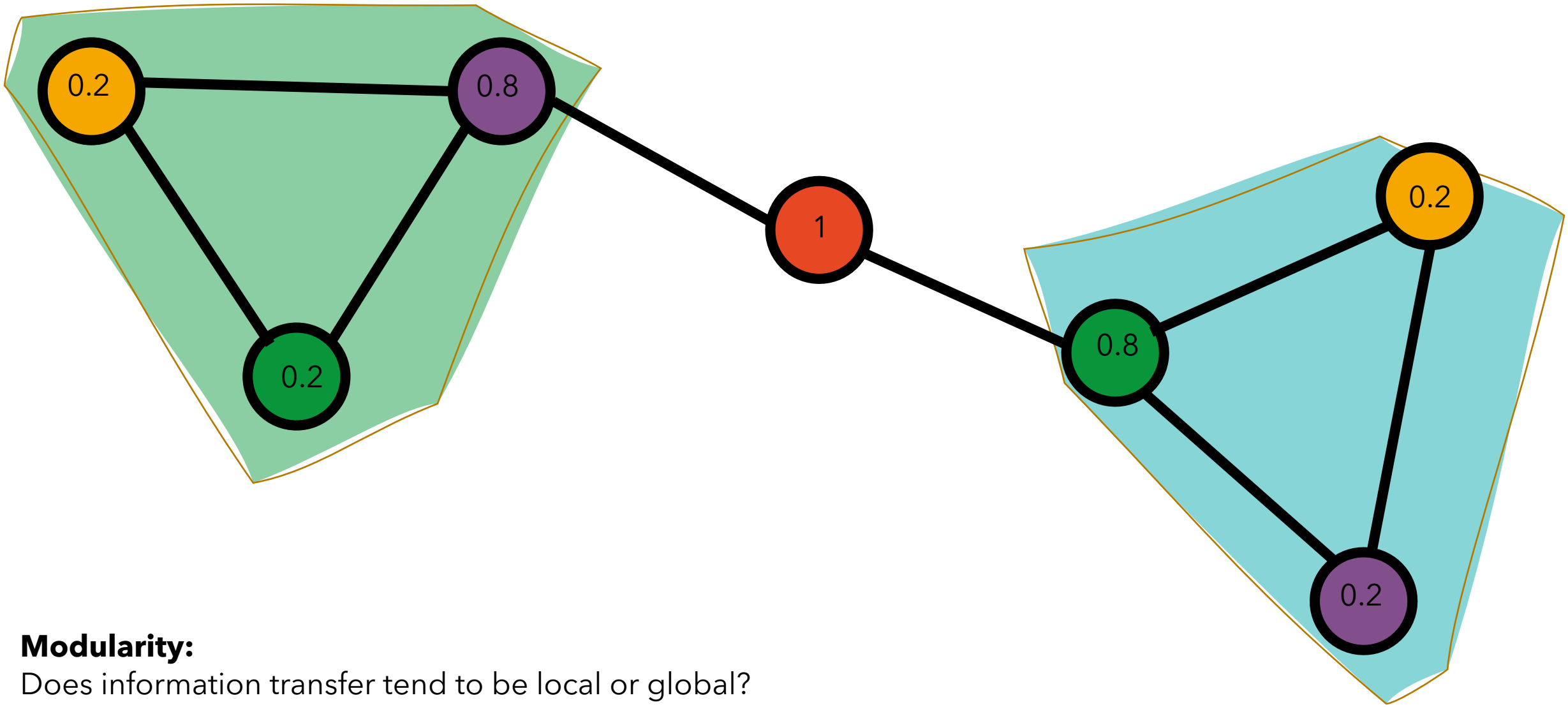
The Posterior Cingulate Cortex forms a structural and functional 'core' of the brain

Hagmann P, Cammoun L, Gigandet X, Meuli R, Honey CJ, et al. (2008) Mapping the Structural Core of Human Cerebral Cortex. PLOS Biology 6(7): e159.



Modularity:
Does information transfer tend to be local or global?

Graphs Theory describes complex relationships between brain regions



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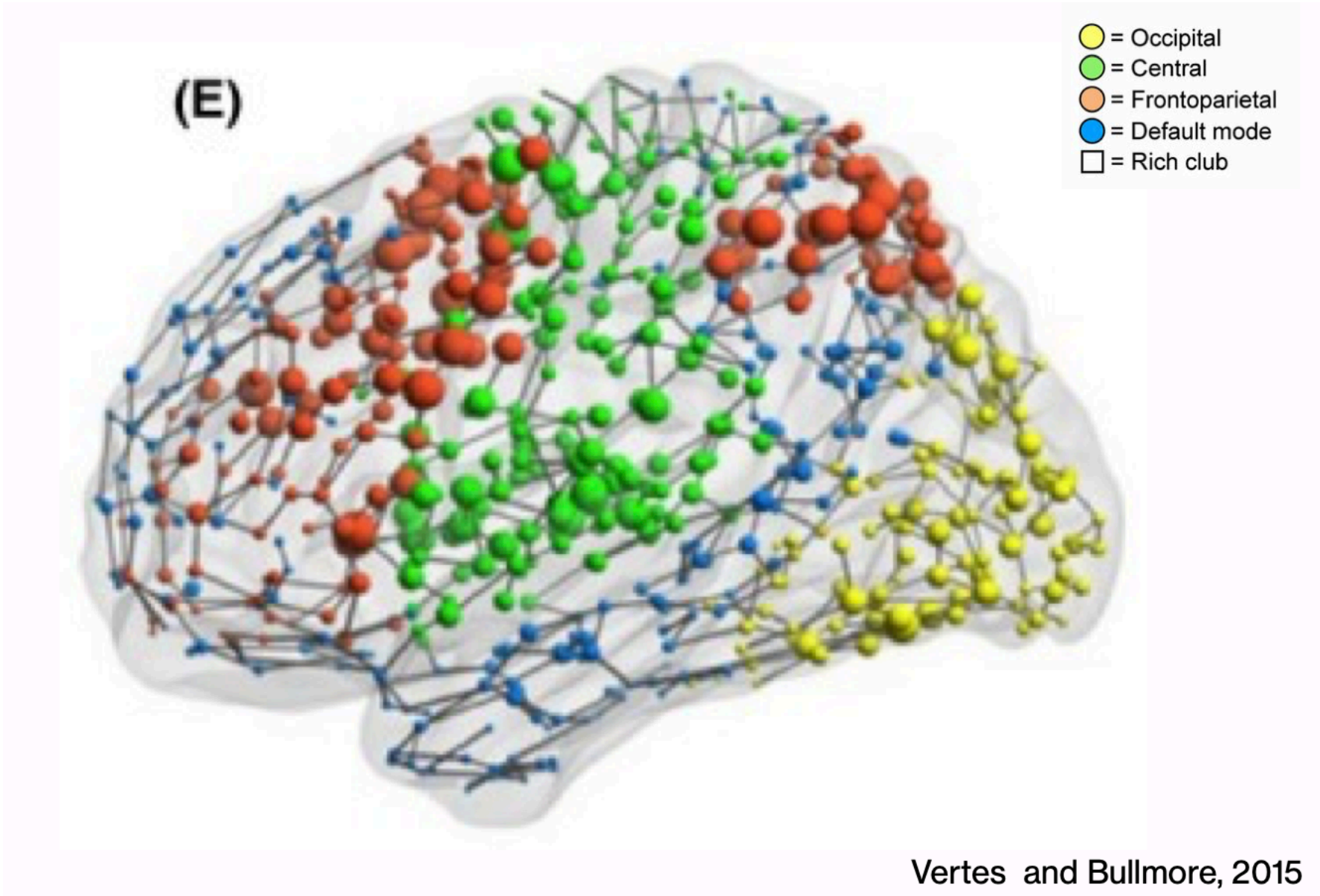
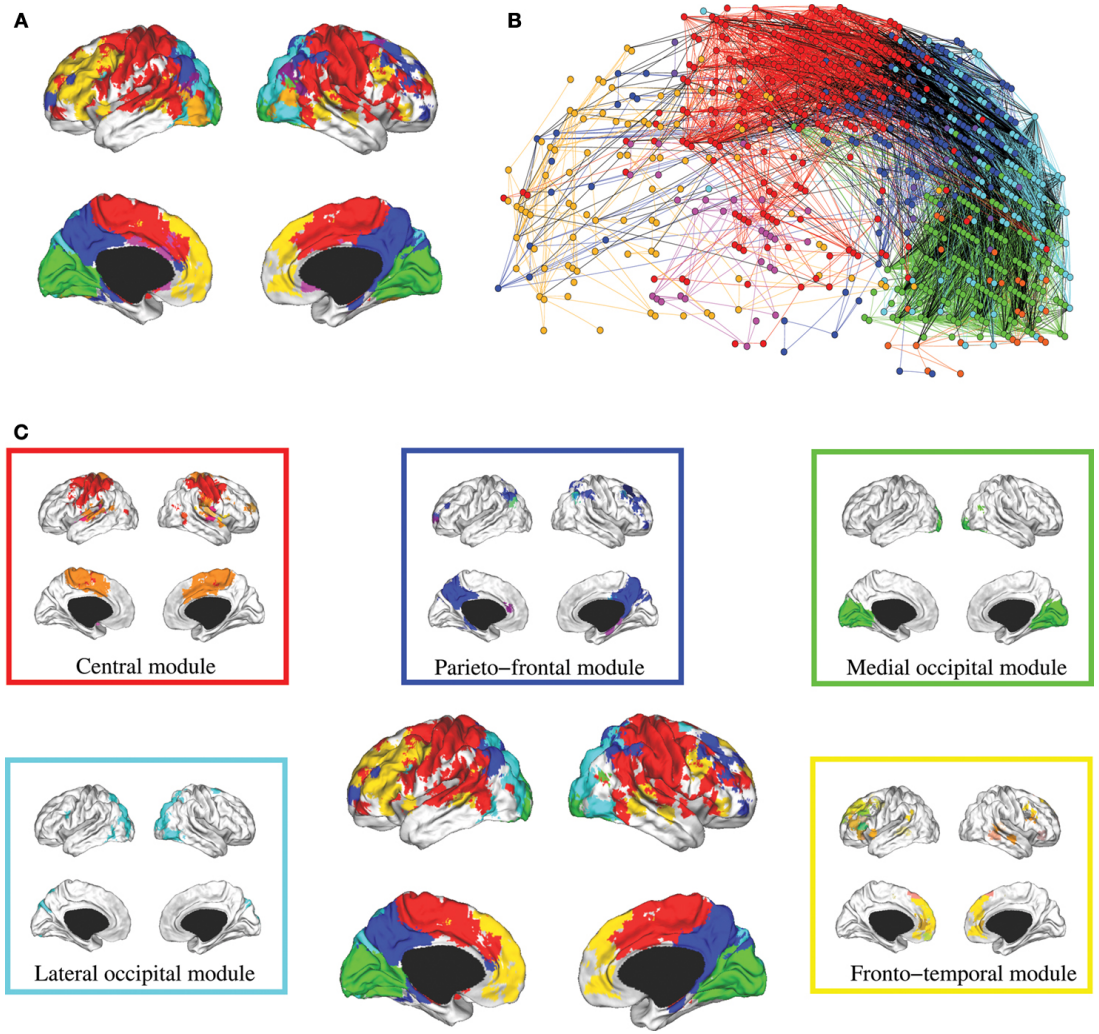
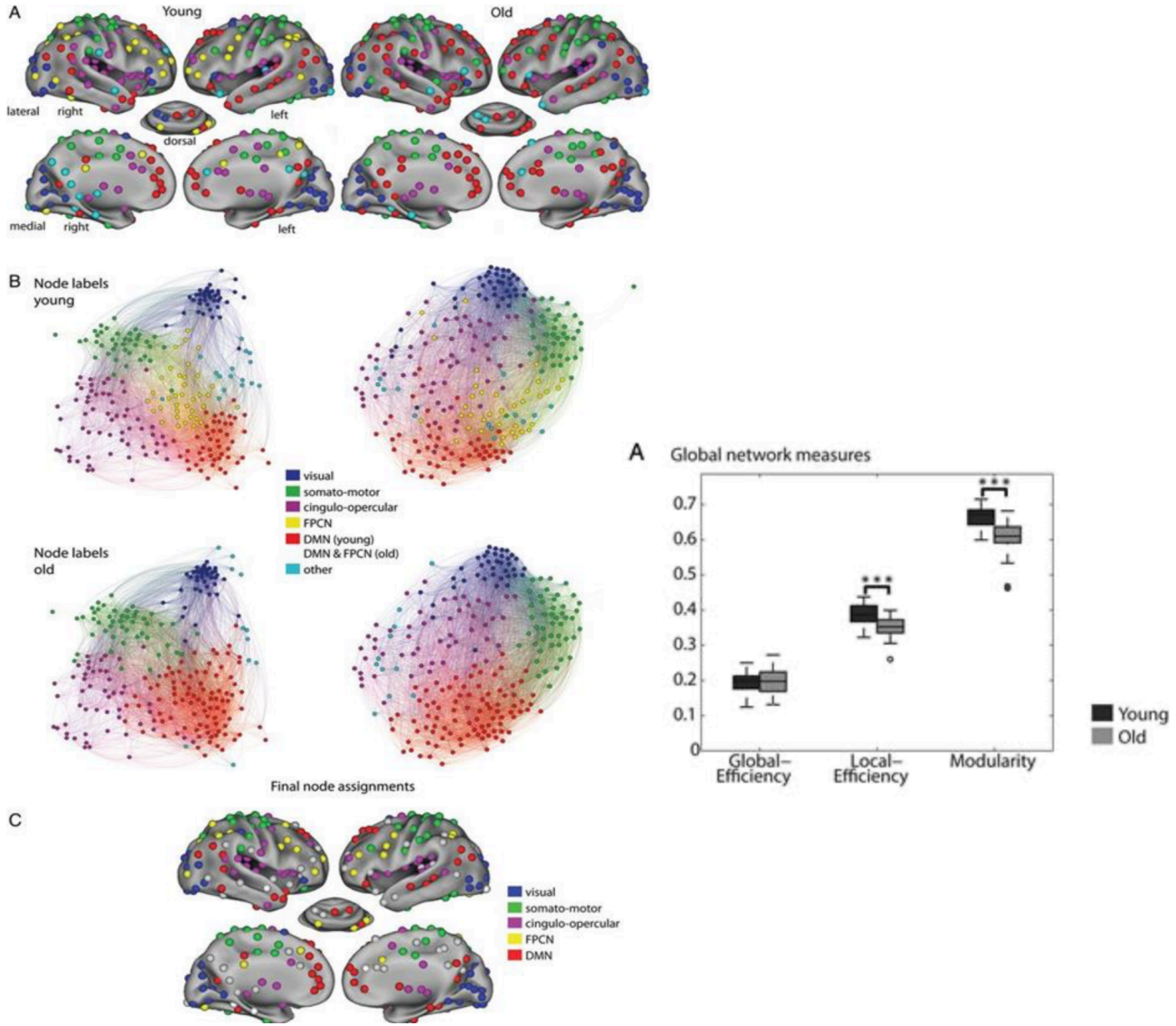


Vertes and Bullmore, 2015



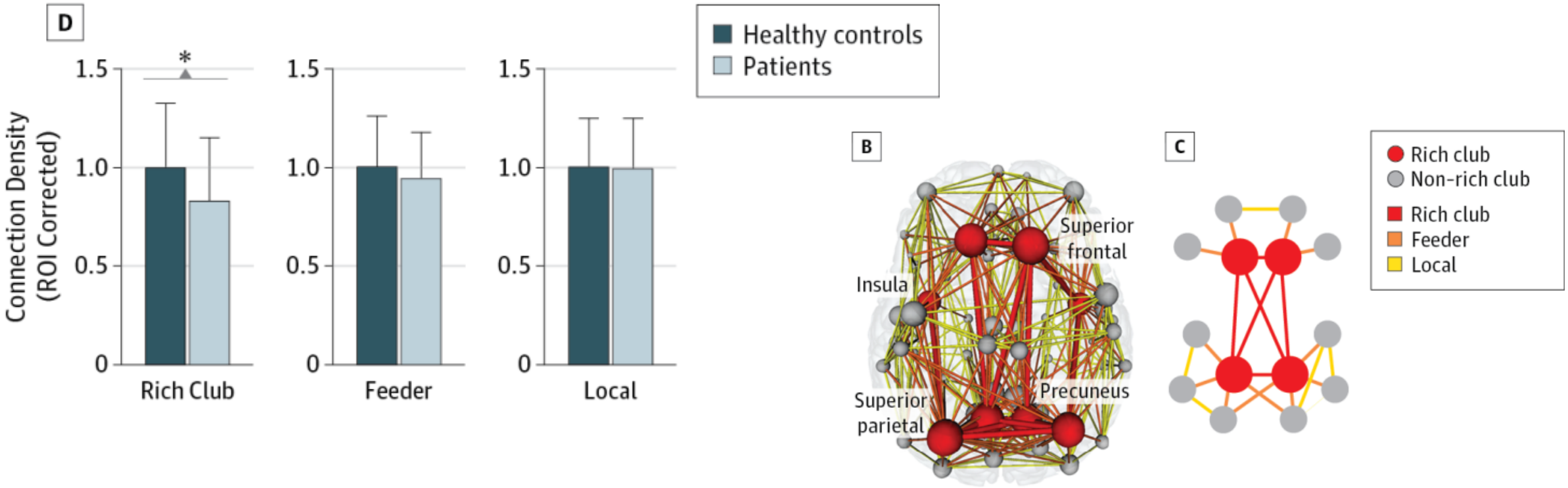
Modules in functional connectivity reflect canonical sensori-motor networks

Meuner et al (2009) Hierarchical modularity in human brain functional networks. Front. Neuroinform.,



Which are modulated by age

Linda Geerligs, Remco J. Renken, Emi Saliasi, Natasha M. Maurits, Monicque M. Lorist, A Brain-Wide Study of Age-Related Changes in Functional Connectivity, *Cerebral Cortex*, Volume 25, Issue 7, July 2015,



•Changes to hubs and clustering properties of networks based on grey matter volume in patients with schizophrenia (Bassett et al., *J Neurosci*, 2008)

Graphs Theory describes complex relationships between brain regions

Analysis of the ‘graph’ representation of the brain:
Understand the structure of the heathy brain
+ understand relationship with behaviour.

Compare changes to function and structure between brain states or disease groups

This afternoon:

Learn how to build a graph, and represent it as a matrix.

Learn to use the ‘Brain Connectivity Toolbox’ to explore some of the metrics discussed this morning

Use graph theory to explore the difference between the brain at rest and during the psychedelic state