Characterization of complex functional brain networks
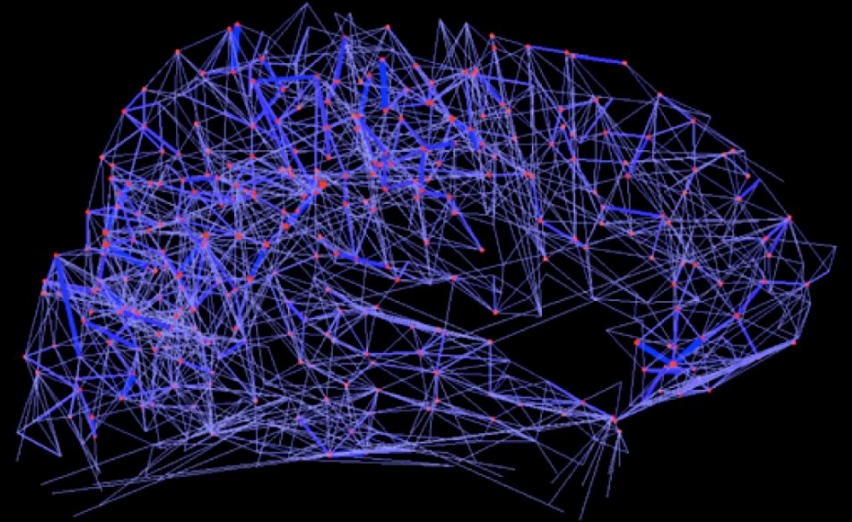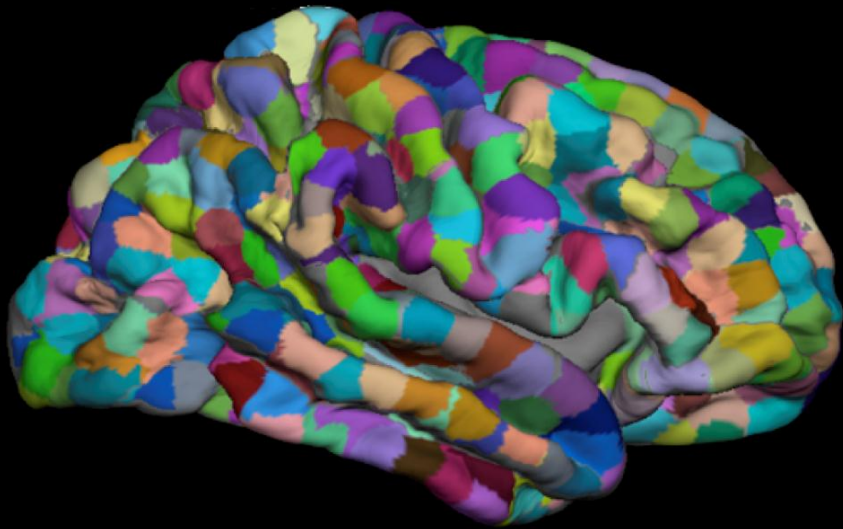
Mika Rubinov

Brain Mapping Unit
Behavioural and Clinical
Neuroscience Institute
University of Cambridge
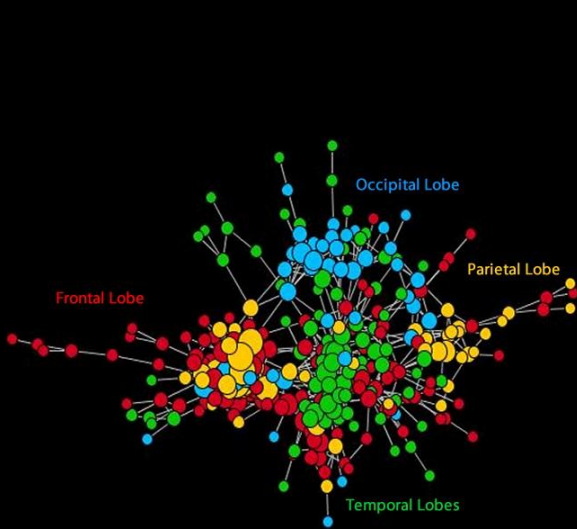
**MRC CBU
Connectivity Interest Group
17 Nov 2011**

Overview

- motivation

- construction

- characterization

- caveats

- brain connectivity toolbox

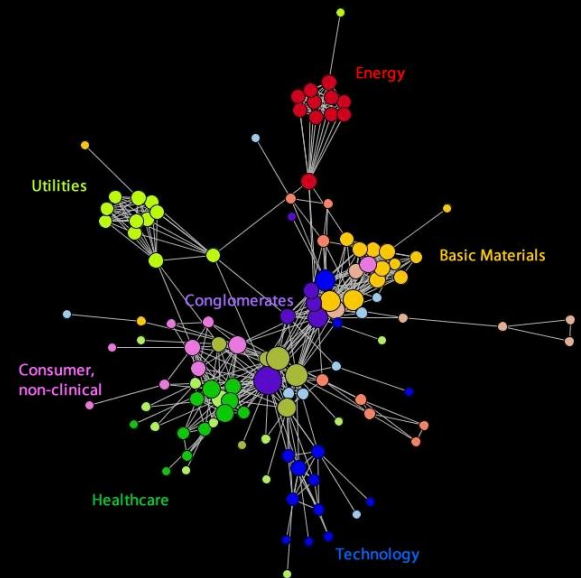# Complex brain networks

Appeal of complex networks

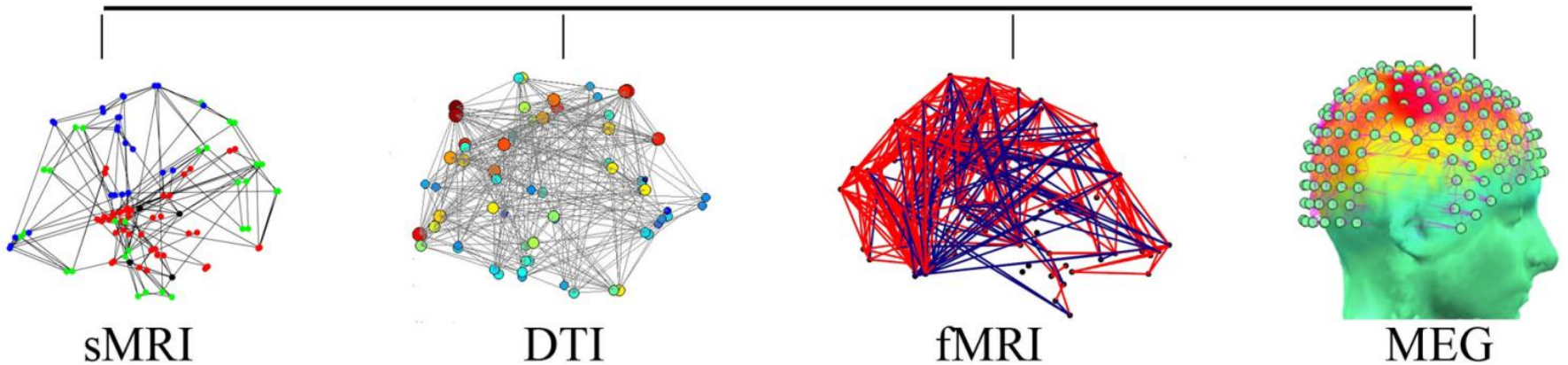## A universal representation of complex systems

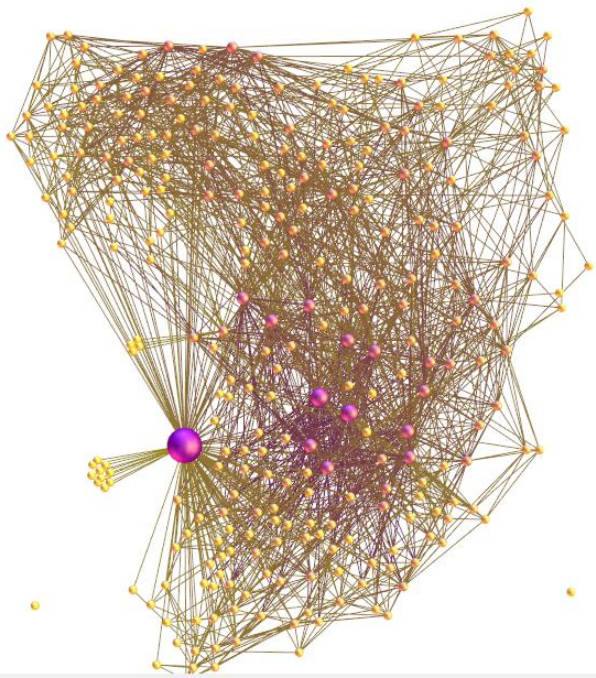fMRI network   twitter network   NYSE network

Appeal of brain networks
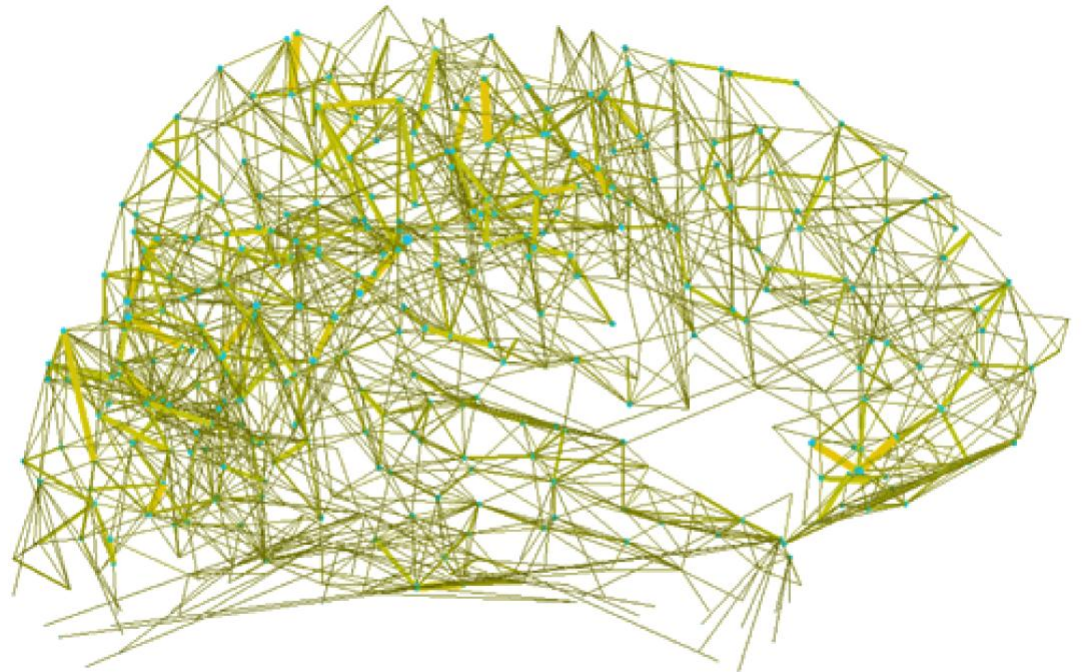
A universal representation of multimodal data

sMRI   DTI   fMRI   MEG

Appeal of brain networks

A universal representation of multiscale data

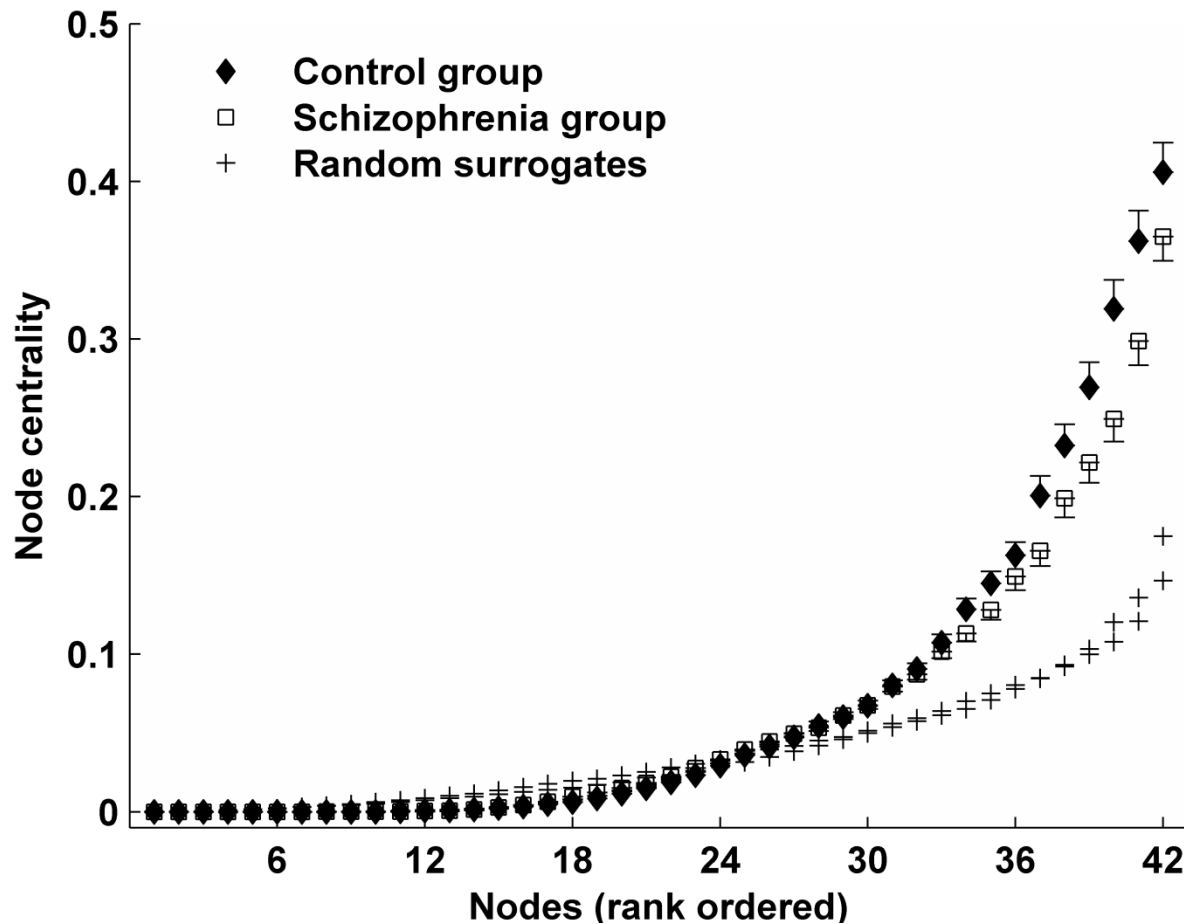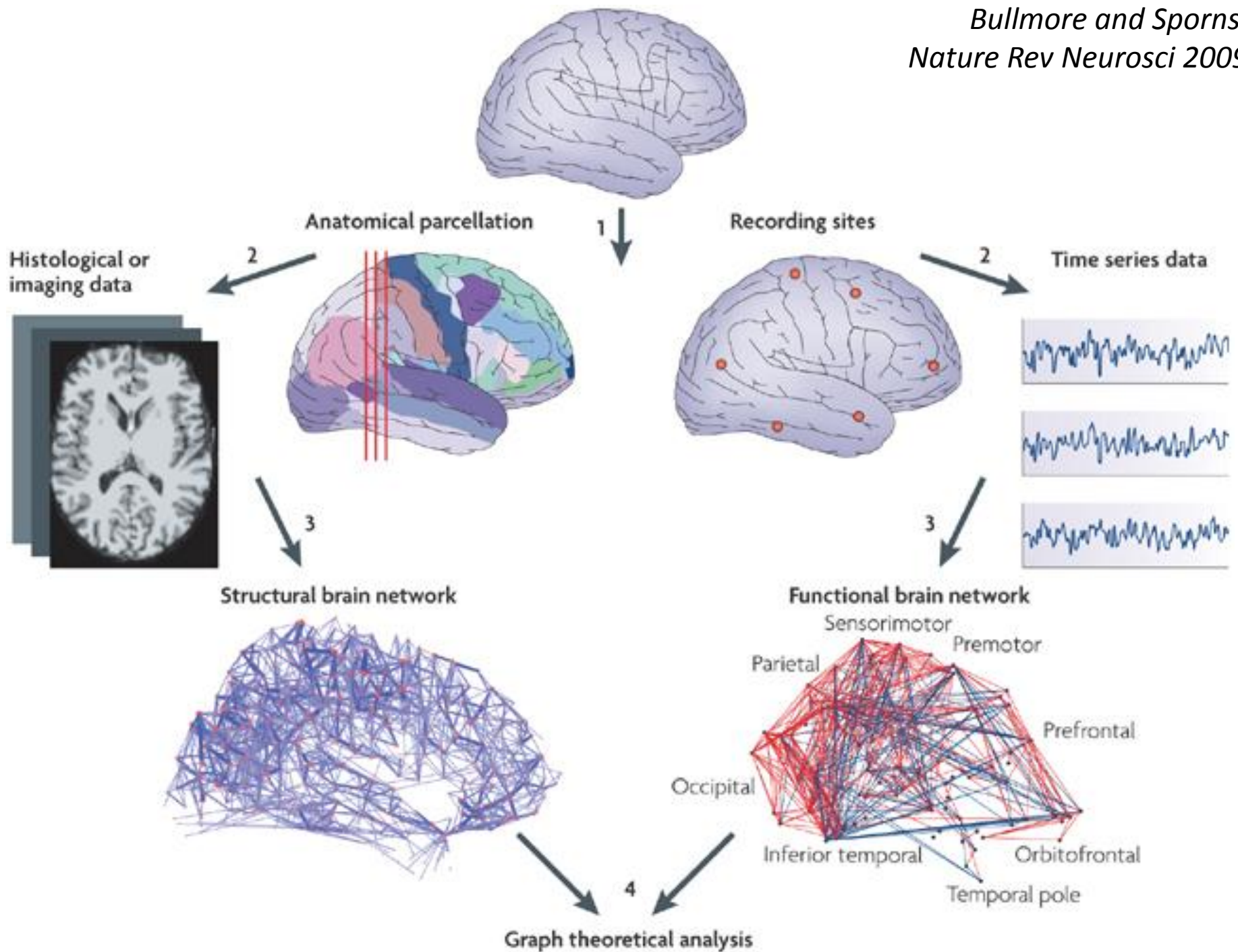*microscale (C. elegans)*   *macroscale (H. sapiens)*
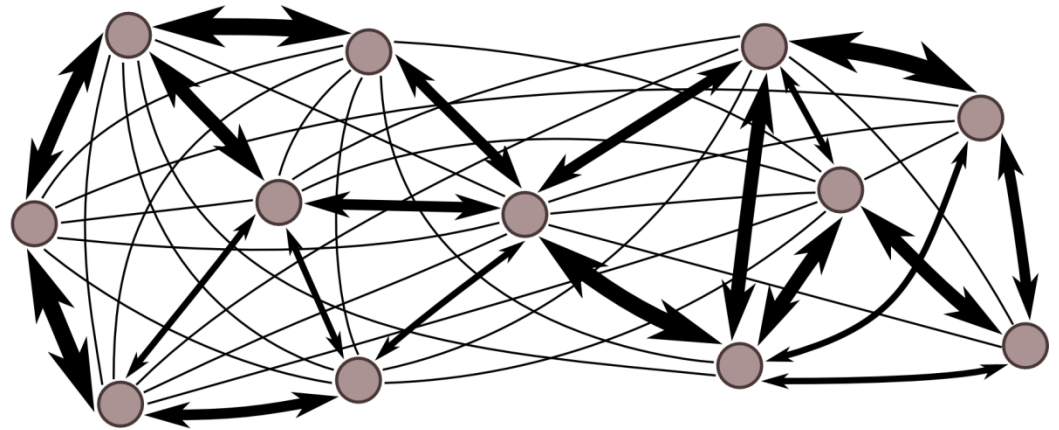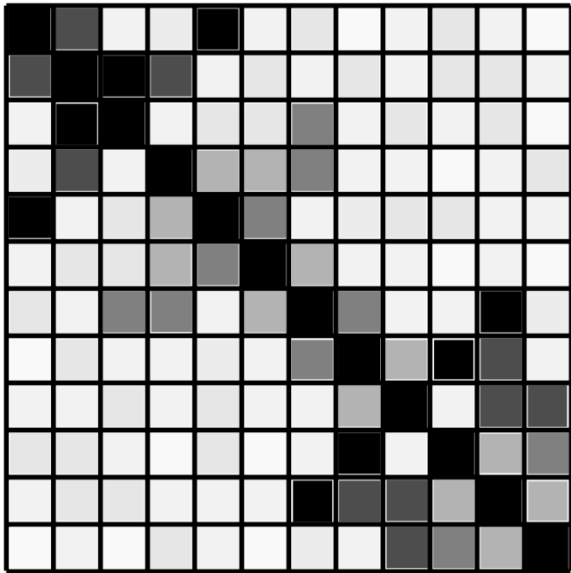
Appeals of brain networks

Potential neuropsychiatric biomarkers

Rubinov et al., Human Brain Mapp 2009

Anatomical parcellation

1

Recording sites

Histological or imaging data

2

2

Time series data

3

3

Structural brain network

Functional brain network

Sensorimotor

Premotor

Parietal

Prefrontal

Occipital

Inferior temporal
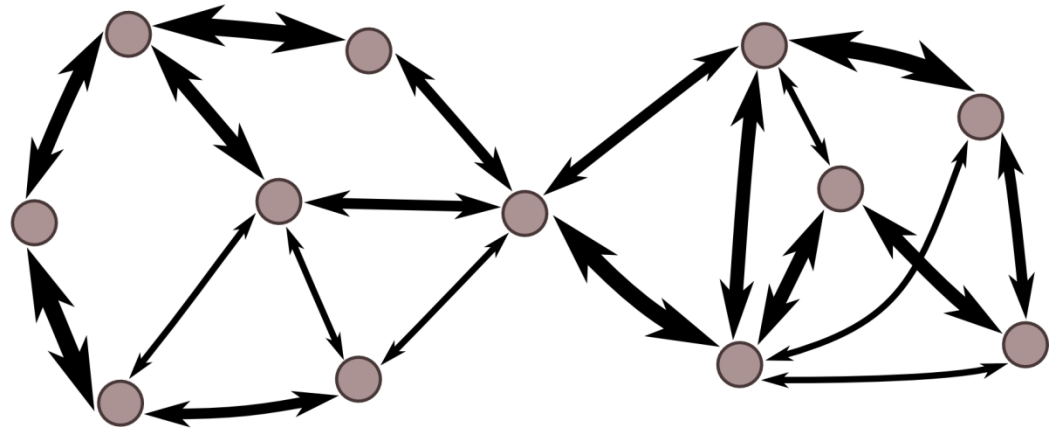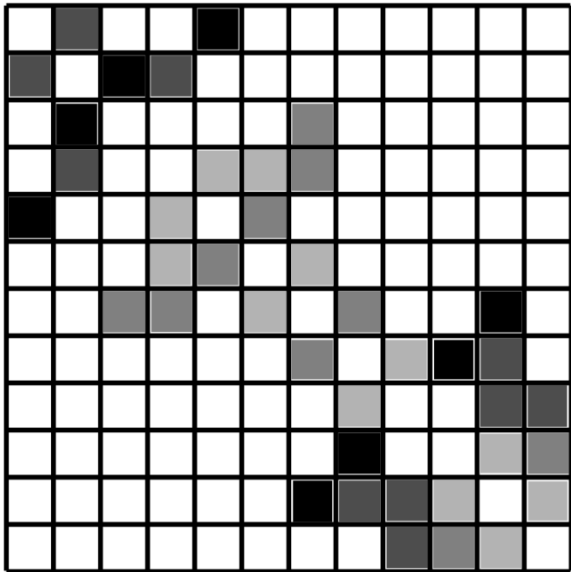
Orbitofrontal

Temporal pole

4

Graph theoretical analysis

Construction of brain networks
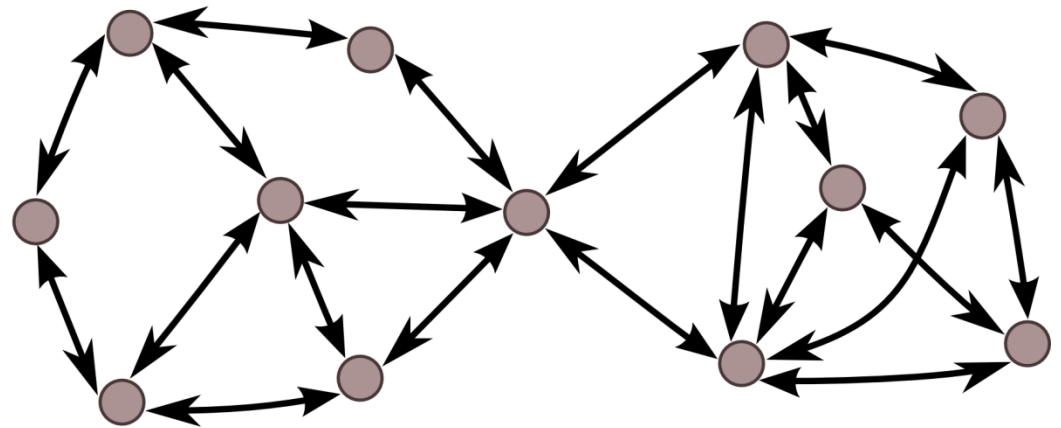
weighted undirected networks

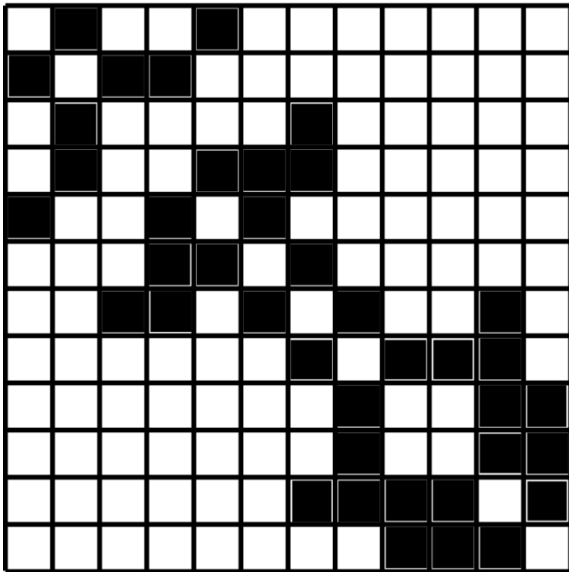# Construction of brain networks
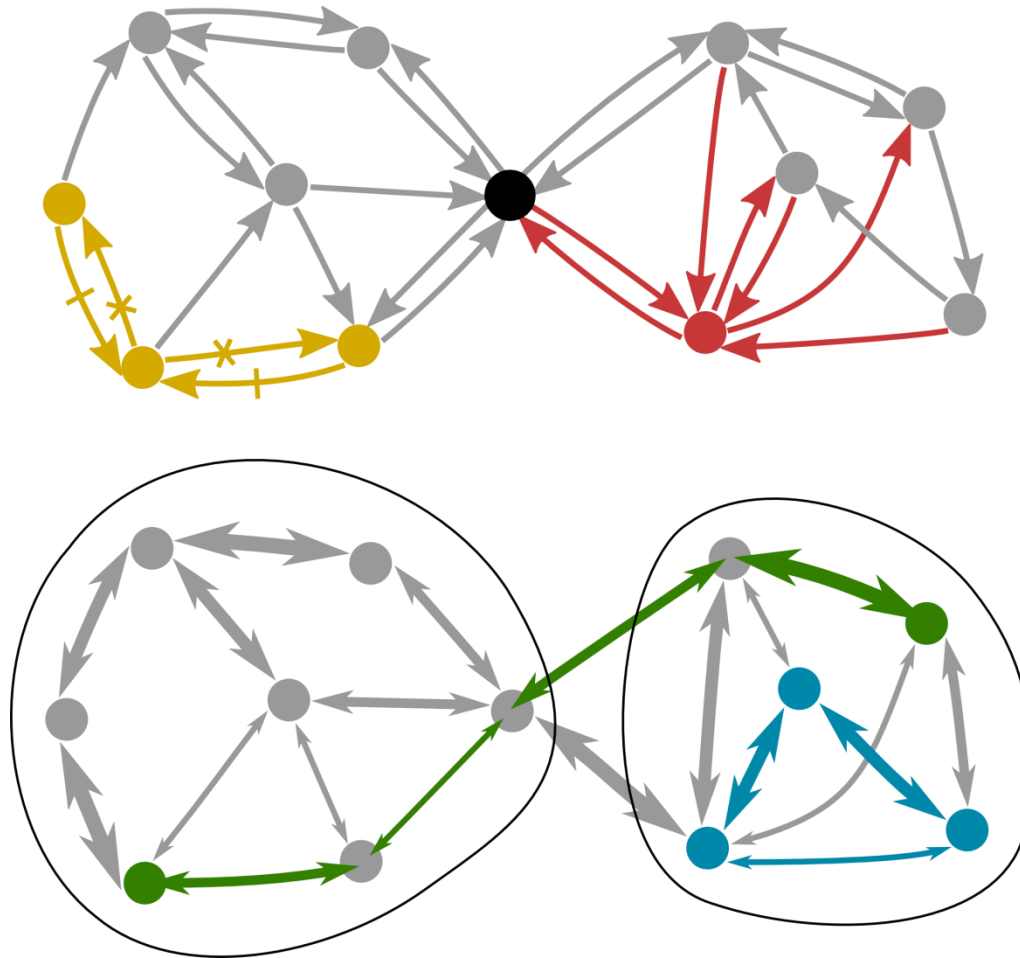
weighted undirected networks

Construction of brain networks
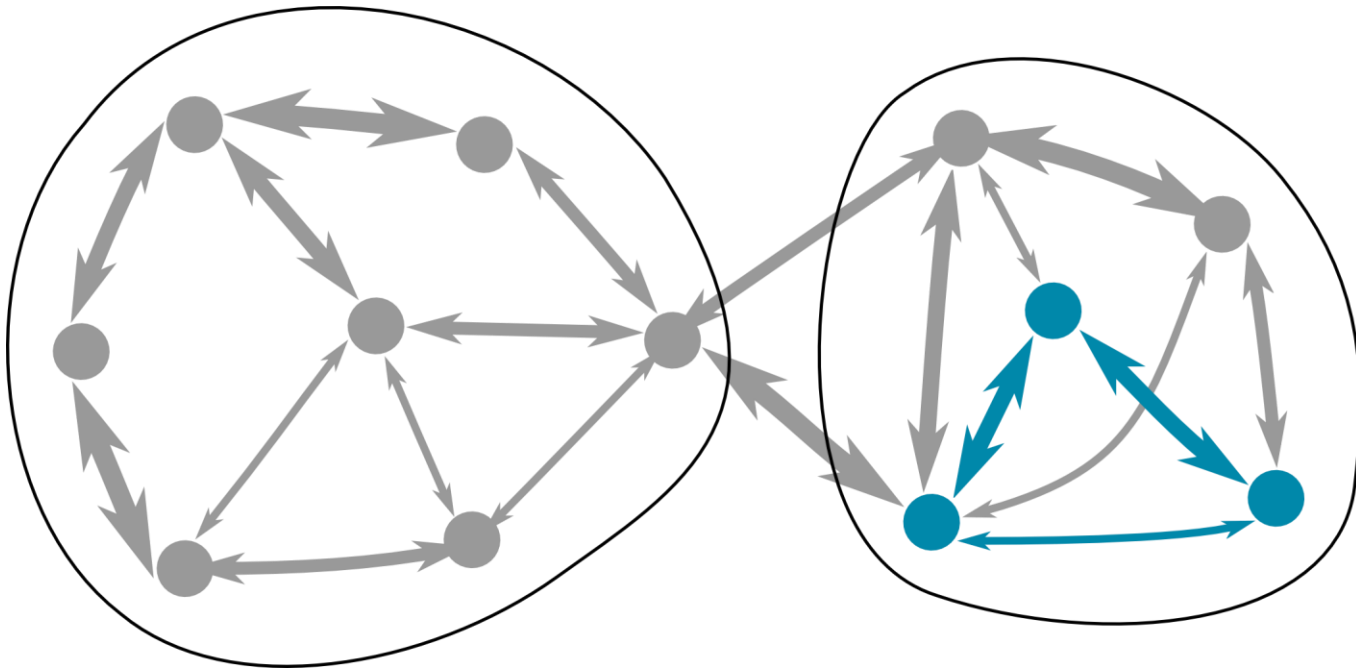

binary undirected networks
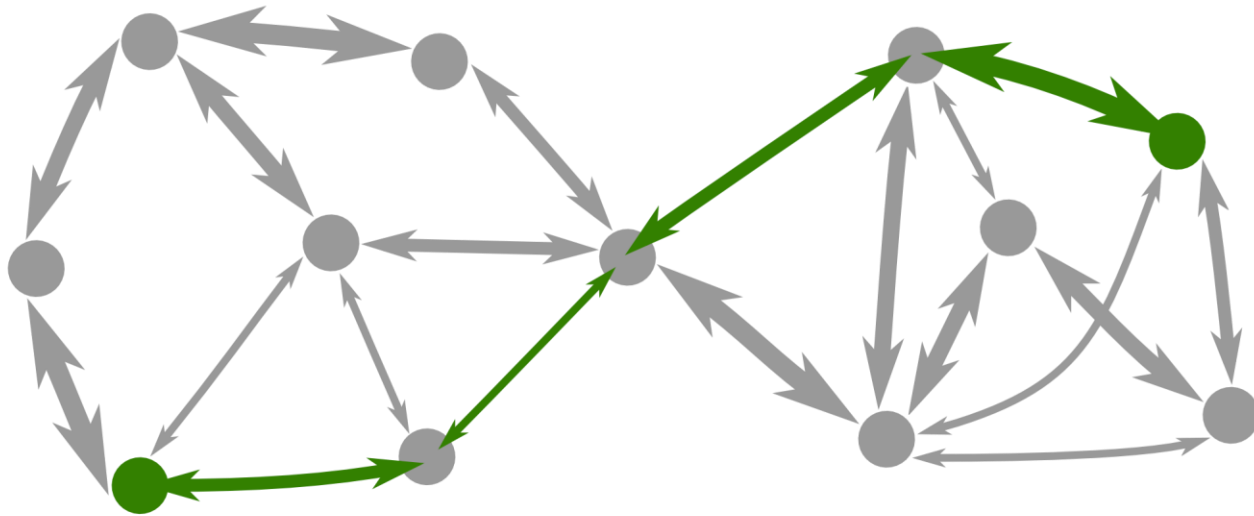
Network measures (by meaning)

Measures of segregation

- clustering coefficient
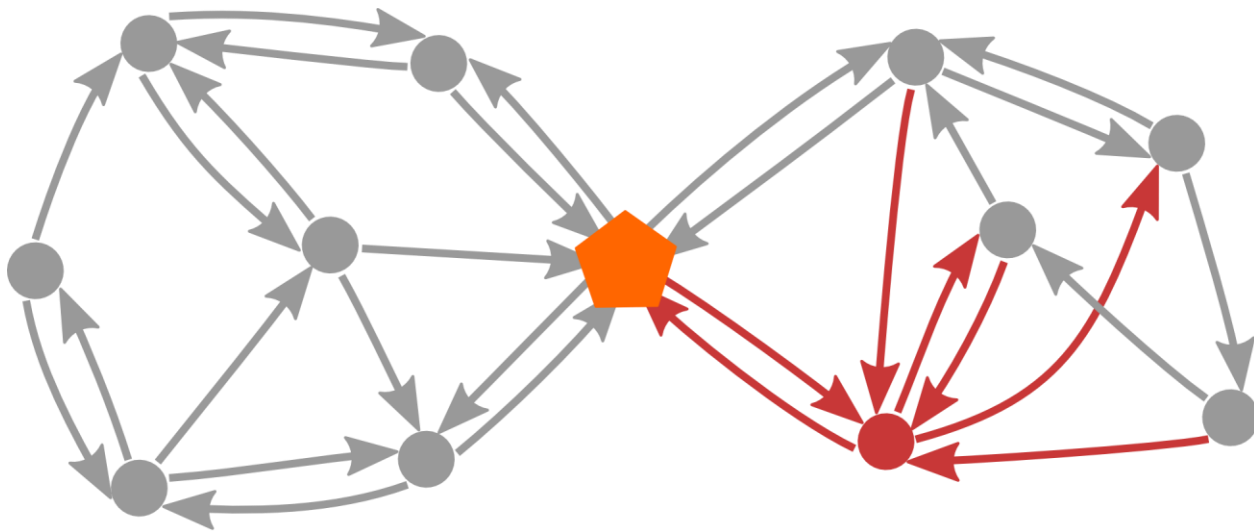- community structure and modularity

Measures of integration

- path length
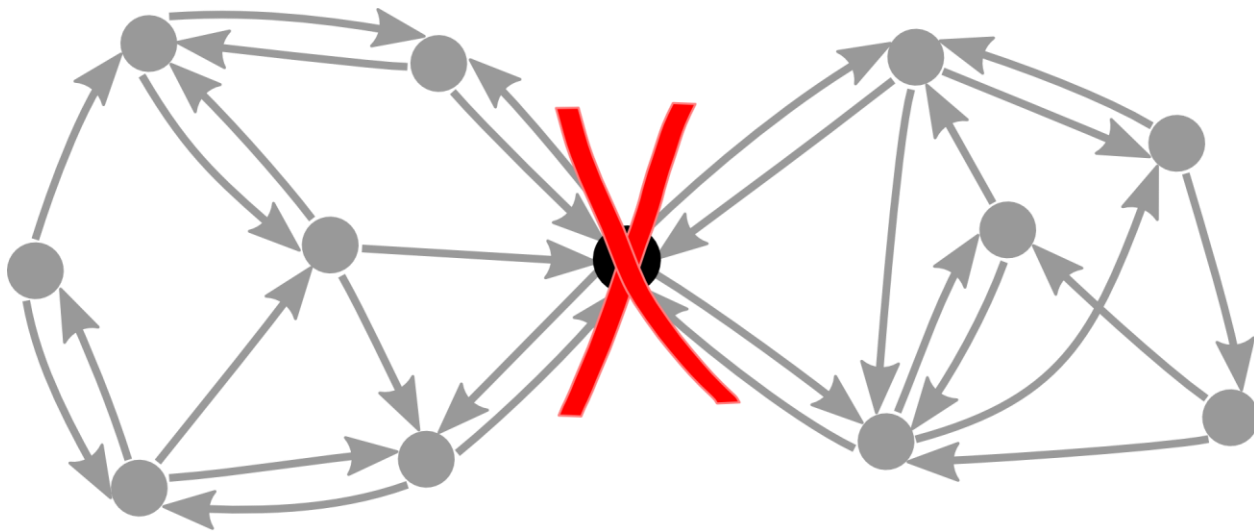- global efficiency

Measures of centrality

- degree centrality
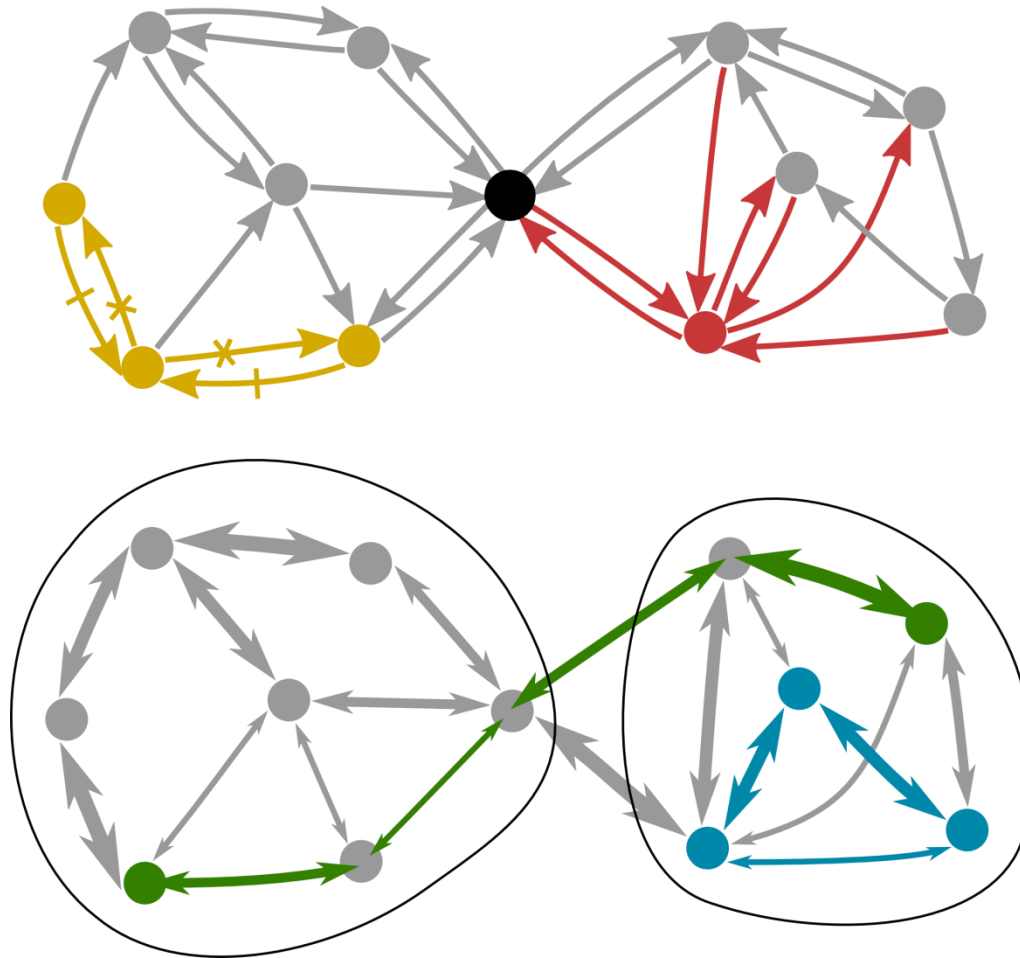- betweenness centrality

Measures of resilience

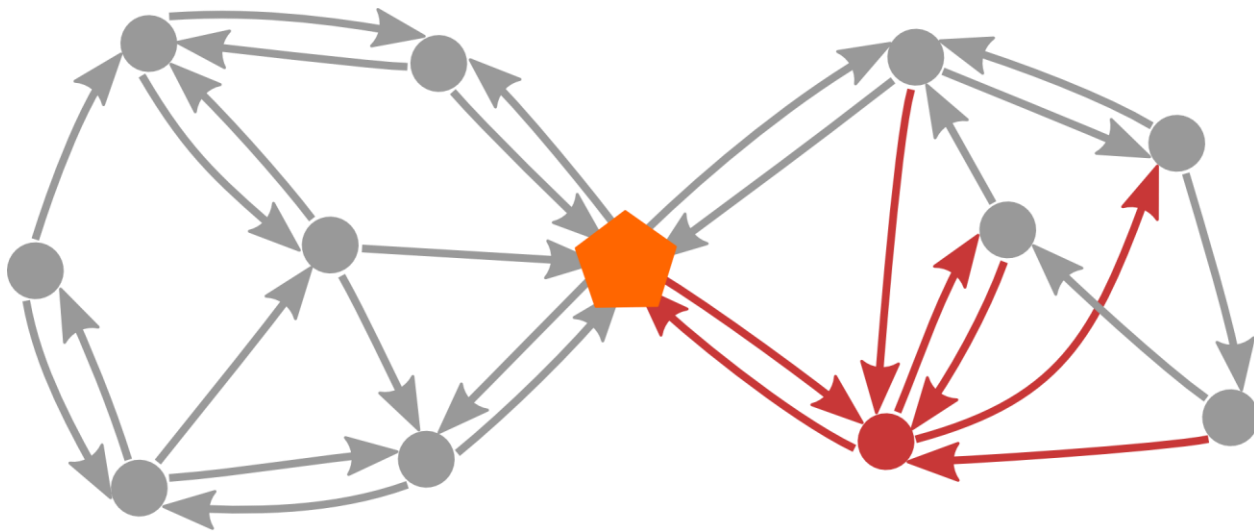- degree distribution
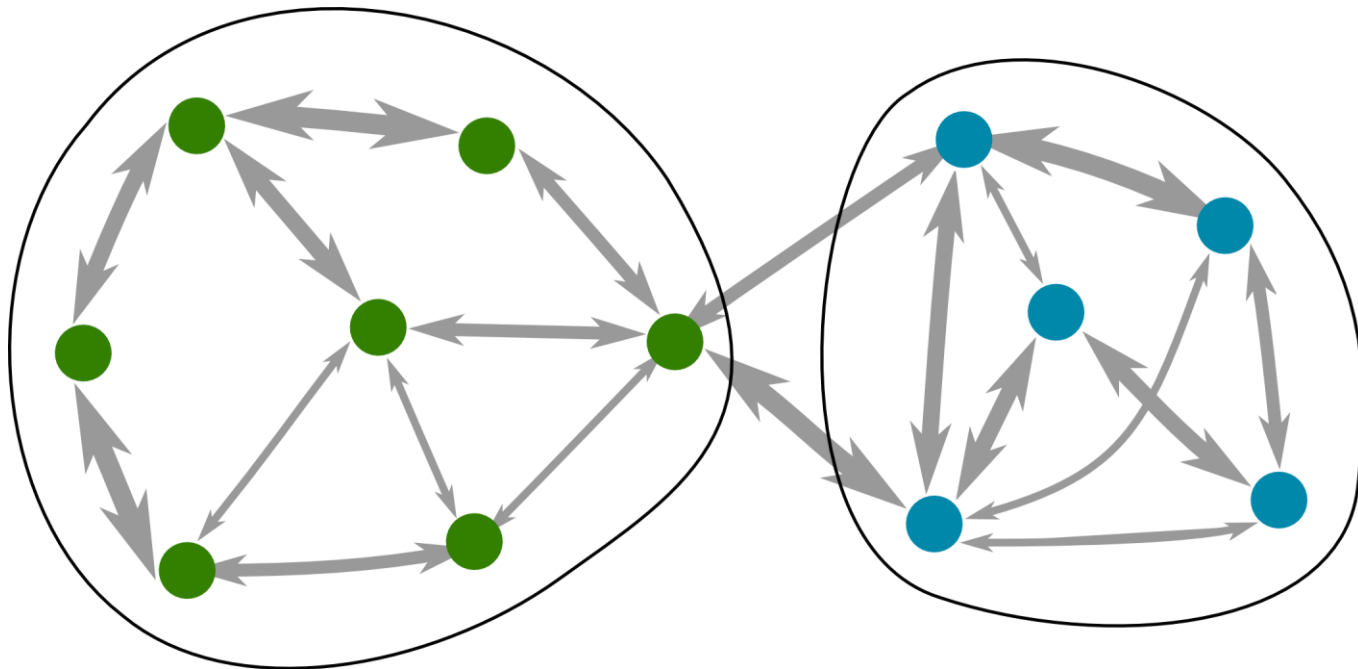- response to lesions

Network measures (by scale)

Measures of network microscale
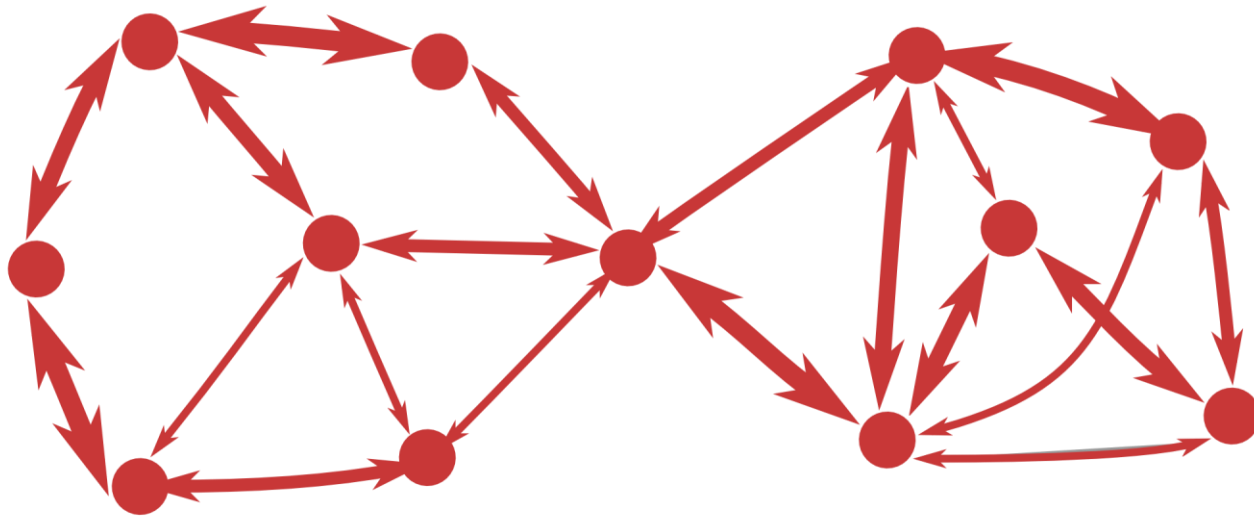
- properties of single nodes
- the centralities

Measures of network mesoscale

- properties of groups of nodes
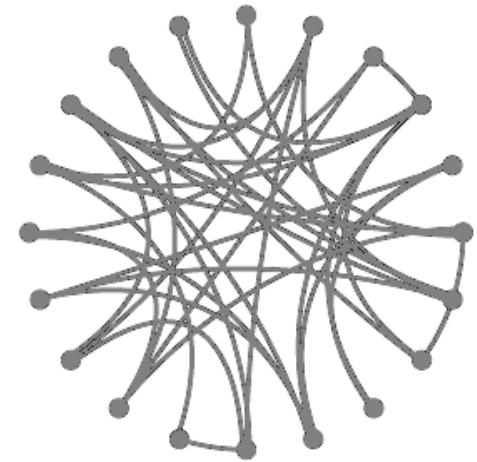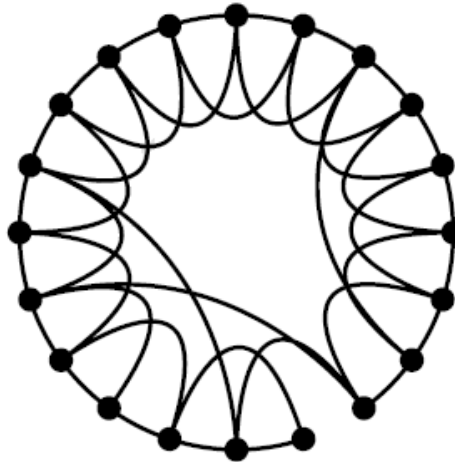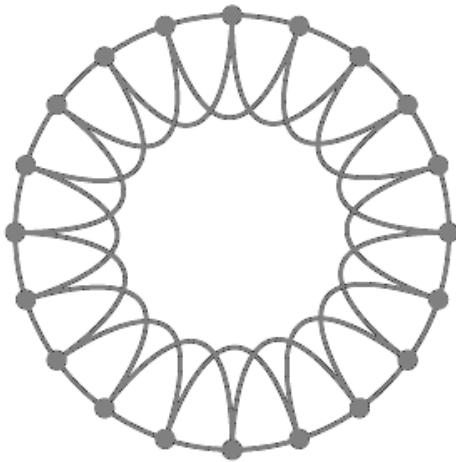- community and core-periphery structure

Measures of network macroscale

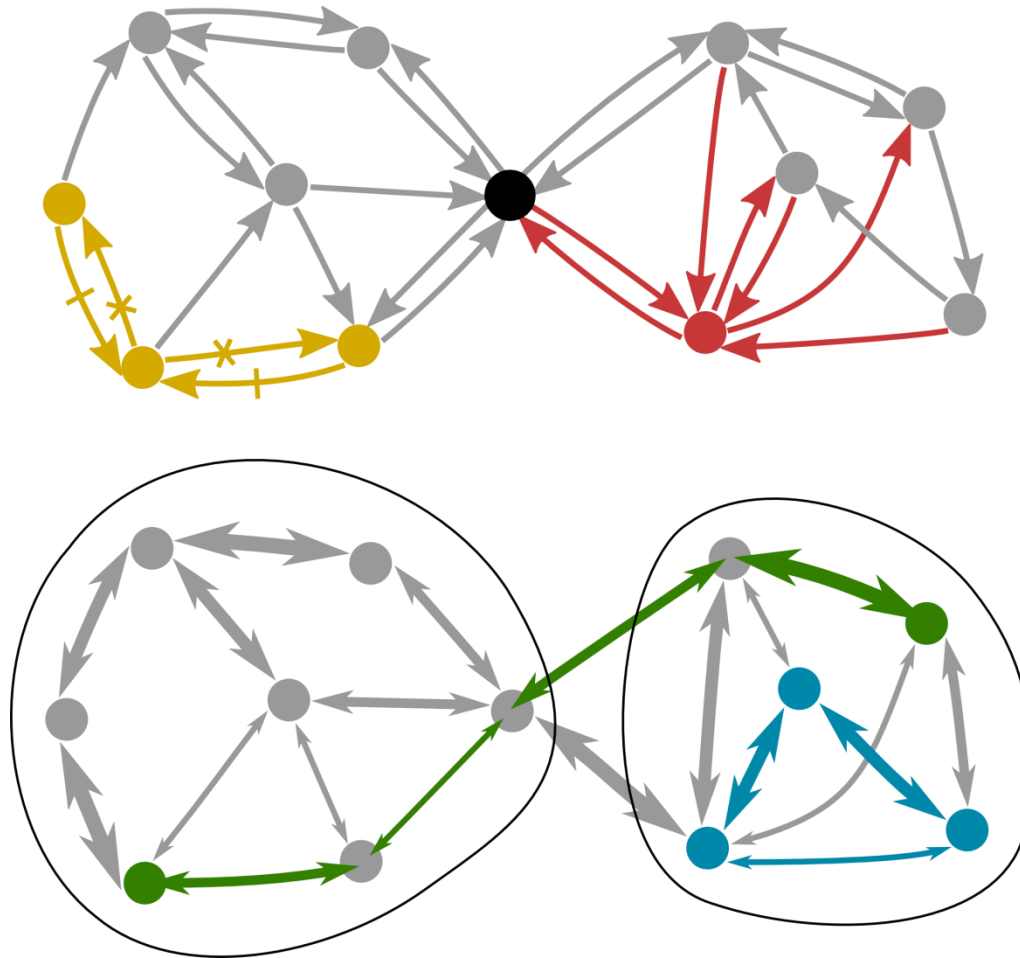- summary statistics for the whole network
- small-worldness

Reference networks
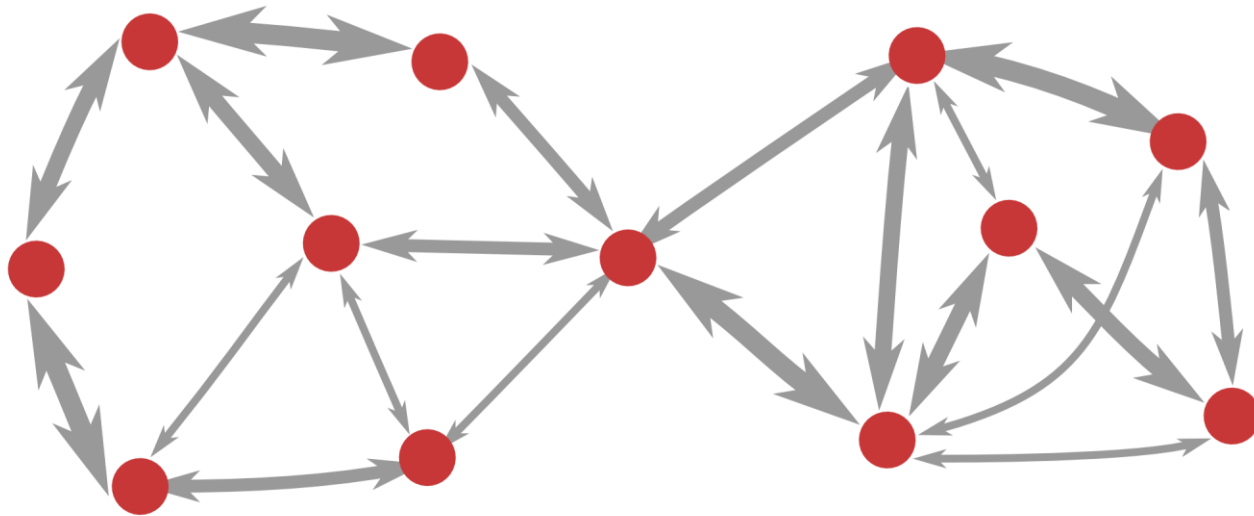
- random
- (lattice)
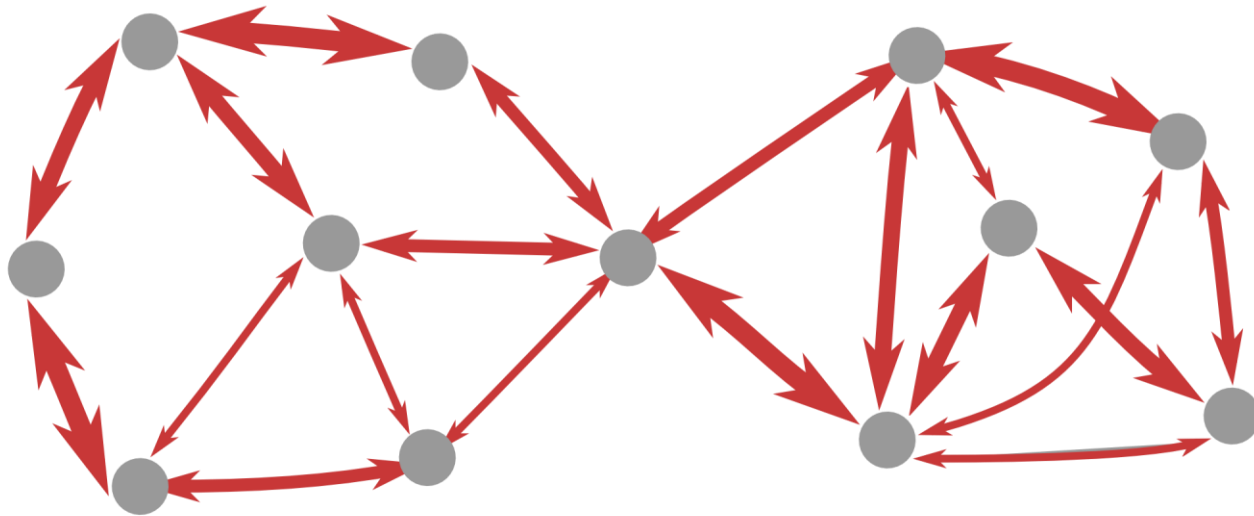- (others)

Open questions and caveats

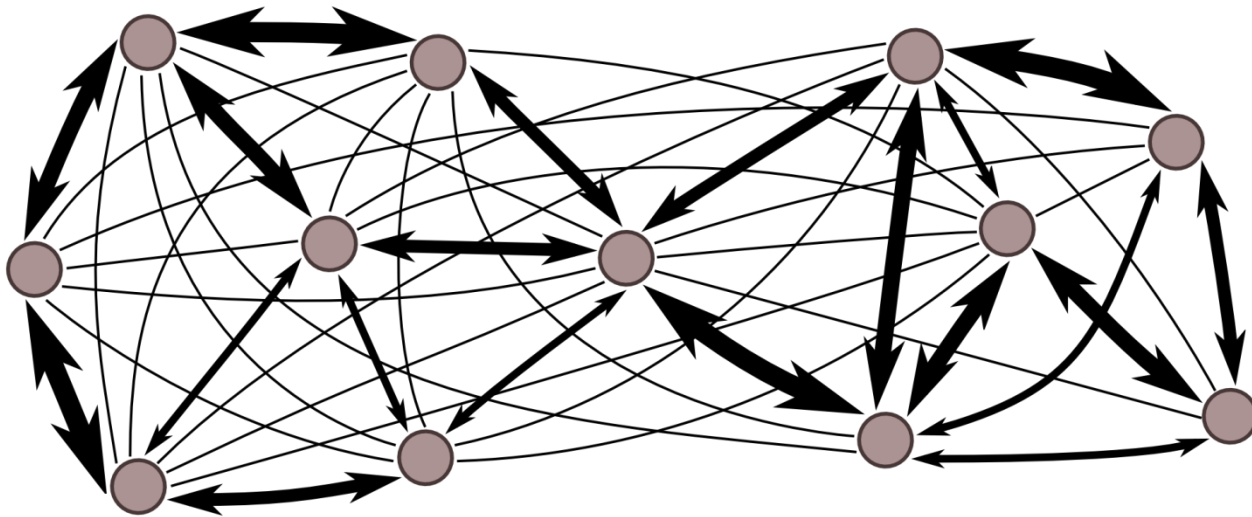# The nature of nodes

- parcellation: "coherent" regions of similar size
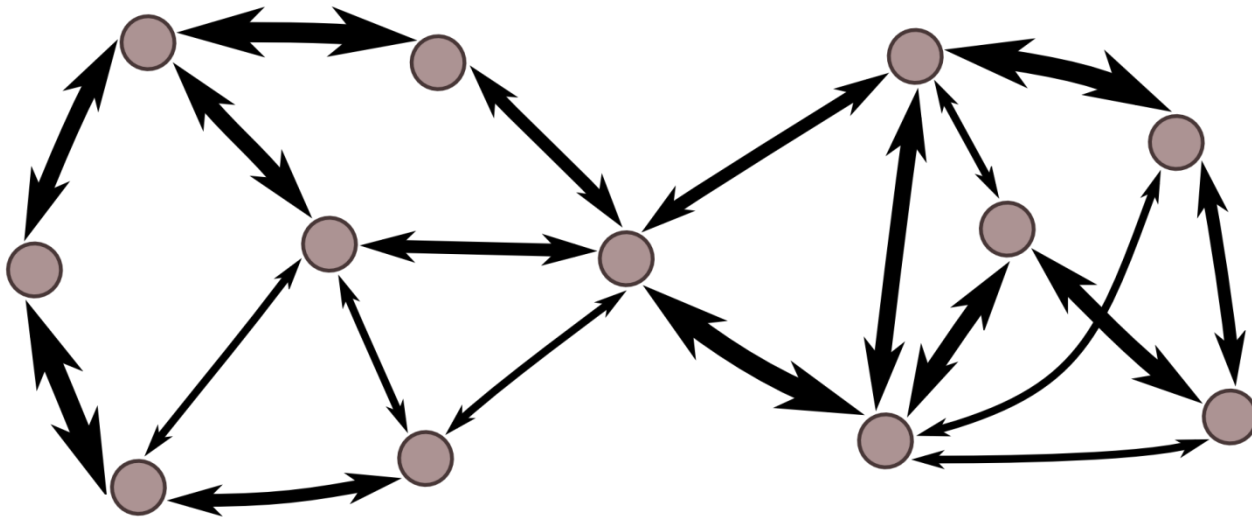
The nature of edges – 1

- connectivity and directionality

The nature of edges – 3
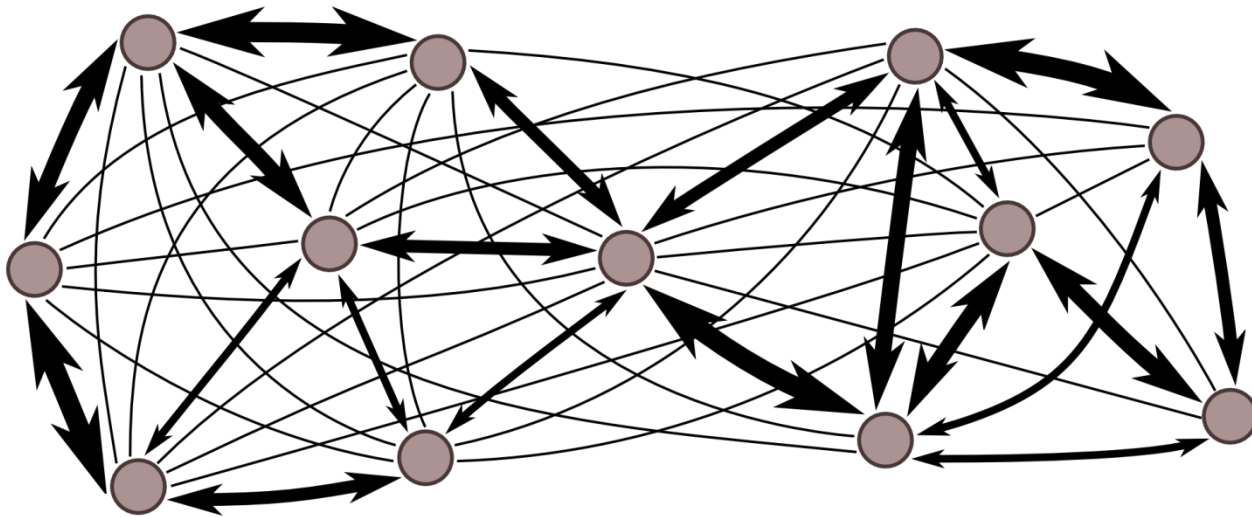
- weight magnitude and sign

- significance

Network comparison

- size and connectivity influence topology

Intrepretability

- measures are model-based and sometimes difficult to interpret

http://www.brain-connectivity-toolbox.net

Brain Connectivity Toolbox

Search Site
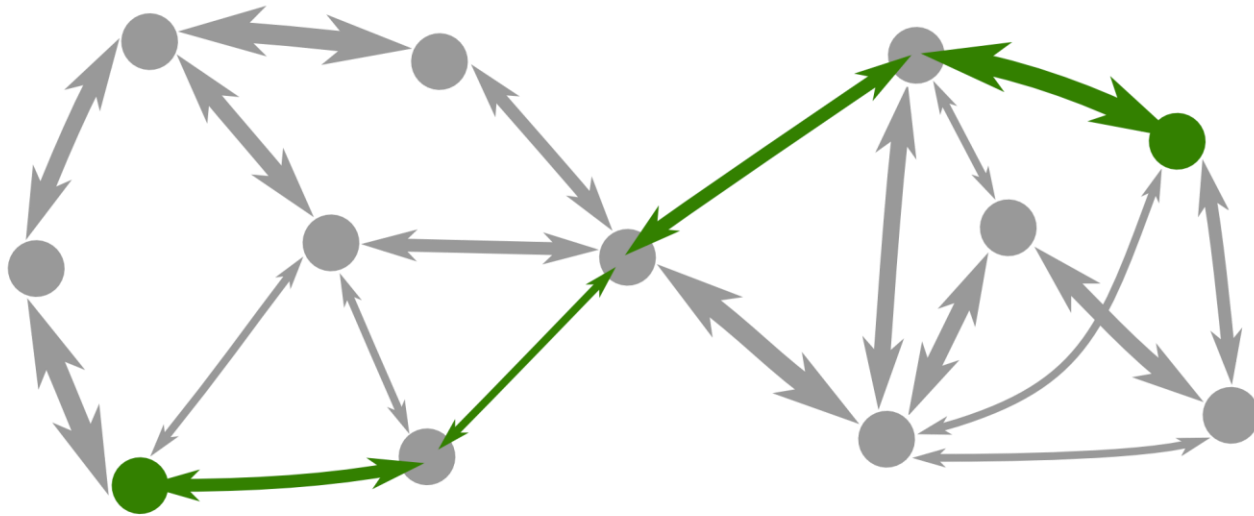
Navigation

Home

Types of Input Networks

Network Metrics

Cortical Connectivity

Data Sets

Synthetic and Reference Networks

Network Visualization

Home

This toolbox combines Matlab functions and neuroanatomical data sets useful in the analysis of structural or functional brain networks.

Toolbox overview

- Matlab-based toolbox

- complex network measures

- example cortical connectivity datasets

- control and reference networks

Further information

Mika Rubinov and Olaf Sporns.
Complex network measures of brain connectivity:
Uses and interpretations. *Neuroimage,* 2010.

Ed Bullmore and Dani Bassett.
Brain graphs: Graphical models of the human brain
connectome. *Annual Review of Clinical Psychology,*
2011.