

# The Analysis of Social Networks

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# The Analysis of Social Networks

Ronald L. Breiger

Study of social relationships among actors—whether individual human beings or animals of other species, small groups or economic organizations, occupations or social classes, nations or world military alliances—is fundamental to the social sciences. Social network analysis may be defined as the disciplined inquiry into the patterning of relations among social actors, as well as the patterning of relationships among actors at different levels of analysis (such as persons and groups).

Following an introduction to data analysis issues in social networks research and to the basic forms of network representation, three broad topics are treated under this chapter's main headings: types of equivalence, statistical models (emphasizing a new class of logistic regression models for networks), and culture and cognition. Each section emphasizes data-analytic strategies used in exemplary research studies of social networks. An appendix to the chapter briefly treats computer programs and related issues.

## From Metaphor to Data Analysis

Network metaphors have long had great intuitive appeal for social thinkers and social scientists. Marx ([1857] 1956: 96) held that “society is not merely an aggregate of individuals; it is the sum of the relations in which these individuals stand to one another.” Durkheim, in his Latin thesis, traced his interest in social morphology to that of the eighteenth-century thinker Montesquieu, who had identified various types of society, such as monarchy, aristocracy, and republic “not on the basis of division of labor or the nature of their social ties, but solely

according to nature of their sovereign authority,” and Durkheim went on to criticize this strategy as a failure to see “that the essential is not the number of persons subject to the same authority, but the number bound by some form of relationship” (Durkheim [1892] 1965: 32, 38). Leopold von Wiese, a writer within the German “formal school” centered around Georg Simmel, asked his reader to imagine what would be seen if “the constantly flowing stream of interhuman activity” were halted in its course for just one moment, and suggested that “we will then see that it is an apparently impenetrable network of lines between men;” furthermore, “a static analysis of the sphere of the interhuman will ... consist in the dismemberment and reconstruction of this system of relations” (Wiese, [1931] 1941: 29-30). In America, Charles Horton Cooley proclaimed the necessity of a “social” or “sociological” pragmatism (Joas 1993: 23), a tradition within which not only consciousness of social relations, but self-consciousness, was theorized explicitly, and within which “a man may be regarded as the point of intersection of an indefinite number of lines representing social groups, having as many arcs passing through him as there are groups” (Cooley, [1902] 1964: 148). The English social anthropologist A. R. Radcliffe-Brown (1940) wrote that ‘direct observation does reveal to us that ... human beings are connected by a complex network of social relations. I use the term “social structure” to denote this network....’

One prominent commentator on the history of social scientific thought and on contemporary development writes that ‘network sociology is doing the very thing that early sociologists and anthropologists saw as crucial—the mapping of the relations that create social structures’ (Turner 1991: 571). Much contemporary research over the past decades can be seen as a move from network thinking as vague metaphors to the elaboration of the network concept to the point where it can be used as an exact representation of at least some central elements of social structure (Freeman 1989, Smith-Lovin and McPherson 1993, Wellman 1988). A

particularly notable move from metaphor to analytical method is the relatively recent development of highly sophisticated computer programs for producing pictorial representations of social networks. Freeman (2000) illustrates some of the newest procedures for producing web-based pictures that allow viewers to interact with the network data and thus to use visual input in exploring a variety of analytical models of their structural properties.

### Qualitative or Quantitative?

Many of the quantitative techniques of data analysis taken up in other chapters of this *Handbook* may be considered to study networks of statistical relationships among variables. In contrast, because social network actors are in most studies concrete and observable (such as individual persons, groups, nations, and alliances) or collectivities of observable agents (such as occupations or classes), the relationships of interest to an analyst of social networks are usually in the first instance social or cultural, binding together and differentiating concrete entities, rather than statistical encodings. Indeed, some social network theorists and data analysts emphasize the extent to which the inductive modeling strategies of network analyses are subversive of the usual canons of statistical methods (Levine, 1999) or they portray network analysts as "eschwing ... interactional approaches such as statistical (variable) analyses ... [in order to] pursue transactional studies of patterned social relationships" (Emirbayer, 1997: 298).

Much progress has in fact been made in recent decades in the statistical analysis of social networks. A number of important extensions of the general linear model have been developed in recent decades specifically to model (for example) the likelihood of a relationship existing from one actor to another, taking into account the *lack* of independence among social relationships and the presence of specifiable patterns of dependence. These statistical models will be reviewed in

this chapter. Nonetheless, it is useful to keep in mind the very considerable extent to which social network analysis as a strategy of empirical research is indeed difficult to contain within the conventionally established headings of statistical data analysis, to the point of suggesting a highly distinctive research orientation within the social sciences. Even the effort to maintain distinctions between quantitative and qualitative forms of data analysis is challenged by the progress that has been made in the analysis of social networks.

Despite the development of important statistical models for social networks, therefore, as one strand of recent research deserving exposition, it will be useful to emphasize other strands that portray network analysis as a form of data analysis moving in directions quite different from statistical modeling. Even with respect to mathematical models, some of the most important progress in network analysis is more likely to be treated in texts on applied abstract algebra (Kim and Roush, 1983; Lidl and Pilz, 1998) than in statistics texts, owing to progress that has been made in visualizing and modeling complex structures as distinct from estimating relevant quantities. A related point is that samples of independent actors or relationships are only rarely the focus of network analysis. It has been famously suggested (Barton, 1968) that, just as a physiologist would be misled by sampling every hundredth cell of a dissected laboratory animal in an effort to understand its bodily structure and functioning, so a scientist interested in social structure and behavior would be misled by reliance on random samples wrenched out of their embedded interactional context; at a minimum, highly innovative sampling theory and methods need to be developed afresh (as they are for example in McPherson, 1982). In contrast to random samples, full data on the presence or absence of social relations among all the members of a bounded population is often required, and network analysts have formulated the problem of boundary specification (Laumann et al., 1983; Marsden, 1990) in an effort to gain analytical

leverage on this requirement. Furthermore, whether in laboratory experiments furthering exchange theory (Molm and Cook, 1995) or in broad observations on new forms of "recombinant property" taking shape in post-Communist Eastern Europe (Stark, 1996), the innovations in data analysis of social networks are very often substantive rather than statistical in nature.

Finally, the very distinction between "quantitative" and "qualitative" approaches to data analysis is called into question by network analysis, in ways that go beyond the distinction between (quantitative) statistics and (qualitative) algebra. Typically a network analysis is a case study (Ragin and Becker, 1992) situated with explicit temporal and spatial reference (Abbott, 1999: 193-226), and important contributions to data analysis have combined ethnographic work and field observation with application of network algorithms, as in Faulkner's (1983) study of the patterning of business relations between movie directors and music composers in the Hollywood film industry. From a more avowedly subversive stance, theorists within contemporary science studies have coined the "intentionally oxymoronic" term "actor-network" as a word that "[performs] both an elision and a difference between what Anglophones distinguish by calling 'agency' and 'structure'" (Law, 1999: 5), and Latour (1988) has rewritten the history of Louis Pasteur as the interpenetration of networks of strong microbes with networks of weak hygienists, viewing the microbes as "a means of locomotion for moving through the networks that they wish to set up and command" (p. 45). In the work of analysts such as these there has arisen a form of "post-modern" network analysis emphasizing the difficulty of establishing clear boundaries between network actors and connections, between agency and structure.

Networks data often arises from actors who are engaged (often directly, often metaphorically), in conversation with one another, and an increasingly prominent strand of network analysis emphasizes the discursive framing and cultural embedding of social networks

(Bearman and Stovel, 2000; McLean, 1998; Mische, forthcoming; Mische and White, 1998; Mohr, forthcoming; Snow and Benford, 1988; Steinberg, 1999), in effect continuing the pragmatist strand of network research introduced above. My goal in this chapter will be to present the most important issues in data analysis pertaining to social networks while seeking to relate the specifics of data analysis to the swirl of strategies (statistical, algebraic, substantive, discursive, and cultural) that are motivating much of the contemporary work.



## Culture and Cognition

The emphasis of network analysis on formal aspects of social structure often seems the opposite of a concern for culture and cognition; indeed, in the early work on structural equivalence “the cultural and social-psychological meanings of actual ties are largely bypassed .... We focus instead on interpreting the patterns among types of tie” (White et al. 1976: 734). However, over the past decade a fusion of concern across structural modeling and problems of culture, cognition, action, and agency has been among the most important developments for an influential segment of the community of networks researchers.

An important spur to network thinking about culture and cognition was White’s rethinking of network theory in his 1992 volume *Identity and Control*. White now wrote of agency as “the dynamic face of networks,” as motivating “ways of ... upend[ing] institution[s] and ... initiat[ing] fresh action” (pp. 315, 245). White (1992) considered discursive “narratives” and “stories” to be fundamental to structural pursuits, writing that “stories describe the ties in networks” and that “a social network is a network of meanings” (pp. 65, 67). Emirbayer and Goodwin (1994), who characterized *Identity and Control* in exactly this way (p. 1437), went on to prod network analysts to conceptualize more clearly the role of “ideals, beliefs, and values, and of the actors that strive to realize them” (p. 1446).

A second spur (reviewed in Pattison 1994) can be identified for reconsidering the boundary between network research and cognitive studies: developments arising internally within the networks paradigm as presented in this chapter’s first two sections. Networks researchers (Bernard et al. 1984) demonstrated substantial discrepancies between records of social interactions and participants’ reports of those interactions, with Freeman et al. (1987)

arguing that the discrepancies could be explained in part by appealing to cognitive biases favoring longer-term patterns of social interactions. Carley (eg, 1986) developed an influential “constructuralist” model of knowledge acquisition according to which individuals’ cognitive structures, their propensity to interact with others, the social structures they form, and the social consensus to which they give rise are all continuously constructed in a reflexive and recursive fashion as individuals interact with those around them. And Krackhardt (1987) launched the study of “cognitive social structure” by suggesting that the usual who-to-whom matrices be replaced by a three-way design in which each actor is asked to provide perceptions on all the who-to-whom interactions. Thus, it is possible to ascertain empirically the "fit" between, *e.g.*, a manager's view of her own centrality to an organization and the average or weighted perceptions of her colleagues (or, for that matter, of the vice president for marketing; see Krackhardt 1987: 123). This formulation allowed Krackhardt to raise such questions as: How does the position of an individual in an organizational network affect his or her perception of the network? (See also Kumbasar et al. 1994).

A third motivation for fresh work on networks and culture was Ann Swidler’s formation of a working group on “meaning and measurement” within the American sociological association’s section on culture, resulting in the publication of new research on networks, culture, and measurement (see DiMaggio 1994, Jepperson and Swidler 1994). In reviewing recent work on culture and cognition, DiMaggio (1997: 283) conceives of networks as crucial environments for the activation of schematas, logics, and frames. He points for example to the role of political protest networks in activating pre-existing identities (Gould 1995), to the correlation between the social network complexity of an occupational group and the diversity of its conversational interests (Erickson 1996), and to the relation between questioning marriage

and the altering of social relations in order to create new new, independent identities as a prologue to separation (Vaughn 1986).

### Culture, Cognition, and Networks: Research Strategies

I will emphasize network analysis of three topics that DiMaggio (1997) touches on in his review of cognition and culture: logics of action, switching dynamics, and the mapping of meaning structures.

LOGICS OF ACTION. Friedland and Alford (1991: 248-49) define institutional logics as sets of “material practices and symbolic constructions” that constitute an institutional order’s “organizing principles” and are “available to organizations and individuals to elaborate.” DiMaggio (1997: 277) describes the concept as “immensely appealing,” in part because it recognizes culture as rooted in rather fragmented sets of local practices without however “surrendering the notion of limited coherence, which thematization of clusters of rituals and schemata around institutions provides.”

Mohr (1994) provided an empirical framework for uncovering such logics with reference to poor relief efforts in New York City a century ago. Using a charity directory for 1907, Mohr constructed a blockmodel reporting relations among categorical descriptors of eligible clients—“tramps (male),” “unwed mothers,” “widows,” and so on—grouped together on the basis of similarity in the patterns of treatment provided (vocational school, domestic training, farm colony, etc.). Mohr (1994: 333) suggested the concept of “discourse role” to shift attention from “how particular individuals are connected to one another by way of specific types of

relationship” and toward the question of “how particular social identities are connected to one another by virtue of having the same types of social welfare treatments applied to them.”

In subsequent work Mohr and Duquenne (1997) employ a different structural technique, Galois lattice analysis (see, e.g., Freeman and White 1993), in order to model more directly the relations between two different kinds of social nodes: the categories of clients and the categories of treatment provided by agencies for poor relief. The authors develop a specific research context for viewing lattice analysis and analysis of affiliation networks as operationalizing a form of “practice theory” according to which the material world (the world of action) and the cultural world (the world of symbols) interpenetrate “and are build up through the immediate association of each with the other” (Mohr and Duquenne 1997: 309). There are some interesting relations between the kind of lattice analysis that these authors apply and the dimension of social and cultural “fields” uncovered by the practice theorist Pierre Bourdieu (on which see Breiger 2000).

SWITCHING DYNAMICS. DiMaggio (1997: 278) argues that the notion of institutional logics can be interpreted as an effort to thematize cognitive schemata and link them to social structure. Exploitation of this insight requires (among other things) an understanding of cultural change, which in turn requires an “understanding of the way in which actors switch among institutional logics” (DiMaggio 1997: 278). An outstanding study of such dynamics was Padgett and Ansell’s (1993) analysis of Cosimo di Medici’s deployment of multiple identities and “robust discretion” to gain power in fifteenth-century Florence; see also Padgett (2001). Traditional social network analysis does not deal well with the disruption of structure, for example with the disruption of the career paths of elite social engineers in the former USSR produced by Glasnost (White 1992: 257). A central problem for White (p. 257) is “getting

action” by reaching “through” existing social structures. Mische and White (1998: 711) observe that a given set of multiple network ties within a self-consistent domain (for example, an interlock of colleague and friendship ties among graduate students) implies a continual juggling of the set of possible stories consistent with the structure. Switchings between network domains (for example, when a graduate student works at night as a self-employed head of a small corporation designing corporate web pages) are discontinuities in sociocultural processes, and may open up opportunities for entrepreneurs to seize action in more projective and practically evaluative ways (Emirbayer and Mische 1998) than would be routine within a domain (perhaps in the example given showing up as efforts to decrease the tension of identities between students and earners of large but erratic incomes). An example of switching dynamics that is receiving the attention of a formal modeler consists of topic changes in group conversations (such as among management team members in a large corporation) and their relation to sequences of the order in which the participants take the floor (Gibson 2000).

MAPPING STRUCTURES OF MEANING. By “structure-mapping” DiMaggio (1997: 281) refers to “the existence of some form of content-related domain-specificity.” Structure exists not only as ties among actors but as networks among cognitive and cultural content that is more or less meaningful to the actors. Carley (1994) for example uses network analysis techniques to map the structure of relations between conceptual terms used in narratives (thirty science-fiction novels written at different times) and then to see these structural representations of meaning to compare cultural phenomena (specifically, changes in the portrayal of robots—from menacing to clever—from the 1950s to the 1980s). Martin (2000) maps relations between occupations and animal species in a well-known children’s book, as part of a larger effort to understand who children are

instructed in realities of social class prior to experiencing those realities themselves. Mohr (1998) elaborates a framework for the uncovering of meaning structures that emphasizes relations among lexical or semantic terms in a classification system and the application of formal network models or pattern-matching techniques. Mohr and Lee (2000) take as their data a massive compendium of 765 different programs that the University of California system maintains with “pre-collegiate” institutions. These authors provide and employ a set of procedures for mapping “the implicit meanings of a system of identity discourses” (Mohr and Lee: 47) and thus they investigate recent changes in the university systems diversity policies.

The implication of the lines of research reviewed in this section is to link network analysis with “understanding of the relationship between culture and social structure built upon careful integration of micro and macro, and of cognitive and material, perspectives” (DiMaggio 1997).

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