The SAGE Handbook of Social Network Analysis

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Introduction

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The *SAGE Handbook of Social Network Analysis* is the first published attempt to present, in a single volume, an overview of the social network analysis paradigm. It includes accounts of the history, theory and methods of social network analysis, and a comprehensive review of its application to the various substantive areas of work in which cutting-edge research is taking place. We do not intend to repeat in this Introduction the ideas to be found in the various individual chapters, but it is important to provide a brief introduction to the discussions that follow.[1]

THE DEVELOPMENT OF SOCIAL NETWORK ANALYSIS

The date at which researchers on social structure began to explicitly use the idea of a 'social network' is difficult to determine with any precision. While structural thinking has deep roots in the sociological tradition, it was not until the 1930s that researchers and theorists began to employ such ideas to represent the shape and characteristics of social structures.[2] This was especially marked in German sociology, where the 'formal sociology' of Simmel and others emphasised the formal properties of social relations and the investigation of the configurations of social relations that result from the interweaving of actions in social encounters. These writers explicitly adopted a novel terminology and referred to 'points', 'lines' and 'connections' in their analyses and descriptions of patterns of social relations.

These formal ideas influenced many people working in social psychology and psychotherapy, especially when looking at the ways in which the structures of small groups influenced the perceptions and action choices of their individual members. This was most explicit in the work of Lewin (1936) and Moreno (1934), who investigated the 'field' or 'space' of social relations and its characteristics as a 'network' (see also Bott, 1928). Moreno referred to this approach as 'sociometry' and invented the 'sociogram' as a way of visually representing social networks with points and lines. Sociometry became a major field of investigation in education (Jennings, 1948; Gronlund, 1959) and community studies (Lundberg and Lawsing, 1937; Lundberg and Steele, 1938). In social psychology it took the form of an emphasis on 'group dynamics' (Cartwright and Zander, 1953; Harary and Norman, 1953), an approach that was particularly developed at the University of Michigan and, in London, at the Tavistock Institute.

The initial insights into community relations by Lundberg had a wider impact through the work of Warner, who initially cooperated with Mayo in a study of the Hawthorne electrical works in Chicago (Roethlisberger and Dickson, 1939). Although sociometry no doubt had some influence on their visual representations, the Hawthorne researchers were also directly influenced by seeing the electrical wiring diagrams in the Hawthorne factory, seeing these as a metaphor for group relations. Warner went on to investigate community structure in American towns and cities. Influenced by the work of the British anthropologist Radcliffe-Brown, Warner looked at the structure of group

relations in large communities and used network diagrams to represent social structure. In his study of the New England town of Newburyport, carried out between 1930 and 1935, Warner presented large-scale community relations in matrix form to represent what he referred to as the 'clique structure' of the city (Warner and Lunt, 1941). In a famous commentary, Homans (1950) advanced on these matrix methods to reanalyze a small clique of women studied by Warner in the southern town of Natchez, Mississippi.

A major advance in social network analysis took place at the University of Manchester in the 1950s, when social anthropologists critical of the emphasis on consensus and harmony in mainstream American sociology sought to recognize conflict and divisions within African and European communities. They were influenced by the 'structuralist' view of society that had been expounded by Radcliffe-Brown since the 1920s; his public lectures delivered in 1937 and 1940 referred explicitly to a 'network of social relations' and 'social morphology' (Radcliffe-Brown, 1940, 1957). The network analysis being developed at the Tavistock Institute and in the work of Warner was the means through which they developed this. This work on African communities was subsequently reported by Mitchell (1969b). This work had a wide influence. In a Norwegian study, Barnes (1954) proposed that the metaphor of the network of relations be taken seriously to explore the warp and weft of community relations, and in a study of kinship in London, Bott (1955, 1956) employed ideas of connectedness and density. Barnes and Bott worked closely with the Manchester researchers and inspired the systematic study by Nadel (1957) as well as Mitchell's (1969a) commentary on this work. The latter provides one of the earliest summaries of a formal social network methodology.

A group of American researchers led by Harrison White had begun to develop and apply a formal methodology for social network analysis by the time that Mitchell published his summary. Building on the work of Lévi-Strauss (1969 [1949]) and his collaborator Weil, White (1963a) had initially used algebra to represent kinship structures. When White moved from Chicago to Harvard University he formed a large and dynamic group of students and associates to develop the network paradigm (see Mullins, 1973: Chapter 10). These researchers included Levine's (1972) work on corporate power as a multidimensional field, Lee's (1969) sociometric study of searches for abortionists, Granovetter's (1973, 1974) investigation of searches for employment, and Mullins's (1973) analysis of modern American sociology. White himself worked with others on algebraic methods for representing and analysing systems of social positions and roles (Lorrain and White, 1971; Boorman and White, 1976; White et al., 1976). This group constituted a new generation of social network researchers who helped to spread social network analysis across the globe.

An important area for the application of social network analysis has been the investigation of corporate power and interlocking directorships. While Sweezy (1939) and others had adopted ad hoc techniques in their early studies for drawing network diagrams of board-level connections, it was not until the 1960s and 1970s that these suggestions were furthered as a result of the technical advances made in social network analysis. A path-breaking paper by Bearden and his colleagues (1975) elaborated on the idea of centrality to explore the power and influence of banks in the American corporate world, connecting with Levine's (1972) documentation of the clusters associated with particular banks and their directors. In the Netherlands, work led by Mokken and Stokman (Helmers et al., 1975) became the basis for an investigation of transnational patterns (Fennema, 1982) and an international comparative investigation (Stokman et al., 1985; see Scott and Griff, 1984). This was extended into a comparative investigation of intercorporate shareholding networks (Scott, 1986) and led to numerous studies in a variety of societies (see the reviews in Scott, 1997, and Carroll and Sapinski, this volume).

Another important area of application has been in the investigation of community structure. Rooted in Warner's studies, it was again a number of researchers influenced by the developments at Harvard who pushed this area forward. Fischer (1977) and Wellman (1979) generated work that completely reoriented the research area. Wellman carried out a series of investigations on the changing structure of communal relations in a Canadian city and examined the role of friendship in social integration. A particular concern was to investigate the changing ways in which people maintained contact: his thesis was that each individual has his or her own 'community', consisting of those to whom the individual is socially connected. Thus, community was reconceptualised as a personal network and liberated from its previous spatial bounds in the neighbourhood (Chua et al., this volume). Wellman has recently explored the impact of electronic means of communication on patterning the structuring and operation of interpersonal networks (Wellman and Hogan, 2006; Gruzd and Haythornthwaite, this volume). This work is connected with network formulations of social support (Song et al., this volume) and has most recently converged with ideas on social capital that developed out of Putnam's (2000) work. The most important contributions to this

work have been the reflections of Lin (2001) and Burt (2005; see also Lin et al., 2001).

Numerous other applications have extended social network analysis into the study of political and policy networks (Bond and Harrigan, this volume; Knoke, this volume), social movements (Diani, this volume), criminality and terrorism (Carrington, this volume; van der Hulst, this volume), the world political economy (Kick et al., this volume), cultural, scientific, and scholarly networks (DiMaggio, this volume; Howard White, this volume), economics (Goyal, this volume), geography (Johnston and Pattie, this volume), the impact of peers on attitudes and behaviour (An, this volume) and many other topics, even including animal networks (Faust, this volume).

At the same time, network theory and theories have been developed, including network exchange theory, network flow theory, small world theory, and the strength of weak ties theory (Borgatti and Lopez-Kidwell, this volume). Many researchers have stressed the links between social network analysis and theories of rational choice, but this has often led to a methodological individualism in which structural features become more outcomes of social action. More recent contributions have investigated the relationship between individual agency and the structural features of social networks. White (1992) and Emirbayer (Emirbayer and Goodwin, 1994; Emirbayer, 1997) have made especially important contributions to the theorisation of a 'relational sociology', while Mische (this volume; Mische, 2003; see also Mische, 2007) has developed White's approach to culture and identity to make important connections with the relational orientation (see Emirbayer and Mische, 1998).

Since the late 1970s there has been a huge increase in technical contributions to social network methodology and in its application. Of particular importance have been major studies by Burt (1982), Freeman and his colleagues (1989), Wasserman and Faust (1994) and an introductory text by Scott (2000; originally published in 1991). Edited collections have included those by Wasserman and Galaskiewicz (1994), Brandes and Erlebach (2005) and Carrington et al. (2005).

The most striking development in social network analysis in recent years, however, has been the growth of interest among physicists in applying network ideas to social phenomena (Freeman, this volume; Scott, this volume). This growing interest from outside the social sciences first became apparent in a paper by Watts and Strogatz (1998), which built on Milgram's pioneering work on 'small worlds' (1967; Travers and Milgram, 1969) and the literature on random networks that had grown up around it. Barabási (2002) and Watts (1999, 2003) suggested that these ideas could be applied to the social world, egregiously ignoring the work on social networks already undertaken by sociologists, anthropologists, economists and political scientists. This lack of awareness of prior research – they proposed, for example, investigations into networks of directorships on the grounds that none had so far been undertaken – surprised and shocked those who had been researching the topics for many years. Reaction in a wider public context was, however, much more favourable. These later researchers' claims to novelty were taken at face value by many journalists and reviewers (see, e.g., Buchanan, 2002) but did create a wider interest in network analysis at a time when practical applications of 'social networking' were also being stimulated by new Web 2.0 technologies.

Freeman's (2004) history of social network analysis undertook a network analysis of citation patterns in research on social networks and showed that the work published by the physicists had rarely cited work by social scientists (see also Freeman, this volume). It also disclosed, however, that social network analysts had been reluctant to engage with the work of the physicists. This division is now breaking down: Watts has moved into sociology, and sociologists have debated the ideas contained in his work. Others such as Barabási, however, still persist in ignoring the work carried out by social scientists during the last century.

The work of the physicists has, however, brought to the forefront of attention a number of issues that received less than their due attention in earlier social network analyses. These physicists had, in particular, stressed network dynamics and change over time, and they helped to develop techniques for investigating these. Such work moves social network analysis beyond the generally static or cross-sectional methods typically used and the new techniques outlined by physicists and social scientists are helping to develop explanations of network processes and to explore processual transformations in network structure.

Social network analysis is a scientific community, or invisible college, with a recognizable intellectual lineage and clusters of researchers based in several centers and loosely linked by cross-cutting collaborations and intercitations (Freeman, 2004). It is also a scientific institution, with dedicated journals (*Social Networks, Journal of Social Structure* and *Connections*), textbooks and handbooks (e.g. Degenne and Forsé, 1994; Wasserman and Faust, 1994; Scott, 2000; Knoke and Yang, 2008), dedicated computer software (van Duijn and Huisman, this volume) and an association (the International Network for Social Network Analysis; see http://www.insna.org/).

Although a well-defined paradigm in its own right, social network analysis is embedded within

traditional disciplines such as social psychology, social anthropology, communication science, organizational science, economics, geography and, especially, sociology. Since its 'take-off' in the 1970s, the volume of published research on social networks has grown exponentially (Knoke and Yang, 2008: 1–2), while the number of subject areas in which it is being employed has experienced almost linear growth, from a handful to almost 60 by the year 1999 (Freeman, 2004: 5). Neither the volume of published research nor the expansion of social network analysis into diverse subject areas shows any sign of leveling off.

CENTRAL IDEAS IN SOCIAL NETWORK ANALYSIS

At the heart of social network analysis is the branch of mathematics called graph theory (Harary and Norman, 1953; Harary et al., 1965; Harary, 1969). This is a set of axioms and deductions that originated in Euler's mathematical investigations of the famous problem of the seven bridges of Königsberg. He explored the problem of whether it was possible to walk through the city crossing each bridge just once and so visiting each of the islands that made up the city. Euler converted this practical problem into an abstract model of points and lines, the points representing the islands and the lines representing the bridges, and showed that there is no solution to the problem: the task is impossible. This proof laid the foundations for studying networks of all kinds as being graphs composed of points and lines.

Social network analysis is a specific application of graph theory in which individuals and other social actors, such as groups, organizations and so on, are represented by the points and their social relations are represented by the lines (Hanneman and Riddle, this volume). This mathematical model formalises the initial insight depicted in Moreno's sociograms. The theorems of graph theory provide a basis for analysing the formal properties of sociograms. It is not, however, necessary to draw sociograms in order to use graph theoretical concepts and measures. Network data on a given social relationship are typically recorded in the form of a square matrix – the 'sociomatrix' – in which the rows and columns of the matrix represent individuals or other social actors and the presence or absence of the social relationship between each pair of individuals is recorded in the cells. Thus, the sociomatrix contains the same information as the corresponding sociogram, taking the rows or columns as its points and the contents of the cells as the presence or absence of lines between pairs of points. Sociomatrices can be analysed using the operations of matrix algebra. This is a great advantage when analysing large-scale data sets for which it is often difficult to draw a meaningful sociogram, or to analyse it.

While most social network research analyses 'one-mode' networks, in which the rows and columns of the data matrix represent the same set of points, or social actors, some work analyses 'two-mode' or 'affiliation' networks, in which there are two distinct classes of points, and the lines exclusively connect points of one class with points of the other class (Borgatti and Halgin, this volume). Two-mode data are represented by a rectangular matrix, in which the rows represent one type of point and the columns represent the other type. For example, one class of points could be persons and the other type could be events in which they were involved, or organizations to which they belonged; each cell entry would indicate whether the indexed person was related to the indexed event or organization. Two-mode networks can easily be converted to one-mode networks.

Graph theory analyses the formal properties of graphs, which are systems of points and lines between pairs of points. The concept of the graph can be extended to take account of the 'direction' of a line, so as to represent asymmetric relations such as friendship choices made or the flow of influence or resources. It can also take account of the intensity or strength of a relationship by assigning a 'value' to a line in order to represent this; the value can be positive or negative. There can be multiple labelled lines between each pair of points, with each type of line representing a different relationship, or 'type of tie'. Points can also have discrete- or continuous-valued properties, representing the attributes of the actors represented by the points, as in conventional social analysis. The term 'network' is used in mathematics for these extensions of a graph, in which the lines and/or points have properties such as direction, valence, weight, multiplicity and so forth: thus, social network analysis is the analysis of systems of social relationships represented by networks.

From this initial basis of representation, network analysis can measure such things as the overall 'density' of a network and the relative 'centrality' of the various points within it. Centrality measures have typically been used as indicators of power, influence, popularity and prestige. Other network analyses based on graph theory include the investigation of cliques and clusters of points, structural divisions within a social network being seen in terms of the existence of particularly dense or well-connected subgroupings, or, equivalently, in terms of particularly sparse or poorly connected areas of the network,

representing points of potential cleavage. Notions of local clustering, cleavage and centrality have allowed the investigation of intermediary or brokerage roles (Burt, 2005), as well as the development of methods for 'network reduction', in which large, complex networks are 'reduced' to smaller, more manageable realisations (Batagelj, this volume).

While graph theory is the heart of social network analysis, a number of other mathematical models have been employed to highlight specific aspects of network structure. The matrix-based algebraic approach used by Harrison White and others looks not at the properties of individuals and groups but at the structural properties of the social positions (or 'statuses') occupied by individuals and the performed roles that are associated with these positions. These so-called positional approaches – sometimes termed 'block models' (Ferligoj et al., this volume) – use methods of matrix clustering that build on Homans's early suggestions to decompose networks into hierarchical positions of the kind documented by Nadel (1957). These approaches have led to various ways of measuring and analysing the 'structural equivalence' or 'substitutability' of individuals within social positions, and to algebraic modelling of systems of compound social roles (Pattison, this volume), corresponding formally to the more familiar systems of compound kinship roles (mother's brother, wife's father, etc.) developed by ethnographers (Douglas White, this volume; Hamberger et al., this volume).

Networks containing more than 20 or so points are difficult to draw accurately and legibly as sociograms. Multidimensional scaling was one of the earliest ways of eliminating the random jumble of criss-crossing lines in order to display points in a way that retains the spatial patterns inherent in relational data. New techniques such as multiple correspondence analysis and spring embedder algorithms have greatly improved graph drawing, and writers such as Batagelj and his colleagues (De Nooy et al., 2005; see also http://vlado.fmf.uni-lj.si/) and Krempel (2005; this volume) have been exploring alternative bases for network visualisation, including moving images of network change.

Special techniques are generally used to obtain or generate network data. Network data can be difficult to obtain, and they raise unique problems of measurement validity and reliability, as well as particular ethical issues (Marsden, this volume). While the emphasis in social network analysis has been on quantitative data and analyses, qualitative approaches are also used and indeed have characterised much of the foundational anthropological work in social network analysis, as well as a growing body of recent work (Hollstein, this volume).

Standard sampling procedures and statistical procedures such as significance tests, regression, and the analysis of variance cannot usually be employed in social network analysis as their assumption of the independence of observations does not hold for network data: indeed, it is the assumption of the interdependence of social actors that is the basis of network analysis. Frank (this volume) has pioneered the investigation of inference from sampled network data. Conventional statistical models have been adapted for use with network data (van Duijn and Huisman, this volume). Building on work by Frank and Strauss (1986), Wasserman and his colleagues (Wasserman and Pattison, 1996; Pattison and Wasserman, 1999; Robins et al., 1999; Robins, this volume) developed novel statistical techniques by generalising Markov graphs to a larger family of models. Their so-called exponential random graph models – or p^* models – define a probability distribution on the set of all networks that can be constructed on a given set of points using specific parameters. Solving the estimating equation for the parameters, which resembles a logistic regression model, provides estimates of the impact of such structural features such as transitivity and reciprocity, as well as of the attributes of the points.

Most recently, agent-based computational methods have been used to explore processes of change in networks, relating structural transformations to the unanticipated consequences of individual-level decision making (see Monge and Contractor, 2003). Knowledge of the rules under which agents make decisions and act can be used to predict broad patterns of change in network structure. Networks change because of the ways in which individual actions are constrained by the structural locations of actors and the wider structural properties of the network, though work on 'small-world' networks has shown that these structural transformations may not be linear in nature. Snijders (this volume; Snijders and van Duijn, 1997; Snijders, 2001, 2005) has developed a powerful approach to this problem in which networks develop through the continual iteration of actions, and in which small, incremental changes can accumulate to a tipping point at which nonlinear transformation in network structure occurs.

CONCLUSION

In preparing this volume, we took the view that social network analysis is a 'paradigm', rather than a theory or a method: that is, a way of conceptualizing and analysing social life that guides

the selection of the social behavior data that are studied, influences the way these data are organized for analysis, and specifies the kinds of questions addressed (Leinhardt, 1977: xiii).

In the most general terms, social network analysis is a structuralist paradigm: it conceptualises social life in terms of structures of relationships among actors, rather than in terms of categories of actors. Harrison White's comment that 'subinfeudation reminds one of industrial decentralization' (1963b: 77) highlighted structural rather than categorical parallels, and illustrates the kinds of questions and insights that arise from the study of social networks:

> The same conundrums that baffled them baffle us. Just as William the Conqueror insisted on submission directly to himself from the chief vassals of his loyal lords ... so a wise President seeks loyalty of subcabinet officers directly to himself (White, 1963b: 78).

A social science paradigm is composed of a theory or theories, a methodology or set of commonly employed methods, and a body of empirical research. This volume is organised around that tripartite division. Readers who are experienced in social network analysis can use this volume as a reference book, referring to particular chapters for up-to-date summaries of knowledge and indications of future trends, in a given topic area. Readers who are new to social network analysis may wish to begin with the introductory chapters by Marin and Wellman and by Hanneman and Riddle, before reading chapters on particular topics. Alternately, a newcomer to social network analysis who is interested in a particular topic, such as kinship or terrorism, or in applications of social network analysis in a particular discipline, such as economics, geography or criminology, may prefer to start with the corresponding substantive chapter, referring back to the introductory, conceptual and theoretical chapters as necessary.

In terms of theory, methods and substantive empirical work, this is an exciting time in social network analysis. The *SAGE Handbook of Social Network Analysis* aims to present a one-volume state-of-the-art presentation of contemporary views and to lay the foundations for the further development of the area.

NOTES

1 See also the introductory chapters in this volume by Marin and Wellman, and by Hanneman and Riddle. An earlier version of some sections of this introduction appeared in Scott (2010).

2 Overviews of the history of social network analysis can be found in Scott (2000: Chapter 2) and Freeman (this volume; 2004).

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