Psychological Networks Summer School
Day 2, part 1: Network Basics

Sacha Epskamp

University of Amsterdam
Department of Psychological Methods

05-07-2016
What is a network?

- A network is a set of *nodes* connected by a set of *edges*
  - Nodes are also called vertices
  - Edges are also called links
  - Networks are also called graphs
Building blocks of a network

Different kinds of networks

Encoding a network

Constructing networks

- Node 1
- Node 2
- Edge
What is a network?

• A network is a set of *nodes* connected by a set of *edges*
  • A node represents an entity, this can be anything:
    • People
    • Cities
    • Symptoms
    • Psychological constructs
  • An edge represents some connection between two nodes. Again, this can be anything:
    • Friendship / contact
    • Distance
    • Comorbidity
    • Causality
    • Interaction
Anne is friends with Laura:
Anne is friends with Laura and Roger, but Laura is not friends with Roger:
Networks can be weighted
Anne is better friends with met Roger than Laura:
Weights can be signed
Anne is friends with Roger and Laura, but Roger and Laura don’t like each other at all!
Edge weights

- Weights can be positive or negative, and indicates the *strength* of an edge, with zero indicating no strength (identical to the absence of an edge)
  - Nodes that are connected by a strong edge can be seen as close by or easily reachable from one to the other
- Sometimes an edge has a *length* rather than a weight
  - This is a positive value indicating the distance between two nodes
  - A length of $\infty$ indicates no edge
  - A weight is often recoded to a length by taking the inverse of the absolute value of the weight
Networks can be directed

Anne likes Laura, but Laura doesn’t like Anne:
- Edges can be weighted or unweighted
  - A network with weighted edges is called a *weighted graph*
  - Otherwise it is called an *unweighted graph*
- Edges can be directed or undirected
  - If all edges are directed the network is called a *directed graph*
  - If all edges are not directed the network is called an *undirected graph*
  - Otherwise it is called a *mixed graph*
Building blocks of a network

Different kinds of networks

Encoding a network

Constructing networks
• A directed network with no cycles is called a Directed Acyclic Graph (DAG)
  • A cycle means that you can not start at a node and encounter it again by following directed edges
  • This includes no self-loops
• As we will see on day 4, DAGs are very useful in that they represent a clear dependency structure between the nodes
• But, the assumption on acyclicity is very strict and often not tenable
Building blocks of a network

Different kinds of networks

Encoding a network

Constructing networks

Cyclic

A
B
C
D

Acyclic

A
B
C
D
In mathematics, a graph $G$ is considered an ordered pair of a set $V$ of vertices (nodes) and a set $E$ edges:

$$G = \{ V, E \}$$

$$V = \{ 1, 2, 3 \}$$

$$E = \{ (1, 2), (2, 3), (3, 1) \}$$
Let $|V|$ be the number of nodes.

- An *adjacency matrix* is a square $|V| \times |V|$ matrix in which each element is 0 or 1.
  - If there is a 1 in row $i$ and column $j$ it means there is an edge from node $i$ to node $j$
  - A 0 denotes that there is no edge
  - Undirected networks are encoded with a symmetrical adjacency matrix
Adjacency matrices

\[ A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \end{bmatrix} \]
Adjacency matrices

$$A = \begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix}$$
Weights Matrices

- An *weights matrix* is identical to an adjacency matrix except it encodes the weight of the edge
  - A 0 still indicates no edge
  - Higher absolute values indicate stronger edges
  - Undirected networks are encoded with a symmetrical adjacency matrix
Weights matrices

\[ W = \begin{bmatrix}
0 & 0.5 & 0 \\
0 & 0 & 1 \\
2 & 0 & 0
\end{bmatrix} \]
Weights matrices

\[ W = \begin{bmatrix}
0 & 0.5 & 0 \\
0 & 0 & -1 \\
2 & 0 & 0
\end{bmatrix} \]
Sexual contacts

Networks can be simulated given sufficient information about a population:

Psychopathology as a virus...
Networks can be obtained from anywhere...
Building blocks of a network
Different kinds of networks
Encoding a network
Constructing networks

Netherlands:

Germany:
Some common measures to construct networks from psychological data:

- Correlations
- Partial correlations
- Regression coefficients
- log-odds ratio
- Ising parameters
- Lag-1 correlations
- Auto-regression parameters
Thank you for your attention!