

Social Networks

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Social network analysis (SNA) provides a direct means for examining the structural foundations of society. A social network is a collection of relationships – referred to as “edges” – connecting individuals, or aggregations of individuals (e.g., schools or businesses) – known as “nodes.” Analyzing social networks allows researchers to shift their focus from nodes and their characteristics to the spaces between them. SNA analysts examine the presence or absence of edges within the spaces between nodes, and systematically analyze the patterning of those relationships within a studied population. SNA can include a variety of node types, including people, computers, places, organizations, etc.; and focus on edges including friendship, trade, sex, shared memberships, conversations, etc. SNA draws on this variety of node and edge types to derive theories and methods that are equally applicable to all potential nodes and edges.

A Brief History

Historically, social network analysis draws its roots from a range of academic disciplines – with mathematics, anthropology and sociology playing especially important roles. Early research in 1920s and 1930s education research and observational developmental psychology began building the language of “sociometry” to describe formal properties of social organization within small groups (Moreno 1934). Later anthropologists – along with others studying kinship in the 1940s and 1950s – dominated networks research with an aim to provide general models of the patterned relationships in kinship structures across a wide range of societies (White 1963).

The 1970s saw a rapid increase in studies incorporating network ideas, shaped in large part by Harrison White and his students. Among the foundational pieces from this period was one of the most readily cited sociological findings – the “strength of weak ties” which demonstrated that, people are more likely to benefit in job searches from their acquaintances than from their closer relationships. Granovetter (1973) argued the mechanism for this finding is based on strong personal relationships likelihood of high redundancy. He shows that weak social ties are much less likely to overlap, therefore branching out into wider ranges of the population, and are thus more productive for seeking novel information.

Simultaneous and subsequent developments in network studies also arose in fields such as developmental psychology, education, communications, business, and most recently – physics and biology (Freeman 2004). The past few decades have seen rapid growth in the volume of network studies produced and the range of topics they address – including: the diffusion of innovations, the spread of infectious diseases, friendship and

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discussion networks, modes of social influence, interlocking boards of directors, and the evolution of academic disciplines. The formation of the *International Network for Social Network Analysis* and founding of the *Social Networks* journal helped consolidate these disparate scholars and range of topics into a relatively cohesive field (Wellman 2000). Freeman (2004) provides an illuminating historical social network analysis of the development of the SNA field.

A New Paradigm?

Social science is driven primarily by only a few prevailing orientations to research – known as paradigms. Paradigms provide the frameworks within which scientists can produce individually testable theoretical propositions – referred to as hypotheses. Further, a paradigm also generally lays the ground rules for the criteria to evaluate those hypotheses – inferring particular methodological approaches. Network scholars have generated numerous theories that have been readily incorporated into existing models of social science – such as the importance of social capital. Others have suggested that SNA provides only a new methodological tool kit for evaluating the variety of existing social theories. These new methods are important because, while many social theories are fundamentally relational in nature, current methodological approaches focus almost exclusively on individual, independent, unconnected nodes.

However, Wellman and Berkowitz, among others, have consistently argued that SNA provides more than simply new theories and methods. Instead, they contend that the fundamental shift of researchers' focus from nodes to edges lays the foundations for a new research paradigm (Wellman and Berkowitz 1988). Freeman agrees with this notion of networks as a new paradigm for social research, which he outlines as being demarcated by its: (a) focus on the structural properties of patterned links between actors, (b) empirical derivation of those patterns; (c) dependence on the graphical representation of those relationships – both intuitively and illustratively; and (d) use of complex mathematical/computational analytic methods (Freeman 2004).

Gathering Network Data

To incorporate network ideas into traditional research methods, surveys of individuals can gather information about portions of their respondents' networks, simply treating this "local network data" as they would any other individual characteristic. Local network studies generally collect information about the focal individual – known as an "ego" – and their ties, such as the number and types of relationships they have, descriptions of the others – known as "alters" – with whom they have those relationships, and possibly details about the existing relationships between those alters.

Researchers interested in analyzing connections that extend beyond an initially sampled population typically expand their efforts in one of two ways. "Partial network data" not only collects information from index respondents about their alters, but also subsequently recruits those alters into the study and asks about their relationships – a process which can be repeated as many or few times as desired. Alternately, "complete network data" defines the boundaries of the population to be studied, then enumerates and describes all of the relationships within that entire population.

These three data collection strategies require vastly different techniques and amount of resources to gather (Morris 2004). They each also produce substantially

different types of data, which provide different options from the varied analytic strategies described below. The aims of the research can help the investigators consider these important tradeoffs.

Analyzing Social Networks

The techniques available for SNA are numerous, but can be classified roughly into measures that focus on node and edge composition, those that describe node position, and those that describe properties of the full network. Several handbooks detail the numerous strategies and the particular individual metrics available for SNA (Carrington, Scott, and Wasserman 2005; Wasserman and Faust 1994).

The first set of measures available provide a means for describing the relations between an ego and its alters. These measures capture properties that describe the composition and distribution of the nodes and edges in this bounded set. One such example calculates the density of ties, which compares the number of ties observed to the number possible. These composition measures can be calculated for local, partial and complete network data, but the additional measures described below cannot be calculated for local network data.

When examining partial or complete networks, there are measures for describing both the position of an individual node in the network and characteristics of the entire network. Individual positional measures describe how a particular node is connected to all of the others. Centrality is a common class of measures capturing a node's position – which conceptually measures the node's comparative importance in a network. One conceptualization of centrality is based on how many edges a node has. Also, the edges in a network can be thought of as pipes through which a “bit” can pass – such as an idea, money, or a disease. With this in mind, other variants of centrality determine the likelihood of a particular node being able to pass that “bit” to other members of the network, or the probability of a “bit” reaching that node (e.g., transmitting or contracting a disease, respectively). A key insight in network studies is that many individual position measures are not directly related to each other – even within a single class of measures like centrality (i.e., having many friends is not the same as having the “right” friends) (Freeman 1979).

Additionally, there are measures focused on describing the patterns of connectivity in an entire network. One example of this type – cohesion – describes methods for identifying subgroups in a network that are more readily connected to each other than to the rest of the nodes in the network.

There are also measures that focus on local composition patterns that are known to impact potential full network connectivity patterns. One of the most common of this type – known as transitivity – takes advantage of the insight that a friend (k) of a friend (j) is likely a friend (of ego – i), and calculates the proportion of observed edges for all possible node-pairs ($i-k$) in an entire network, given the existence of two edges that share a node ($i-j$ and $j-k$) (Holland and Leinhardt 1972).

Virtually all of the measures described here can be calculated separately for undirected edges (e.g., had a conversation) and directed edges (e.g., gave money to) – and many vary depending on whether analyzed as directed or not.

Network Visualization

Network data can be visualized both for purely to illustrate the patterns found in the data, or can be used as a means to assist in the discovery of those patterns. These visualizations typically use dots to depict nodes and lines connecting those dots to illustrate edges. Early network scholars manually produced visualizations; however, computer routines for producing these representations have become increasingly automated, and are even being developed for displaying dynamic networks (Bender-DeMoll and McFarland 2006). Network visualization techniques employ layout algorithms meant to suppress non-informative patterns, while drawing attention to the meaningful. As an example, Figure 1 displays the friendship network of a single high school (Moody 2005). Nodes are colored according to grade, and edges represent a friendship between two nodes. This image conveys that middle-schoolers (7th and 8th grade, red and blue respectively) are highly clustered (i.e., much more likely to have *within-* than *across-* grade friendships). This can be seen since there are substantially more edges within the left part of the figure (*among* 7th and 8th graders) than edges that bridge them to the right part of the figure (9th-12th graders).

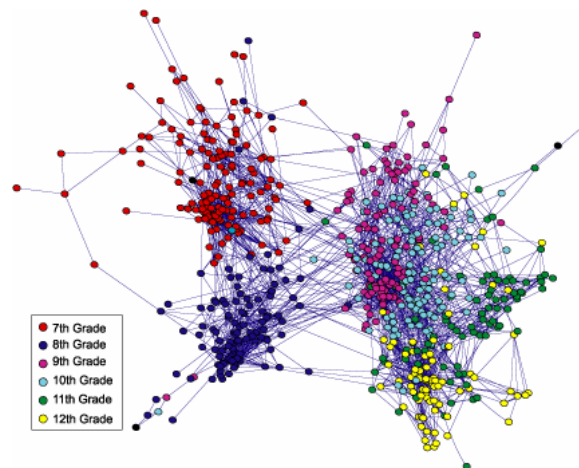


Image Source: <http://www.soc.duke.edu/~jmoody77/presentations/freemantalk1.ppt>

Networks and Life Course Research

Many of the insights available via SNA have been slow to influence research not explicitly focused on developing network methods. This is largely because population-based studies common in social science use strategies to identify samples, which rarely are able to connect study participants to one another with any relationship information gathered. This limits analytic possibilities only to those developed for “local network data”. To overcome this limitation, institutional settings have been particularly attractive for network data collection – disproportionately including young persons (e.g., in schools) and the elderly (e.g., in nursing homes or medical facilities). Further, because network data is often more intensive to gather, network data spanning long periods of extended observation are rare. Because of these limitations, existing work incorporating SNA into life course research typically focuses on networks immediately surrounding specific life course events, rather than network trajectories over time.

In adolescence, existing studies focus on key transitions and turning points that presumptively shape later life trajectories. For example, one substantial area of literature

examines the important roles social networks play in teens' uptake and frequency of substance use. Network studies have confirmed that peer friendships substantially influence individuals' decisions to begin smoking and using other substances. Perhaps more important for later health outcomes is the finding that those who do smoke, drink or do drugs are more likely to subsequently choose friends who share those behaviors than ones who do not (Kirke 2004). As a result, once started, teens are then more likely to spend time with other teens who also use, thus decreasing their likelihood of quitting.

Sexual debut and subsequent sexual activity is another key transition that generally takes place in adolescence and has been linked to a variety of later life outcomes. Therefore, many studies have examined the role teens' social networks play in determining the timing of sexual debut, and in regulating who can become potential sexual partners. On the latter point for example, one study demonstrates that high schoolers sexual partnering behaviors often adhere to unarticulated local configuration prohibitions – e.g., they don't partner with a former partner's current partner's former partner, described as “avoiding closed 4-cycles” (Bearman, Moody, and Stovel 2004). This effectively creates “spanning-trees” in connecting most of the sexually active population to each other indirectly (through partners' partners' partners, etc.). This structure has direct implications for the potential spread of sexually transmitted infections in high schools – in that those with long infectivity windows (e.g., herpes or HPV) are more likely to spread within adolescent populations than infections with shorter windows (e.g., HIV), which are likely to have limited spread because the timing of relationships readily breaks apart long singly-connected chains.

Some work addresses how social network patterns change over the life course, particularly in response to specific age-staged events. For example, studies of “dyadic withdrawal” demonstrate that networks of married and cohabiting people are more constricted than those observed prior to partnering, and likely increasingly overlap with their partner (Kalmijn 2003). Furthermore, the segregation of social networks into age homogeneous clusters “reflect institutional, spatial and cultural segregation associated with a tripartite life course” (Hagestad and Uhlenberg 2005). These age configurations are especially exacerbated in non-kin relationships, and slightly muted when limited to kin-only ties.

New Agendas

Two of the most important ongoing areas of SNA work are developing methods for analyzing dynamic networks and generating statistical methods for analyzing network data. In addition to expanding the umbrella of SNA, these efforts are also likely to help bridge some of the gaps to more ready inclusion of network ideas into life course research. They happen to coincide with the recent completion of additional waves of several ongoing longitudinal studies that have been collecting data for a number of years – such as the National Longitudinal Study of Adolescent Health, which has an explicit focus on gathering network data (Bearman, Jones, and Udry 1997). Each of these advances combines to provide possibilities for researchers to explore how adolescent social networks contribute to outcomes later in life – both in terms of durability of previously observed behaviors and the contribution of behaviors not observed in respondents' adolescence. These new techniques and newly available data will also

provide opportunities to examine how social networks change throughout the life course and the ways those changes differentially influence behavior and trajectories.

Using Networks for Good

Valente and colleagues (2003) demonstrate that health promotion programs can strategically use the observed structure of social networks to enhance the spread of targeted information. However, the research is inconclusive regarding how readily these strategies can be applied to efforts that are more general and whether they successfully transition from attitudinal shifts to behavioral change. Present uncertainties aside, more explicitly examining individuals' social network properties, and employing that knowledge in outreach efforts, at worst will help us better understand the potential that social networks hold for changing the relational contexts within which people experience critical life events. Further, these approaches may also provide key points of entry (relational, not temporal – though given the advances described above, in the best case scenario, perhaps a combination of the two) into individuals' lives to intervene for altering trajectories or providing alternative means for managing experienced events.

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