



# Networks in Psychology/Linguistics/Education

CSE 5339: Topics in Network Data Analysis

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# Associationism

*“Some of our ideas have a natural correspondence and connection with one another: it is the office of excellency of our reason to trace these...” –John Locke*

- This theory considers the connections between experiences as a model for human cognition.
- There is debate over the founder of this theory:
  - Some claim it comes from Plato, and is found in the works of Aristotle (Boeree, 2000).
  - Others give credit to philosopher John Locke in his second book of “An Essay Concerning Human Understanding” (Warren, 1921).
- These models are limited to linear progressions which are represented by path graphs (Elman, 1996).

Definition: A *path graph* with vertices listed in the order  $v_1, v_2, \dots, v_n$ , only has edges  $\{v_i, v_{i+1}\}$  where  $i = 1, 2, \dots, n - 1$ .

# Four Laws of Association

Aristotle considered the following four laws related to associations (Boeree, 2000):

- **1. The law of contiguity.** Things or events that occur close to each other in space or time tend to get linked together in the mind.  

For example, if you think of a cup, you may think of a saucer; if you think of making coffee, you may then think of drinking that coffee.
- **2. The law of frequency.** The more often two things or events are linked, the more powerful will be that association.  

For example, if you have an éclair with your coffee every day, and have done so for the last twenty years, the association will be strong indeed -- and you will be fat.
- **3. The law of similarity.** If two things are similar, the thought of one will tend to trigger the thought of the other.  

For example, if you think of one twin, it is hard not to think of the other. If you recollect one birthday, you may find yourself thinking about others as well.
- **4. The law of contrast.** On the other hand, seeing or recalling something may also trigger the recollection of something completely opposite.  

For example, if you think of the tallest person you know, you may suddenly recall the shortest one as well. If you are thinking about birthdays, the one that was totally different from all the rest is quite likely to come up.

# Connectionism

*“The multi-layer nets connectionists use are nonlinear dynamical systems, and nonlinear systems can learn relationships of considerable complexity.” (Elman, 1996).*

- This theory is initially credited to psychologist Donald Hebb (Elman, 1996). He is well known in computational neuroscience for the Hebbian Learning Rule.
- It considers more complex connections for models for human cognition when compared to Associationism.
- Many Connectionists consider biological plausibility when creating models.
- Neural networks are a common tool used by Connectionists.

# Opposition

Assumptions are made for the Connectionist theory. They do not completely agree with the following two theories:

- Theory of Nativism/Innatism: These theories consider the possibility of preexisting cognitive functions not developed by the association of experiences.
  - This argument is similar to that of nature vs. nurture (Pinker, 2002).
  
- Theory of Systematicity: This theory is difficult to explain, see (Cummins, 1996; or Pullum & Scholz, 2007)

# Networks in Linguistics

- Sociolinguistics — Social Networks
- Natural Language Processing
- Mental Lexicon Networks

# Sociolinguistics

- This subfield of linguistics broadly considers the following ([Editorial], 1997):
  - Socially grounded research into linguistic varieties;
  - textual and discourse processes; and
  - linguistic and other communicative aspects of social life.
  
- There is thought to be overlap with linguistic anthropology (Gumperz & Cook-Gumperz, 2008).
  
- The use of social networks has played an important role in the development of graph theory.

# Social Networks (Theory)

- As an early example of introducing graph theory to the study of social networks, and vice versa, Cartwright and Harary (1956), describe a process for creating networks:
  - Considers balances necessary to describe relations (edges) in social networks, referred to as Heider's Conception of Balance theory.
  - It uses P-O-X units (i.e. person, another person, and impersonal entity). With relational units L and U for attitudes and cognitive unit formation, respectively.
    - e.g. (a) **PLO** reads "P likes, loves, values, or approves of O..."
    - (b) **P~LO** reads "P dislikes, negatively values, or disapproves of O."
    - (c) **PUX** reads "P owns, made, is close to, or is associated with X..."
  - Remark: Of Aristotle's Four Laws of Association, these rules seem to neglect frequencies.
- The combination of negative relations ( $\sim L$ ) and unsymmetric relations, requires the use of *signed digraphs*, (Cartwright & Harary, 1956).
- When considering two relationships on persons (**L** and **U**), we have *graphs of type 2*, (Harary & Norman, 1953).
- Additionally, they define the *degree of balance of an s-digraph*.

Definition: A *directed graph (digraph)* is a graph in which the edges are ordered pairs.

Definition: A *signed digraph (s-digraph)* is a digraph in which every edge is weighted as positive or negative.

Definition: A *graph of type r* is a graph in which the edges can be assigned any one distinct color from the option of r different colors.

# Social Networks (Application 1)

- Daniel Nettle (1999) uses social networks to explore the evolution of language:
  - Uses Social Impact Theory (i.e. ones beliefs, attributes, or behavior is influenced by those around them).
  - Considers two variants, p and q, of the same grammatical item.
  - Of 400 individuals, each learn either p or q. These are based on particular rules (Nowak, Szamrej, & Latané, 1990).
  - Updates the network, based on the previously cited rules.
  - From simulations, he concludes that some speaking persons (nodes) are more influential on the evolution of the networks, even when they do not share the majority grammatical variation.

Remark: For a more detailed compilation of research/methods involving networks of language change before 2005, see Marshall (2004).

# Social Networks (Application 2)

- The conference paper by Fagyal et al., (2010), is a more modern approach to Nettle's research:
  - Considers social influence as asymmetric, and so the networks use directed edges.
  - Network formation considers the work of Barabási and Albert (1999):
    - Social networks have small diameter;
    - they have high clustering; and
    - they evolve with a scale-free degree distribution.
- Concludes there is a biased adoption of grammatical variants from individuals who are more "popular," and these persons must be aware of their hierarchy status.
- Additionally, they describe the necessity of peripheral members (i.e. those who are less "popular") as necessary to regulate the diffusion dynamics within the population.

# Natural Language Processing

- This is a subfield of computational linguistics.
- It incorporates the use of artificial intelligence algorithms which are also used by neural networks.
- Some of the many applications include the following:
  - Machine translation;
  - Natural language understanding;
  - Natural language generation;
  - Optical character recognition; and
  - Speech recognition.

Remark: This research is very similar to that of neural networks, and I will leave this topic for a later discussion. For more information, read *Handbook of Natural Language Processing* (Dale, Moisl, & Somers, 2000).

# Mental Lexicon

- See (Collins & Quillian, 1969; or Dyne & Storms, 2008).

# Networks in Education

- See (Miller & Gildea, 1987).
- Investigate models by Kintsch.
- Investigate more works by Thorndike.

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# Questions and Comments