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Review

Linton C. Freeman, The Development of Social Network Analysis: A Study in the Sociology of Science, Empirical Press, Vancouver, BC, 2004.

From 1960 to 1975, 20 articles about social network analysis were listed in Sociological Abstracts. From 1990 to 2005, the number was over 3000. No one today is more equipped to explain how this happened than Linton C. Freeman.

Freeman divides the history of social network analysis (SNA from here on) into four eras: (1) everything up to the end of the 1920s; (2) the 1930s; (3) the 30 years from about 1940 to 1969; and (4) the modern era, beginning when Harrison White (who had moved to Harvard in 1963) began producing the students who would become a who's-who of modern SNA.

For every era, Freeman's rhetoric is devoid of disciplinary chauvinism. He draws from sociology, anthropology, psychology, mathematics, and physics and shows how it all came together, sometimes on purpose, sometimes by sheer accident, to become the international, multidisciplinary band of scholars who call themselves social network analysts today.

In the Introduction, Freeman establishes the organizing principle of the book. Modern SNA, he says, is an organized paradigm for research and is defined by four features:

(1) it is "motivated by a structural intuition" and focused on ties between actors rather than on attributes of actors;
(2) it is based on systematic collection of data about those ties;
(3) it relies on graphics; and
(4) mathematical/computational tools to make sense of the welter of information about all those ties (p. 3).

As a true paradigm for research, in the Kuhnian sense of the word, modern SNA is a normal and cumulative science (p. 6). The rest of the book is devoted to showing how this happened.

1. Prehistory

Chapter 2 covers prehistory—early examples of the four features of SNA. This chapter is full of surprises. For example, Freeman shows that, long before Durkheim, August Comte had a strong structural intuition and saw clearly that ties between actors are as important as attributes of actors. Strongest credit for this intuition, however, goes to Georg Simmel for

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the explicit statement that, if there is ever to be a science of society, "it must exclusively investigate [reciprocal] interactions" among people (Freeman, p. 15).

Freeman credits the Swiss naturalist, Pierre Huber, with the first systematic study of patterned social interaction—for Huber's 1802 research on bumblebees—and the anthropologist, Lewis Henry Morgan, with the first application of this approach to humans in the study of American Indian kinship systems (1871). Freeman also uncovered a two-mode table from an 1894 book by John Atkinson Hobson, about the rise of capitalism that shows the co-membership of six men on the boards of directors of the five largest companies in South Africa. Hobson produced a Venn diagram from the data in that table showing the interlocking directorates—the earliest example that Freeman found of this kind of imagery to display social patterns.

The one ingredient that Hobson lacked was any use of mathematical or computational tools to analyze his data. Credit for this, according to Freeman, goes to Irénée Jules Bienaymé, a French mathematician, who formulated a model in 1845 to account for turnover in the surnames of noble families. Bienayamé's work was explicitly structural and explicitly mathematical, though it lacked the other elements of modern SNA: systematic data collection and graphics.

2. Early births and deaths

Chapters 3 and 4 are devoted to what Freeman shows were two independent births—and deaths—of modern SNA in the 1930s: Jacob Moreno's work on sociometry and the work of a group of scholars at Harvard on a variety of studies. Moreno's 1934 book, Who Shall Survive, had three of the four elements of modern SNA: it was explicitly structural; it was based on systematically collected data; and it was full of diagrams showing the patterns of links. According to Freeman, it was probably Moreno's assistant, Helen Hall Jennings, who saw the need for mathematical tools and who brought a young mathematician and sociologist, Paul Lazarsfeld, on board. In any event, in 1938, with Lazarsfeld's probability model of sociometric choices, Moreno's work had all four elements of modern SNA.

Moreno's work was quite famous in its time and remained well known for decades (I studied it in the 1950s as an undergraduate), but it wound up being of little influence in the development of modern SNA. What happened? According to Freeman (who recalls seeing Moreno give presentations at sociology meetings in the 1950s), it was a case of bad personality. Moreno's "commitment to mysticism, his bombastic personal style, and his megalomania drove most of his early supporters away," says Freeman (p. 42), and so modern SNA was born and abandoned.

And, says Freeman, it was apparently born and abandoned at Harvard at the same time. W. Lloyd Warner, a young anthropologist and a disciple of A. R. Radcliff-Brown, had studied the complex kinship system of the Murngin in Australia. It was Warner, says Freeman, with his structural perspective, who turned Elton Mayo's study of the bank wiring room from a focus on individuals to a focus on relations among sets of individuals. And it was Warner who developed the Yankee City studies (of Newburyport, Massachusetts) and the Deep South studies (of Natchez, Mississippi), both of which involved systematic collection of data on social structure. One of the most famous data sets in SNA (the matrix of attendance

by 18 women at 14 social functions) was produced in the Deep South study by Davis et al. (1941). (No fewer than 21 analysts have tackled this data set. See Freeman, 2003.)

These studies all take an explicitly structural perspective (they even use the term "clique"); contain lots of systematic relational data; and rely on graphics to display patterns of interaction among the actors. As Freeman tells the story, it was two more young anthropologists, Conrad Arensberg and Eliot Chapple, fresh off the Yankee City study, who saw the need for more formal measurement of interaction and for mathematical tools to analyze the mountains of data that were being produced in the Harvard studies.

Chapple built a special typewriter—he called it the "interaction chronograph"—for recording who-to-whom interactions by direct observation (Chapple, 1940). It was a big, clunky contraption—nothing you could take easily to the field, like today's PDAs—but it could be used in situations (like the bank wiring room) where you can set up and watch people interacting. Chapple's vision was to build a science of network analysis (he used that exact term in 1953) in which "we can determine the effects of any change in the quantitative values assigned to any link on its neighbor in the network pattern" (quoted in Freeman, p. 63). But, according to Freeman, Chapple's and Arensberg's attempts to make the Harvard studies of social structure more formal were rejected by their colleagues at Harvard and, along with Warner and several others in this project, left Harvard in the mid-1930s. Once again, according to Freeman, network analysis was born and died.

3. The dark ages

Chapters 5, 6, and 7 are devoted to what Freeman calls, satirically, the dark ages of social network analysis: the 1940s, 1950s, and 1960s. He identifies 14 more-or-less independent traditions of network analysis during these 30 years. One of these was Kurt Lewin's Research Center for Group Dynamics at MIT with his former students, Leon Festinger and Dorwin Cartwright, and a graduate student, Alex Bavelas. On getting his degree at MIT, Bavelas joined the faculty and recruited R. Duncan Luce to be what Luce later called Bavelas's "captive mathematician." Bavelas's famous experiment at MIT on forms of communication caused a brief stir and had all four elements of modern SNA, but its impact was short-lived. When Lewin died in 1947, Cartwright and Festinger went to the University of Michigan. In 1951, Cartwright teamed up with Frank Harary, then a newly minted Ph.D. This group produced much work that network analysts cite today as key to the development of the field, but, at the time, according to Freeman, it had little impact outside of social psychology.

Charles Loomis kept sociometry alive at Michigan State College in the 1950s and recruited the mathematician, Leo Katz, who, in turn, made major contributions to the analysis of sociometric matrices. This work, too, "failed to re-kindle widespread interest in sociometry" (Freeman, p. 77). In 1948, at the University of Paris, Claude Lévi-Strauss (1949) presented his dissertation on the rules governing kinship systems and asked André Weil, a mathematician, to add an appendix with an algebraic model of the Murngin kinship system that Warner had studied 20 years earlier. This work had all four properties of modern SNA, but "it never seemed to capture the imagination of people working in others areas of social research" (Freeman, p. 81).

In the 1950s, at the University of Lund in Sweden, Torsten Hägerstrand (1952), a geographer, built and tested a Monte Carlo model of the diffusion of innovation. Hägerstrand's work had all four components of modern SNA and stimulated a lot of research in his own field, but "apparently," says Freeman (p. 84), "the links between social geographers were too weak to encourage adoption of this approach as a general model for structural research."

At the University of Chicago, a group of applied mathematicians, known as the Committee on Mathematical Biology, produced their own full-fledged field of network analysis. One member of this group was Anatol Rapoport, who described the group's demise in anti-communist witch hunts of the 1950s. Members of the Committee were fired and, as Rapoport describes it, a congressional committee investigating so-called un-American activities, was welcomed on at the University of Chicago (see Rapoport, 2000:106; quoted in Freeman, p. 89).

Some threads of modern SNA in the 1950s were not dead ends. Everett Rogers rediscovered Moreno's work and applied it to the study of diffusion of innovations. Later, Rogers would be instrumental in establishing the field of communications studies, working in a long career until his death in 2004. His students, including Ronald Rice, Thomas Valente, and William Richards, have become major figures in modern SNA.

At Columbia University, sociologist Robert Merton and mathematician-sociologist Paul Lazarsfeld teamed up on a series of studies that were informed by Lazarsfeld's earlier work with Moreno and by Merton's work at Harvard during the Warner years. Their students included James Coleman, Elihu Katz, Herbert Menzel, Peter Blau, and Charles Kadushin, all of whom are now recognized as progenitors of the modern field of SNA.

At the University of Manchester, England, Max Gluckman (another disciple of Radcliff-Brown's) developed a networks seminar that included John Barnes, J. Clyde Mitchell, Elizabeth Bott, and Sigfried Nadel. They, and Jeremy Bosissevain in Holland (another anthropologist of the same generation whom I would add to Freeman's list), all referred to their work as network analysis. They spoke explicitly of some key concepts in the field (network span, multiplexity, density), though (with the exception of Mitchell) they did little computational work. On balance, says Freeman, "their influence on subsequent work in the field was huge" (p. 105).

Another more-or-less independent thread of network analysis was developing in the 1950s at MIT, with the work of political scientists Karl Deutsch and Ithiel de Sola Pool. De Sola Pool wanted to build a formal model of how patterns of acquaintanceship influenced people's thoughts and actions. And once again, says Freeman, it was the addition of a mathematician, Manfred Kochen, to the team that made possible the development of a full-fledged network study. In fact, for me, the strongest message in this book is the remarkable consistency with which breakthroughs occur in the field when mathematicians and social scientists team up to work on a problem.

Freeman tells us about his own epiphany in 1961 regarding network analysis. His undergraduate mentor in the late 1940s, St. Clair Drake, had been one of the ethnographers on Lloyd Warner's Deep South study. That was Freeman's introduction to the structuralist perspective. Then, in 1952, when Freeman was an MA student at the University of Hawaii, a young geographer, Forrest Pitts, introduced him to the work of Hägerstrand on diffusion. Freeman had been friends since graduate school with Elizabeth Bott, who was then going to England to do her now-famous study of family and social networks (Bott, 1957). Then, in

the 1960s, Freeman and Morris Sunshine, along with Thomas Fararo, Warner Bloomberg, and Stephen Koff used principal components analysis of two-mode data to reveal how community issues were linked through their association with the same sets of decision makers (Freeman, Bloomberg et al., 1960; Freeman, Fararo et al., 1962, 1963). And then, Freeman tells us, he read Anatol Rapoport and William Horvath's (1961) paper on analyzing a large sociogram, and the generality of structural analysis all came together.

There were other threads of modern SNA building throughout the 1960s. In 1963, Claude Flament at the Sorbonne published Applications of Graph Theory to Group Structure and today, "Flament's work is widely recognized as foundational in the field" (Freeman, p. 114). Edward Laumann got his Ph.D. at Harvard in 1964 and went to work at Chicago, joining Peter Blau and James Davis. Laumann, it turns out, had learned about Warner's structuralist approach and, says Freeman, "like Arensberg and Chapple before him. . . set out to make it more systematic" (p. 115). Laumann has since trained a generation of prominent network scholars, including Ronald Burt, Joseph Galaskiewicz, Alden Klovdahl, David Knoke, Peter Marsden, and Martina Morris.

In Amsterdam in the late 1960s, Robert Mokken, a mathematical statistician, worked with a computer programmer, Jac Anthonisse, and a graduate student in political science, Frans Stokman. This group produced a network study on the power of interlocking directorates in Holland that got major press coverage there. By the mid-1970s, the group had also produced computer programs that generated graphs from a set of relations. Like so many other groups, the work of these Dutch scholars contained all four components of modern SNA. Unlike other work before it, the work in Amsterdam has been widely recognized and continues to this day.

"The overall pattern," says Freeman, "seems to be one in which each succeeding contribution [during the dark ages] introduced a new segment of the social science community to the structural perspective. But at the end of the 1960s, no version of network analysis was yet universally recognized as providing a general paradigm for social research. By then, however, the broad community of people engaged in social research was ready to embrace a structural paradigm" (p. 120).

4. Coming of age

Chapter 8 deals with what Freeman calls the renaissance at Harvard and Harrison White's singular role in the development of modern SNA. White earned his first Ph.D. in 1955 at MIT in theoretical physics. He had taken a course with Karl Deutsch and found that the same tools one would use for analyzing electrical circuits could apply just as well to interactions among people. White did a second Ph.D., in sociology, at Princeton in 1960, but had been hired at Chicago a year earlier to teach courses in mathematical sociology. During his years at Chicago, White wrote Anatomy of Kinship, extending Lévi-Strauss's and Weil's work and also began his study of how people move from one job vacancy to another within a profession. (White's student at Harvard, Mark Granovetter, would extend this work and develop the strength-of-weak-ties theory (Granovetter, 1973).

White moved to Harvard in 1963 and began teaching network analysis. Freeman's list of White's students who are active network analysts is simply astonishing and makes his

influence on the field clear: Peter Bearman, Paul Bernard, Phillip Bonacich, Scott Boorman, Ronald Breiger, Kathleen Carley, Ivan Chase, Bonnie Erickson, Claude Fischer, Mark Granovetter, Gregory Heil, Joel Levine, Siegwart Lindenberg, François Lorrain, Barry Wellman, and Christopher Winship. Freeman credits Harrison White with establishing the field of social network analysis. He makes clear that White and his students are "not the only ones who could lay claim to the social network approach," but says that "certainly the majority of the published work in the field has been produced by White and his former students" (p. 127).

In Chapter 9, Freeman describes what I think can fairly be called the small miracle of SNA coming of age. He asked 21 of the people whose work he describes as leading up to the modern synthesis to list the literatures and people who influenced them. The 21 scholars listed a total of 68 influentials, 49 of whom are mentioned once and only two of whom (Moreno and Harary) more than three times. There was simply no agreement about the intellectual foundations of modern SNA. Furthermore, the co-citations that do exist form two loose cliques that are almost entirely separated. (Freeman displays this dramatic result graphically, of course.)

Under these conditions, says Freeman, we expect, from Kuhn's work, for competing scholars to bicker over claims to priority. Instead, throughout the 1970s, 1980s, and 1990s the modern field of SNA developed into a normal science—one in which cumulative knowledge is produced by a community of scholars who read and build on each other's work.

In fact, says Freeman, this is all still happening today. Beginning in the late 1990s, a group of physicists discovered that the structural properties of social groups are an interesting part of nature, and began publishing on the small-world problem in journals typically read by scholars in their own field. There was, of course, a substantial literature in the social sciences on the small-world problem, but, the two groups of scholars (those in the emergent SNA field and those in physics), according to Freeman, "cite others in their own community about 98% of the time" (p. 165). This, he said, leads to "reinventing existing tools and rediscovering established empirical results" (p. 166), but, Freeman asserts, as it had earlier, the modern field of SNA is incorporating this new group of scientists, some of whom are now publishing in Social Networks and other social science journals and joining sociology departments. If the trends that he documents in this book continue, says Freeman, "it will not be long until the physicists who do social network analysis are fully integrated into the larger social network community" (p. 167).

The field of SNA became so thoroughly inclusive, says Freeman, through a series of conferences, the founding of a journal, the development of a Ph.D. program devoted to SNA, the production of easily transported computer programs for analyzing and visualizing structural data, and the development of an international organization.

The conferences brought people from different traditions together, physically and electronically. The 1975 conference at Dartmouth, for example, brought together sociologists, anthropologists, social psychologists, and mathematicians from the United States and Europe. Linton and Sue Freeman's NSF-funded experiment, from 1978 to 1981, with an early e-mail system called EIES, brought together 40 network analysts, from across several disciplines. We take e-mail and listservs for granted today, but it was quite revolutionary in 1978. It was a kind of permanent conference, and it gave all of us who were fortunate enough to be in it an introduction to one another's work. The Sunbelt Social Network Conference,

founded in 1981 and going strong today, developed from conversations held on that early e-mail system.

Freeman gives greatest credit for unification of the field to Barry Wellman, founder of INSNA the International Network for Social Network Analysis and its newsletter (and now fully fledged journal), Connections. It was Wellman who brought the Sunbelt Social Network Conference into INSNA, and both the conference and the organization have given colleagues from many disciplines and many countries a place in which to exchange ideas and develop a unified and cumulative science of structural analysis.

5. Freeman's own influence

But Freeman's own influence in the development of the field cannot be overestimated. He founded the journal, *Social Networks*, in 1978. The lead article of the first issue—a fugitive paper, written 20 years earlier, by Pool and Kochen, on the small-world problem and the structure of acquaintance networks—made quite a statement. This new field of social network analysis was to be an interdisciplinary, cumulative science. The following year, 1979, Freeman went to the University of California at Irvine as dean of the social sciences and with a mandate to establish an interdisciplinary Ph.D. program in SNA. And in 1983, he was one of the authors of UCINET, the suite of programs that has become the dominant player in the field (Borgatti et al., 2004).

Freeman continues to contribute to the integration of the field—most recently with the publication of this remarkable little book. Every senior student of social network analysis will recognize his or her own intellectual journey in it. More important—much more important—this book will make it difficult for new generations of students to imagine their own discipline and their own tutors as the center and beginning of things. It will give new students a choice of points from which to embark and a choice of bearings from which to plot a career.

We don't know what the next generation of network researchers will do. It's a good bet, I think, that more studies will be done on what differently shaped networks cause (if anything), as contrasted with what causes those different shapes to emerge (the dominant intellectual concern up to now). And it's a good bet that we'll see more research on personal networks, as contrasted with studies of whole networks (another dominant intellectual concern up to now). But whatever happens, when the next history of the field is written, Freeman's book will still be essential reading.

References

Bienaymé, I.-J., 1945. De la loi de multiplication ed de la durée des familles. Bulletin of the International Statistical Institute 40, 1055–1057.

Borgatti, S., Everett, M.G., Freeman, L.C., 2004. UCINET 6.69. Analytic Technologies, Harvard, MA.

Bott, E., 1957. Family and Social Network. Tavistock Publications, London.

Chapple, E., 1940. Measuring human relations: an introduction to the study of the interaction of individuals. Genetic Psychology Monographs 22 (1), 3–147.

Chapple, E., 1953. Discussion of patterns in biology, linguistics, and culture. In: Tax, S., Eisley, L.C., Rouse, I., Voegelin, C.F. (Eds.), An Appraisal of Anthropology Today. University of Chicago Press, Chicago, pp. 299–321.
Davis, A., Gardner, B.B., Gardner, M.R., 1941. Deep South. University of Chicago Press, Chicago.
Flament, C., 1963. Applications of Graph Theory to Group Structure. Prentice-Hall, Englewood Cliffs, NJ.
Freeman, L., 2003. Finding social groups: a meta-analysis of the southern women data. In: Breiger, R., Carley, K., Pattison, P. (Eds.), Dynamic Social Network Modeling and Analysis. The National Academies Press, Washington, DC, pp. 37–77.
Freeman, L.C., Bloomberg Jr., W., Koff, S., Sunshine, M.H., Fararo, T.J., 1960. Local Community Leadership. Syracuse University College, Syracuse, NY.
Freeman, L.C., Fararo, T.J., Bloomberg Jr., W., Sunshine, M.H., 1962. Metropolitan Decision Making. Syracuse University College, Syracuse, NY.
Freeman, L.C., Fararo, T.J., Bloomberg Jr., W., Sunshine, M.H., 1963. Locating leaders in local communities. American Sociological Review 28, 791–798.
Granovetter, M., 1973. The strength of weak ties. American Journal of Sociology 78, 1360–1380.
Hägerstrand, T. 1952. The Propagation of Innovation Waves. Lund Studies in Geography, Series B, vol. 4.
Hobson, J.A., 1894/1954. The Evolution of Modern Capitalism; A Study of Machine Production. Allen and Unwin, London.
Huber, P., 1802. Observations on several sprecies of the genus Apis, known by the name of humble bees, and called Bombinatrices by Linneaus. Transactions of the Linnean Society of London 6, 214–298.
Lévi-Strauss, C., 1949/1969. Elementary Structures of Kinship. Beacon Press, Boston.
Moreno, J.L., 1934. Who Shall Survive?. Nervous and Mental Disease Publishing Company, Washington, DC.
Moreno, J.L., Jennings, H., 1938. Statistics of social configurations. Sociometry 1, 342–374.
Morgan, L.H., 1871 [1997]. Systems of Consanguinity and Affinity of the Human Family. University of Nebraska Press, Lincoln.
de Sola Pool, I., Kochen, M., 1978. Contacts and influence. Social Networks 1, 5–51.
Rapoport, A., 2000. Certainties and Doubts. Black Rose Books, Montreal.
Rapoport, A., Horvath, W.J., 1961. A Study of a Large Sociogram. Behavioral Science 6, 279–291.
White, H., 1963. Anatomy of Kinship. Prentice-Hall, Englewood Cliffs, NJ.

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