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The Nature of Networks

Theory and research in social networks are far from monolithic. Instead, there are a variety of network theories, a number of basic concepts, and also a set of shared principles. Together, these constitute what many have termed the network perspective. The purpose of this chapter is to lay out and illustrate some fundamentals of a network perspective. To this end, we will both highlight the features of this perspective that are distinctive and also explore the commonalities and overlap with similar approaches. Particularly important is how network research strives to move beyond the reduction of information to an individual-level trait. Instead, the network approach focuses more on the ties themselves, examining the composition of networks (e.g., are they made up of family members, friends, coworkers?), the nature of relationships and exchange between members of a network (e.g., do members of a network share information, resources?), and the structural positions of various actors (e.g., does a person have influence by virtue of direct or indirect access to others?).

1.1 WHAT ARE NETWORKS?

Simply stated, a network is a "set of actors and the ties among them" (Wasserman & Faust 1994) or "nothing more than a collection of objects connected to each other in some fashion" (Watts 2003a: 28). Social networks have also been termed the "structures of relationships linking social actors" (Marsden 2000: 2727). These relationships or ties are the most basic components of social experience, mapping the connections that individuals have to one another (Pescosolido 1991). The networks perspective is, if not unique, distinctive in that it embeds individuals and their

decisions, outcomes, and life chances in the larger social context of relationships, group membership, and community.

Doing network research requires a different way of thinking about how any phenomenon works. All network theories directed toward human action are based on a fundamental premise: social ties and interactions, rather than individual actors, represent a major "engine of action" underlying behavior. And while actors can be humans, network theories are not restricted to them, and can include larger social units like families, organizations, and nations, or smaller social units like insects, neurons, or proteins. So, the structure of ties between and among countries are critical in determining the global balance of economic and political power. Even at the molecular level, proteins interacting with other proteins in biological organisms, or even brain loci sending signals to other loci, may be just as important for understanding disease as traditional structures. For the sake of simplicity, we concentrate primarily on the nature of human actions, including the institutions and places that they build.

Thus, despite all differences in training, interests, or level of analysis, what network scientists share is the fundamental proposition that connectedness represents a basic vector of action. This means networks cannot simply be added as one more variable in a traditional model: use of the network paradigm changes the very nature of the model itself. Moreover, it is not one more utility in an economic cost-benefit analysis; it is not one more motivational factor that matters for action. Rather, it is a differential point of departure for theorizing, for thinking about data collection, and for doing analyses.

1.2 NETWORKS AS METHOD AND THEORY

In the field of network science, there has historically been a tension between the primacy of method and theory. On the one hand, network science is often seen as an analytic method, a tool for analyzing data. Network science *does* provide solutions to the analytic challenges posed by relational data. Typical linear regression models are often not appropriate for network data because these violate the assumption of independent observations. Networks imply the opposite – cases are, by their very nature, interdependent or connected. Thus, even from the earliest days when quantitative network data were collected, questions have arisen about how such data should be analyzed.

On the other hand, many researchers consider social networks to be a theoretical perspective that lends itself to many different kinds of

analysis (Borgatti & Halgin 2011). Networks as theory are based on the fundamental premise that interconnectedness represents the mechanism of action. In other words, social interaction, rather than individual motivation, calculation, or beliefs, are the principal bases of behavior. Individuals shape their everyday lives through consultation, suggestion, support, and nagging from others, not to mention conflict and competition. Furthermore, this perspective suggests that social networks set a context in formal organizations and institutions that influences what people do, how they feel, and what happens to them. Finally, network theorists observe that the patterns of relationships among actors – who is connected to whom and in what ways – has important consequences, determining what and how much is shared or flows from person to person in a network, and how much power or advantage individual actors possess. More generally, the position of individuals in a social network is thought to determine, in part, the opportunities and constraints they will encounter.

In reality, networks as method or as theory are mutually reinforcing propositions. Network science requires a new toolbox precisely because it brings to the table a different explanatory perspective. At its core, network science is about connectedness and its implications not only for individual actors, but also for the networked system as a whole. It shifts the focus from an object-oriented to an interaction-oriented approach. When considered broadly, a network science perspective can be applied to virtually any substantive area in which two or more actors or objects interact, from biological brain networks to global transport routes, making it extremely powerful. The most pressing challenges of our time, including technological, demographic, and environmental changes, are in complex systems where underlying interconnections and interdependencies are the key to scientific understanding and real-world solutions.

1.3 THE BUILDING BLOCKS OF NETWORKS

To provide a foundation for the remainder of the book, we briefly present some of the more frequently referenced terms here. This is neither an exhaustive nor a technical lexicon of network terminology; rather, the goal is to provide an orientation to network language and its basic variants (also see Monge & Contractor 2003). As required in the chapters that follow, these terms will be reintroduced, expanded, or illustrated. Others will be newly introduced in more complex or sophisticated nominal and operational definitions.

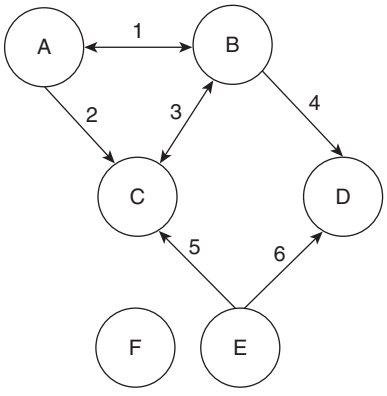

FIGURE 1.1 Representation of network ties in a sociogram

- ***Network diagram***: A network diagram, also called a sociogram, is a picture of the relationships among members in a social network. Figure 1.1 is a network diagram.
- ***Node***: The term "node" (alternatively "actor" or "agent") refers to the units that are connected through networks. In the social sciences, nodes typically refer to individuals, but may be families (Padgett & Ansell 1993), organizations (Galaskiewicz 1985), nations (Alderson & Beckfield 2004), or any other entity that can form or maintain formal (e.g., legal, economic) or informal (e.g., friendship, gossip) ties. In Figure 1.1, the circles labeled A through F represent "nodes."
- ***Ego and alter***: We use "ego" throughout the book to refer to any node that is the current focus of attention. In ego network research, ego is the respondent. We use the term "alter" to refer to any actor with whom ego has a tie.
- ***Ego network***: An ego network (also called a personal network or egocentric network) consists of the alters connected to ego, along with the ties between ego and alters, and ties among alters. When we refer to a person's network in this book, we mean their ego network.
- ***Ties***: The network connections between and among actors are referred to as "ties," "links," or "edges." Ties can be directed (i.e., sent or received) or not directed (e.g., joint organizational memberships). In Figure 1.1, a tie is sent from B to D; D receives a tie from E; and A and B send and receive ties to each other. Double-headed arrows indicate "bidirectional," "symmetrical," or "reciprocal" ties. Ties may be binary (present/absent) or

	A	B	C	D	E	F
A	0	1	0	0	1	1
B	1	0	1	0	0	1
C	0	1	0	1	1	0
D	0	0	1	0	0	1
E	1	0	1	0	0	0
F	1	1	0	1	0	0

FIGURE 1.2 Matrix representation of a network

measured on a scale, as in duration or strength of tie. In Figure 1.1, ties are depicted using lines 1 through 6.

- ***Adjacency matrix*:** Network ties are often recorded as a square actor-by-actor matrix. A value in a given cell of the matrix indicates that there is a tie from the row actor to column actor (ties received; see Figure 1.2).

1.4 PRINCIPLES OF A NETWORK PERSPECTIVE

Our shared position is that network science is a perspective or framework that can be tailored to generate theories applicable to specific phenomena. The following basic principles establish key considerations in applying the network perspective to a particular substantive problem (adapted and revised from Pescosolido 2006).[1]

Proposition 1: Connections are a key mechanism of social action. Social actors, whether individuals, organizations, or nations, shape and are shaped by consultation, formal agreements, information and resource sharing, support, and regulation (White, Boorman, & Brieger 1976). Individuals are neither puppets of the social structure nor purely rational, calculating individuals. Rather, they are "sociosyncratic," both shaping and reacting to the networks in their environment (Pescosolido 1992). They are always seen as interdependent rather than independent (Wasserman & Faust 1994).

That said, differences in theorizing, while sharing this point, reflect varying degrees of structure and agency. For example, while Coleman (1986) saw all network interactions as "purposive" (under a more

[1] While these propositions build a foundation, many issues remain to be addressed in carrying them forward in the research process.

individual rational choice frame), others see "habitus" (under a cultural habit frame which sets predispositions) as playing a major role in day-to-day interactions (Bourdieu 1990). Perhaps most interesting, when considered simultaneously, these different theoretical perspectives give rise to a question: When might an actor change from habitus-driven interaction to purposive-driven interaction? For example, family history and tradition may cause a voter to generally pull a single party lever in the US presidential elections time after time. What factors would cause a shift toward a cost-benefit decision-making process? One answer postulated by network scientists would focus on change in the economic, social, and political networks that surround the individual (Beck et al. 2002).

Proposition 2: Human networks are fundamental building blocks of non-human entities such as institutions, cultures, communities, and social systems. Tilly (1984) argued that institutions and organizations represent the crystallization of network interactions that are so fundamental or routine that they shift from informal to formal structures. That is, networks set the culture within groups, formal organizations, and institutions for those who work in or are served by them. These network-based cultures, in turn, affect what people do, how they feel, and what happens to them (Pescosolido 1992). Put differently, networks can be thought of as a bridge between the macro and micro levels of society (Coleman 1990; Lin & Peek 1999). An individual's dyadic relationships provide a basis for network structures and cultures, upon which communities are built and sustained.

For example, as Glisson and Hemmelgarn (1998) demonstrated for the operation of child mental health programs, it was not the number or training of the team therapists that mattered for whether children with mental health issues improved. It was whether the network of providers created a cultural climate that allowed for flexibility, consultation, and maximizing the skills of each member. Further, as Gould (1991) showed, the preexisting network ties among soldiers, not their bravery, training, or age, determined whether they stayed at their posts or deserted them during the insurgency in the Paris Commune of 1871. Units composed of soldiers from the same neighborhoods stood their ground because of their informal bonds to each other. Other units, who were a mix of previously unconnected individuals, scattered in the face of certain defeat.

Proposition 3: Four dimensions of social networks are distinct – structure, function, strength, and content. We find it useful to think about networks

in terms of these four dimensions. Network *structure* reflects the architectural aspect of networks, including the presence and patterns of linkages between actors. This is the most typical focus of network research, and common concerns are the overall size of the network, and also how tightly knit it is (e.g., density or how well alters know one another).

However, the structure of the network reflects only one aspect of what is important about networks. Network researchers are also concerned with *function* – or the types of exchanges, services, or supports accessible through ties to alters. That is, there are specific functions that ego networks serve, including providing emotional support (e.g., care, concern), instrumental aid (e.g., lending money, providing transportation, babysitting), appraisal (e.g., evaluating a problem or solution), and monitoring (e.g., making sure a person with diabetes watches his or her diet and takes insulin shots) (Pearlin & Aneshensel 1986). As Umberson (1987) found for married men, it is not only the support that comes with marriage that is essential to men's health, but also the kind of regulatory behavior that wives exert in influencing their husbands' health habits. Although providing emotional support and caring are important, so too are nagging and monitoring.

In network research, *strength* is often conflated with function because they are closely related. After all, your strongest ties are often the people who are most willing to do things for you. Network strength captures the intensity and duration of bonds between an ego and alters within the network (Marsden & Campbell 1984). Others define tie strength using the concept of durability, arguing that strong ties are characterized by commitment to maintaining a relationship (Shi et al. 2009). An individual's strongest ties are also often those with whom contact is most regular, though distant ties can sometimes be affectively close, such as old college friends.

Finally, network *content* matters because it taps into the substance of social networks. Attitudes, opinions, and beliefs, as well as more tangible experiences and collective memory, are held within networks (Emirbayer & Goodwin 1994). Network content also provides information about actors' active or potential access to economic or cultural capital and other resources. Network content is tied to function and strength, since these properties of networks often determine whether network content like knowledge, money, and skills is actually leveraged as support provision or toward instrumental ends. Likewise, if we conceptualize the structure of the network as a set of connections between people, then content represents the types of things that flow from or to

each person. In recent social media studies, for example, examining the emotional valence of tweets led to interesting and important understandings of how political information flows across Twitter networks (Conover et al. 2011).

Proposition 4: Network effects are a function of interactions among these four dimensions. To use a biological metaphor, structural aspects of networks make up the skeleton of social relationships. In contrast, the more substantive properties of networks (i.e., the function, strength, and content) are the muscle, blood, and skin of social networks. The four dimensions interact, often in complex ways, to influence individual outcomes and behaviors. For instance, structural elements (e.g., size) and network strength (e.g., intimacy) may tap the amount of potential influence that can be exerted by the network (i.e., the "push"). However, the network's content (e.g., attitudes) and function (e.g., regulation) may indicate the direction of that influence (i.e., the "trajectory").

For example, individuals with mental health problems in Puerto Rico are less likely to access the formal health care system if they have a large social network on whom they can depend for advice and care in the community – an interaction between structural and functional components of networks (Pescosolido, Brooks-Gardner, & Lubell 1998). Among Puerto Ricans on the island, problems are considered to reside squarely in the family; it is this group that holds the responsibility for care of its members. Medical or mental health care is a last resort. This contrasts sharply with the social networks of other cultural groups on the US mainland, where Charles Kadushin (1966) documented the opposite. On the Upper West Side of Manhattan, larger weak and informal social networks, which he called the "Friends and Supporters of Psychotherapy," were likely to encourage the regular and routine use of the formal mental health system for emotional problems. More broadly, in early network research in medical sociology, considering structure alone led to contradictory findings on the importance of networks in health behavior and a near dismissal of the approach (McKinlay 1972).

Proposition 5: Network ties are not always beneficial. The early linkage of networks with social support and social capital resulted in a bias toward researching the positive functions of sociality. Studies have found that having networks can, indeed, reduce stress, lead to major employment advantages, transfer key information for migrant group

survival, and even shape identity. However, social interactions can be positive or negative, helpful or harmful. They can integrate individuals into a community and, just as powerfully, shun them. Early on, the sociologist Edwin Sutherland, in his theory of "differential association," saw interaction in deviant groups as the key to delinquency and crime. While it was later interpreted more as a learning theory of deviance, newer research has revived the role of network structure, content, and function in the criminal "career." In particular, network density and cohesion appear to be crucial to the influence of peer ties translating into delinquency during adolescence (Haynie 2001). Certainly, theories of disease epidemics target the negative implications of contact (Colizza et al. 2006), and the search for the "dark networks" of covert or illegal organizations have also clarified the multivalent nature of network ties (Bright, Hughes, & Chalmers 2012).

Proposition 6: "More" is not necessarily better with regard to social ties. Following in part from the early studies which motivated the idea that networks are positive, there was a concomitant notion that it was only the absence of ties that was problematic. But as Durkheim (1951 [1897]) pointed out, too many network ties can be stifling and repressive. Similarly, strong ties are not necessarily optimal. They can provide the emotional support that individuals need; however, they can be limiting. As Granovetter's classic work on the employment search demonstrated, "weak" ties often act as a bridge to different resources and information (Granovetter 1983). Further, the absence of ties around a person can represent an opportunity that can be exploited (Burt 1980).

Proposition 7: Networks across all levels are dynamic, not static, structures and processes. The ability to form and maintain social ties may be just as important as their state at one point in time. For personal networks, research suggests that membership turnover rates hover between 25% and 50%, while structural elements such as size tend to remain stable (Suitor & Keeton 1997; Wellman & Berkowitz 1997; Perry & Pescosolido 2012). As Moody, McFarland, and Bender-deMoll (2005: 1209) note, "... an apparently static network pattern often *emerges* through a set of temporal interactions." Importantly, failing to identify the substantive nature of this "network churn" and relying only on aggregate measures of networks as a whole produces a distorted sense of stability (Sasovova et al. 2010). The underlying reasons for change mark important dynamics in the operation of social networks. For example, in the early

stages of a crisis, such as illness, it appears that support ties are activated and networks appear to swell; but, as the crisis continues, only network members that have a specific function and a close connection tend to be retained (Perry & Pescosolido 2012). In fact, Carrington and colleagues (2005) refer to the analysis of social networks over time as the "Holy Grail" of network research.

Proposition 8: A network perspective allows for, and even calls for, multimethod approaches. Any notion that there is only one way to approach understanding the nature, functioning, and effects of network ties is outdated and inefficient. There is no doubt that mathematical and quantitative research powerfully describes the structure of networks and documents whether their effects are significant or not, in a statistical sense. However, only by tapping into qualitative research can we describe the "on the ground" mechanisms of network process and functioning. While it is important to define classic types of network research, such as egocentric or sociocentric as we do in Chapter 2, they are, in essence, ideal types on a methods spectrum. It is sometimes difficult, if not impossible, to cleanly classify a study as one or the other. And, as network science becomes more sophisticated over time, mixed designs are likely to be more commonplace.

Further, there is no standard way to collect network relationships, as both qualitative and quantitative approaches are relevant. Networks may be derived from a list on a survey where individuals are asked to name people they trust, admire, dislike, or with whom they share information. Alternatively, the information may be generated from observations of individuals' behavior (e.g., who they talk to in their work group), "scraped" from the Internet, or recorded from archival sources. For example, in Bearman and Stovel's (2000) research on how individuals were recruited into the Nazi party in the 1930s, autobiographical texts were used to identify the nature of network ties that translated into political action. In fact, as network research proceeds, the ability to draw in different kinds of network data, from different sources, will likely become an increasingly better match to the complexity of most systems and phenomena (Pescosolido et al. 2017).

1.5 MAJOR THEORETICAL TRADITIONS

There are a number of theoretical traditions in the social sciences that share a concern with connectedness, all of which have roots in Emile