A Connected World: Social Networks and Organizations

Martin Kilduff
UCL School of Management
Lei Liu
University of Exeter Business School
Stefano Tasselli
University of Exeter Business School
&
Erasmus University Rotterdam

This material has been published in *A Connected World: Social Networks and Organizations* by Martin Kilduff, Lei Liu, and Stefano Tasselli in the Cambridge University Press Elements Series
https://www.cambridge.org/core/elements/connected-world/C7FCEB101CA3FCD83A2A7DCA23F4237E

1. Introduction

Social network research provides an alternative research tradition to the focus within economics, sociology, and psychology on the demography, attitudes, and other attributes of individuals (e.g., Erickson 1988). Network research moves beyond the study of individual attributes to focus on the social relations among a set of actors, including the connections among the actors as well as the gaps where connections are missing. When we use the word "actors," we refer to individual people or to other social units such as teams (e.g., Chung & Jackson 2013) or organizations (e.g., Powell, Koput, & Smith-Doerr 1996). Because of the focus on relationships, a bounded social network (one in which we know who all the actors are -- e.g., an organizational department) is often represented as a graph in which points represent actors and lines represent connections (e.g., Mehra, Kilduff & Brass 1998), an approach pioneered in organizational behavior as far back as the Hawthorne studies (Roethlisberger & Dickson, 1939: 501-507).

Indeed, the social network tradition derives intellectual capital from the pioneering social scientists, such as Fritz Heider, Kurt Lewin, and Jacob Moreno, who applied field-theoretic ideas (heralded by Einstein and others) to social interaction. In the work of Lewin (1936), there was a prescient emphasis on a dynamic and mathematical approach to individuals embedded within the field of social interaction. Moreno (1934) initiated the idea that an individual's position in a social network exposes the individual to social influence from others. Decisions made by individuals (such as decisions by delinquent girls to run away from their group home) can be understood not solely on the basis of individual predispositions but also on the basis of social network connections. Fritz Heider, the co-translator of Lewin's (1936) book, went on to develop the parallels between mathematical representation and social interactions in his balance theory (Heider 1946; 1958). From Heider's perspective, individuals who perceive their friendship relations as unrequited, or who perceive that their friends are not friends of each other, experience a strain toward balance -- a tendency to correct these imbalanced relationships.

These advances by leading social scientists have influenced the development of social network research in terms of theory, topics, and methods. Lewin's emphasis on topology and a mathematical approach to social relations continues in the graph-theoretic basis of contemporary social network analysis (e.g., Wasserman & Faust 1994). Moreno's deployment of social network diagrams ("sociograms") to depict and clarify patterns of interaction and influence has become a leading characteristic of social network research (Freeman 2004). Balance theory has developed to include not just the cognitive perceptual field envisaged by Heider (1946) but also to include any set of influence or affect relationships that can be represented in graph-theoretic terms (Cartwright & Harary 1956; Doreian & Mrvar 2009).

In organizing this book, we describe the distinctiveness of the social network approach, cover current theoretical developments, review research methods, discuss current debates, and look to future research trends. Prior reviews provide succinct overviews of the social network approach (e.g., Brass 2022), introductions for researchers (e.g., Prell 2012), extensive coverage of methods (e.g., Scott & Carrington 2011) and coverage of specialist topics such as brokerage (Stovel & Shaw 2012) and dyadic ties (Rivera, Soderstrom & Uzzi 2010). The social network research area continues to accelerate in terms of new scholarship with recent reviews covering network brokerage (Kwon et al. 2020), gender and brokerage (Halevy & Kalish 2021), network agency (Tasselli & Kilduff 2021), the psychology of networks (Kilduff & Lee 2020), and networks in international business (Cuypers et al. 2020). In the organizations area there are distinctive social network communities devoted to research within organizations (reviewed by Raider & Krackhardt 2002) and between organizations (reviewed by Shipilov & Gawer 2020). What holds this research together so that researchers across topics and levels can communicate? The answer lies in the emergence of leading ideas (Kilduff & Brass 2010) and common methods (as incorporated, for example, in such standard software packages as UCINET -- Borgatti, Everett & Freeman 2002). Together ideas and methods constitute a dynamic program of distinctive research.

2. Distinctiveness of Social Network Research

Argument and debate drive theory and research forward (Lakatos 1970). One of the distinctive features of the social network field is the extent to which it hosts major debates concerning, for example, whether to ignore attributes of individuals to focus on structural patterns (Mayhew 1980); and whether social influence is better explained in terms of rivals in the social network striving to gain advantages over each other or in terms of connected colleagues providing help and advice to each other (Burt 1987). In this sense, social network research is characterized by a distinctive set of evolving ideas rather than paradigmatic sterility (Kilduff, Tsai & Hanke 2006). Assumptions are challenged and leading ideas renewed through contention.

Thus, social network research exhibits a coherence at its core that allows it to embrace a variety of phenomena at different levels of analysis and across substantive areas. Researchers from across social science find in network research and analysis a common set of approaches and ideas. This commonality enables dialog across divides and generates innovative research endeavors.
What, then, are the distinctive ideas that drive the social network research program? The leading, interlocking ideas that drive the organizational social network program include the following (Kilduff & Brass 2010): an emphasis on social relations as constitutive of organizational functioning; a recognition of the extent to which economic and other transactional exchanges are embedded within these social relations; an assumption that networks of relationships exhibit structural features such as clustering, gaps across clusters, and core/periphery features; and an understanding that actors' positions in social networks provide advantages and disadvantages.

2.1 Emphasis on Social Relations

Certainly, the most basic emphasis in social network research is on the importance of social relationships (Freeman 2004). These relationships between organizational actors include positive ties such as friendship (Tasselli & Kilduff 2018), advice (Krackhardt 1990), and knowledge exchange (Tsai 2001); but also include negative ties such as hindrance (Clarke, Richter & Kilduff 2021), and a

preference to avoid coworkers (Labianca, Brass & Gray 1998). Together positive and negative ties constitute the social capital potentially available to an actor, defined as the goodwill inherent in the structure and content of social relations (Adler & Kwon, 2002: 18). As James Coleman (1988: 108) noted, ties such as friendship and acquaintanceship can be appropriated for other purposes such as getting a job (Fernandez, Castilla & Moore 2000; Granovetter 1973) or facilitating team performance (Clarke et al. 2021). Ties to high status contacts can facilitate career advancement (Lin 2001) whereas ties to leaders who are peripheral in their advice networks are detrimental to an actor's level of influence (Sparrowe & Liden 2005). People who have many negative ties, relative to those who have few, are more likely to harm others and be the target of harm from others (Venkataramani & Dalal 2007).

In the modern evolution of network research, the emphasis on social relationships has expanded to include relationship change (Rivera et al. 2010). Researchers have responded to the critiques concerning the neglect of network change (Emirbayer & Goodwin 1994) with an increasing interest in network dynamics (Chen, Mehra, Tasselli & Borgatti 2022). Informal network connections are dynamic in the sense that social relationships shift and change over time as new technology is introduced in organizations (Barley 1990; Sasovova et al. 2010), as new management is appointed (Burt & Ronchi 1990), as new people are hired (Carley 1991), and as people are promoted (Podolny & Baron 1997). As networks of relationships change, our chances of becoming happy (Fowler & Christakis 2008), depressed (Rosenquist, Fowler & Christakis 2011), or obese (Christakis & Fowler 2007) also change.

In their everyday work lives, people have frequent opportunities to expand their networks by meeting new people but, it seems, relatively few people take advantage of social occasions to forge new relationships (Ingram & Morris 2007). Patterns of relationships such as friendship stabilize relatively quickly within a bounded social system (such as a student living group -- Newcomb 1961) but under the surface there is likely to be considerable movement. Some actors form stable relations but others

"dance between friends throughout the observation period" (Moody McFarland & Bender-deMoll, 2005: 1229).

The amount of churn individuals experience in their personal relations with others may derive in part from differences in underlying personality related to the ease with which individuals manage impressions and social relationships (Sasovova et al. 2010). Similarly, individuals with a propensity to engage in brokerage (Burt et al. 1998) are likely to experience considerable network change given that brokers trade across gaps in social structure (i.e., structural holes, Burt 1992) and these gaps are subject to rapid decay in competitive organizations (Burt 2002). Figure 1 illustrates some possibilities of how brokerage opportunities (structural holes) can expand, remain the same or close over time. Relations between brokers and the unconnected parties to whom they offer a service tend to be fragile in part because of distrust of brokers who benefit from others' communication difficulties (Stovel, Golub & Milgrom 2011).

[Insert Figure 1 here]

Figure 1. Brokerage opportunities change or remain the same over time.

2.2 Embeddedness

An influential review declared that "embeddedness in social networks is increasingly seen as a root cause of human achievement, social stratification, and actor behavior" (Rivera et al. 2010: 91). Embeddedness refers to the overlap between social ties and economic ties; or the nesting of social ties within other ties (Kilduff & Brass 2010). People are embedded to the extent that they show a preference for economic transactions with fellow network members (Granovetter 1985). Embeddedness, including reliance on favored contacts for buying and selling, is important to the extent that markets are inefficient (Burt 1992) but even in markets reputed to be highly efficient people tend to neglect interpersonal relationships at their peril (Abolafia & Kilduff 1988; Baker 1984). Social ties are forged, renewed, and extended through the network rather than through actors

outside the network (Uzzi 1996). Social connections between people that exist at one point in time tend to be repeated in the future (Rivera et al. 2010: 100).

People develop more embeddedness when they overlay one type of connection (such as online friendship) with another type of connection (such as face-to-face interaction) (Reich et al. 2012) -- that is, when they develop multiplex ties in which more than one relationship is involved. Partners in law firms mitigate problems of status competition among their coworkers by developing multiplex ties of advice and friendship (Lazega & Pattison 1999). Leaders of teams develop multiplex ties when they form both advice and friendship links with team members. These ties help leaders improve team performance when team social capital is otherwise impoverished (Clarke et al. 2021). People who are embedded (in terms of having large, dense, and high-quality relationships with colleagues in the workplace) tend to believe that the organization values their contributions and cares about their well-being (Hayton, Carnabuci & Eisenberger 2012). Individuals who are embedded in dense groups also tend to engage in interpersonal citizenship behaviors in organizations (Chung et al. 2011). But a pair of individuals tends to be less creative to the extent that their dyadic relationship is embedded within a dense network of common third parties – social pressure inhibits creative expression (Sosa 2011).

Firm embeddedness refers to social ties among business owners within a community. This type of embeddedness both constrains and enables firm-level outcomes (Uzzi 1997). On the plus side, social ties in a region create channels for contacts among managers and employees of firms, making it easier for firms to obtain knowledge about opportunities in foreign markets. Business relations embedded in social relations tend to affect outcomes in transitional economies relative to market economies (Luk et al. 2008). Managers rely more on relational ties as asset specificity and uncertainty increase (Zhou, Poppo & Yang 2008). But as ties become denser, there is an increasing likelihood that firms will interact only with local actors rather than pursuing foreign markets (Laursen, Masciarelli & Prencipe 2012). At the same time, potentially lucrative opportunities for entrepreneurs lie beyond embeddedness within their international communication networks (Ellis 2011).

Embeddedness inhibits opportunism according to social capital theory (Granovetter 1985). But the effects of embeddedness may be culturally contingent. A study of 192 international joint ventures found that, within collectivist versus individualist cultures, embeddedness, in the form of interparty attachments and boundary-spanning ties, was a stronger inhibitor of opportunism (Luo 2007). A related finding is that among managers, affect and cognition-based trust is more intertwined in the collectivist culture of China relative to the individualist culture of the USA (Chua, Morris & Ingram 2009). What happens when West meets East? For partnerships between Western-based and Eastern-based firms, commitment to further exchanges predicts export performance, and is itself driven by the reciprocal, reinforcing cycle of each partner's perception of the other's commitment (Styles, Patterson & Ahmed 2008).

Because organizations are dependent on each other for resources (Pfeffer & Salancik 1978) they form alliances that help them survive in competitive markets. In knowledge intensive industries such as biotechnology, firms embedded in collaborative alliances benefit from knowledge exchange that promotes learning and firm expansion (Powell et al. 1996). In these networked organizations (Powell 1990), innovation happens in the interstices between firms rather than from internal research and development (Furnari 2014). These cross-unit collaborations provide benefits to multinational organizations to the extent that they organize themselves as collaborative networks (Ghoshal & Bartlett 1990).

2.3 Structural Patterning

Following on from the discussion of embeddedness, the third leading idea that distinguishes the social network research program concerns structural patterning -- the notion that beneath the complexity of social relations there are enduring patterns that can be discovered through analysis to show, for example, how actors cluster together or how networks are controlled by a few actors (e.g., Burt & Ronchi 1990). Some social systems are organized in terms of a cohesive subgroup of core actors and a more peripheral set of actors loosely connected to the core. Where individuals are placed with respect

to this core/periphery structure affects their outcomes including their creativity (Cattani & Ferriani 2008).

Other social systems can be understood as teams of actors forming and reforming over time. The success of these teams at any point in time depends not just on the accumulation of talent and motivation inherent in the team members (their human capital) but also on the extent of "connectivity and cleavage" (Wellman 1988: 26) across the whole social system: the success of the team is dependent upon the social structure of the system within which the team operates (Uzzi & Spiro 2005).

Structural analysis reveals the patterns of presence and absence in social networks that indicate clustering, connectivity, and centralization. Block model analysis (e.g., DiMaggio 1986) and small world analysis (e.g., Kilduff et al. 2008) are configurational approaches that analyze patterns at the social network level rather than at the level of the individual (Dorogovtsev & Mendes 2003), thereby permitting the study of the whole and the parts of social networks simultaneously (Wellman 1988). Interest in the effects of structural patterning at different levels of analysis is growing. Individual attitudes, behaviors, and outcomes cannot be fully understood without considering the structuring of organizational contexts in which people are embedded; whereas social network structuring and change in organizations cannot be fully understood without considering the psychology of purposive individuals (Tasselli, Kilduff & Menges 2015).

It is worthwhile emphasizing that the social structure of networks is by no means obvious to those who are members of such networks. Individuals are often mistaken concerning the patterns of relationships that include themselves and their colleagues (Landis et al. 2018). People tend to perceive themselves as more central in their friendship networks than they really are (Kumbasar et al. 1994). They also forget casual attendees at meetings, tending to recall the meetings as attended by the habitual members of their social groups (Freeman, Romney & Freeman 1987). In one memorable example, a CEO of a troubled company that was subject to vandalism and bomb threats examined his

firm’s social network (gleaned from archival data by researchers) with bafflement. He had perceived his employees as "waves of turtles coming over the hill; hired as they made it to our door" (Burt 1992: 1). He had not noticed the networks of kin, neighbors, and friends that constituted his personnel. The CEO had no clue about the deep cleavages that existed between employees, and therefore no understanding of how redundancy notices for network leaders might affect employee action. Social network research has the possibility of emancipating people from default structural effects once structure and structural position are understood.

One of the most influential ideas in social network analysis relates to the uncovering of structural features by revealing the extent to which any pair of individuals are structurally equivalent to each other, that is, connected to the same other individuals (Lorrain & White 1971). Through structural equivalence analysis, classes of equivalently positioned individuals can be detected (Boorman & White 1976; White, Boorman & Breiger 1976). People who are structurally equivalent in terms of having similar relations to other people in advice and friendship networks tend to have similar views with respect to the organization and the support it offers to employees (Zagenczyk et al. 2010). Further, structurally equivalent employees tend to experience similar levels of emotional exhaustion at work even though their exhaustion levels are unrelated to those of their friends and supervisors (Zagenczyk, Powell & Scott 2020).

2.4 Network Outcomes

Fourth, of major importance to contemporary social network research is the emphasis on outcomes. The subfield of social capital research develops the theme that social network connections constrain and facilitate outcomes of importance to individuals and groups (Burt 2000). Debates rage over the precise meaning of social capital (e.g., Borgatti, Jones & Everett 1998) given that it can be defined as "shared norms or values that promote social cooperation" (Fukuyama 2002: 27) on the one hand and "investment in social relations with expected returns in the marketplace" (Lin et al. 2001: 19) on the other. At the individual level, social capital typically refers to the benefits that accrue from individual

network connections (Tsai & Ghoshal 1998). The value of social capital to an individual depends on the number of other people occupying the same social network position (Burt 1997) -- in this sense social capital is an arena for competition. The fewer the competitors who are structurally equivalent or who in other ways occupy the individual's place in the social system, the greater the information and control benefits of brokerage across structural holes.

We live in an age in which people accumulate hundreds of friends and acquaintances through social media (Tong et al. 2008) while at the same time people report they have fewer people in whom they can confide than was the case even a decade earlier (McPherson, Smith-Lovin & Brashears 2006). Social networks are important for survival -- people who lack social and community ties are more likely to die than those with more extensive contacts (Berkman & Syme 1979). Yet social and community engagement is declining outside the ranks of affluent young white people (Sander & Putnam 2010). It might be thought that the massive increase in connectivity since the discovery that people could connect with complete strangers through about five intermediaries (Travers & Milgram 1969) would drastically shrink the small world of interpersonal communication. But research suggests that it still takes between about five and seven intermediaries for e-mail users to reach target persons by forwarding messages through acquaintances (Dodds, Muhamad & Watts 2003).

Social capital, irrespective of definitional debates, relates to outcomes of social network positions. Two of the major outcomes of importance to human beings are health and career progress. Health outcomes are clearly related to social capital. For example, longevity in cancer patients is greater for those with larger networks, and this is especially so for younger patients (Pinquart & Duberstein 2010). People with more types of social ties (e.g., spouse, parent, friend, workmate, member of social group) are less susceptible to catching the common cold (Cohen et al. 1997). Social networks can affect health through a variety of mechanisms including social support, social influence, access to resources, social involvement, and person-to-person contagion (see Smith & Christakis 2008 for a review). However, despite the strong and reliable association between the diversity of social networks and longevity and disease risk, there is still little understanding of how interventions might influence

key components of the network to improve physical health (Cohen & Janicki-Deverts 2009). Complicating matters is evidence that the relationship between health and networks is bidirectional: health behavior also affects social networks. For example, adolescents select friends whose smoking levels are similar to their own. Rather dismayingly, the data show that adolescent smokers are more likely than non-smokers to be named as friends (Schaefer et al. 2012).

Social capital relates not just to health but also to important career issues. Bankers who have strong ties to colleagues from whom they receive important information concerning deals but whose colleagues are only sparsely connected among themselves receive high bonuses (Mizruchi et al. 2011). People who can potentially act as go-betweens for colleagues who are themselves not connected tend to have higher performance (e.g., Mehra, Kilduff & Brass 2001). As a major review of the network structure of social capital makes clear, people who develop large, sparse, nonhierarchical networks rich in opportunities to broker connections across structural holes tend to be more creative; and they tend to receive more positive job evaluations, early promotions, and higher earnings (Burt 2000). In contrast, people whose work-related networks feature dense cliques of friends tend to experience substandard performance in organizations and substandard rewards.

The contrast between brokerage and closure networks is shown in Figure 2 illustrating a situation in which Robin has taken over Jen's job. Jen had a relatively closed network, spanning across only one structural hole between groups 1 and 2. Robin restructured the network and expanded the social capital associated with the job by adding two new clusters of people in addition to the two clusters reached by Jen's network. Robin like Jen only had to manage four ties, but in the reconfigured network Robin bridges across six structural holes between the four groups. Thus, Robin's network is both more efficient and more effective than Jen's.

[Insert Figure 2 here]

Figure 2. Managing structural holes between groups.

Despite the importance of maintaining a diverse network that provides information and control benefits, the individual is also well advised to build cohesive and dense ties with the "buy-in" network -- that small group of people in the organization who have control over the individual's fate. A lack of cohesiveness among those with fate control impedes the individual's advancement, whereas the individual's average closeness to those with fate control has a strong positive effect on mobility (Podolny & Baron 1997). Cohesion is also valuable in teams. Meta-analysis shows that the higher the density of ties within the team, the more that team members commit to staying together and achieving their goals (Balkundi & Harrison 2006). But ties external to the team are also crucial. To the extent that the team leader is connected to popular team leaders within the overall organization, the team tends to be more productive (Mehra et al. 2006). More generally, teams that have numerous non-redundant connections beyond the team will have access to a broader diversity of perspectives, skills, and resources, and therefore can be expected to perform well (Burt, 2000: 398).

These leading ideas (summarized in Table 1) -- the emphasis on social relations, embeddedness, structure, and network outcomes -- will interweave throughout this review (Kilduff & Brass 2010).

[Insert Table 1 here]

Table 1. Social network leading ideas.

3. Theoretical Developments

Social network theory tends to develop through a series of juxtaposed perspectives. For example, the structural equivalence approach (emphasizing competition between rivals for the same network position – White et al. 1976) has been pitted (Burt 1987) against the cohesion approach (emphasizing cooperation among friends and acquaintances -- Coleman, Katz, & Menzel 1966). The weak tie approach (Granovetter 1973) has been challenged by the strong tie perspective (Krackhardt 1992). And the structural-hole perspective has been contrasted with closure (Burt 2005). The first debate (between structural equivalence and cohesion) has generated a fascinating body of research

concerning conflicting empirical claims (see Kilduff & Oh 2006 for a review). Recent research shows that both cohesion and structural equivalence help explain how teenagers target their aggression as they strive for social status (Faris, Felmlee & McMillan 2020). This research advances the argument, previously made by Burt (1987) that structurally equivalent alters represent rivals for the individual's social position, an argument that has the potential to be developed theoretically and empirically given the upsurge in interest in rivalry (e.g., Kilduff 2019).

We will concentrate on the second and third contrasts mentioned above because these approaches dominate theoretical framings in our literature; and resemble each other in that a bridging perspective (weak ties or structural holes) contrasts with a bonding perspective (strong ties or closure).

Indeed, in social network theory and research, there are two distinctive traditions, one emphasizing the micro dynamics of strategic engagement among people who know each other well and who work in close proximity, the other emphasizing the network structures and distant influences that inhibit and facilitate the outcomes not just of individuals but also of communities. These two traditions, which date back to Simmel and Durkheim's work, have contributed to the development of theoretical approaches that continue to inspire contemporary research in the field. We summarize a brief history of these perspectives and discuss the two juxtaposed perspectives that spring from this theoretical tension: structural-hole and weak tie theory.

The strategic engagement perspective is exemplified in Georg Simmel's (1950, originally published 1908) analysis of *tertius gaudens* -- the third who benefits from the conflict or disunity of the other two members of a three-person group. According to Simmel, "the non-partisan may... make the interaction that takes place between the parties and between himself and them, a means for his own purpose" (Simmel, 1950: 154). This strategic engagement approach can be traced forward through the work of Goffman (1969) concerning the discovery and transmission of information between individuals in face-to-face interaction; and is continued in current game-theoretic treatments of how individuals can extract profit from social network brokerage (e.g., Goyal 2007). In contemporary

social network research, it is the structural hole perspective (Burt, 1980; 1992; 2005; 2010) that most clearly exemplifies this emphasis on *tertius gaudens* strategic engagement.

Quite different in its emphasis is the community structure tradition that can be traced back at least as far as Emile Durkheim, who analyzed the ways in which individuals' most personal decisions were explicable by their location in social and societal contexts (e.g., Durkheim 1951, first published in 1897). Rather than being free to manipulate outcomes in the ways that strategic engagement perspectives suggest, the people in Durkheim's account are portrayed as fortunate or unlucky recipients of social and cultural influence. As more recent research shows, the nature of the relationship between two people reflects the structure of relations around each person in his or her own distinctive network. How two people relate to each other is not entirely within their control (Bott 1955). Further, social encounters themselves reflect numerical properties of the groups to which people belong rather than just people's own volitions (Blau 1977). As one empirical investigation demonstrated, "the greater the heterogeneity the greater are the chances that any fortuitous encounter involves persons of different groups" (Blau, Blum & Schwartz, 1982: 47). Economic migrants, who might be thought to be suffering from anomie, benefit from chains of influence involving co-ethnics within local and worldwide communities (Wellman 1979). Further, the structure of community ties is itself affected by individuals' private decisions in ways that individuals themselves are unaware of, as noted by a theorist commonly associated with the "closure" tradition of social networks. An example given by Coleman is of a family deciding to move away from a community because of a job opportunity elsewhere, a decision that severs relations with those left behind thereby potentially weakening norms and sanctions that aid parents and schools in socializing children (Coleman, 1990: 316). As this example illustrates, community members can be affected by others' decisions over which they have no control.

The community structure theme was taken up by Stanley Milgram (1967) with his emphasis on connectivity in small worlds – defined as social networks that exhibit two features rarely found together, i.e., clustering and connectivity (Kilduff et al. 2008). Small world research shows that a) that

the success of a team's artistic production depends on the overall state of community small worldedness (Uzzi & Spiro 2005); and b) that small world structures derive from chance rather than strategic action by dominant forces (Baum, Shipilov & Rowley 2003).

This Durkheimian emphasis continues in research examining how connections far removed from the individual affect the individual's loneliness (Cacioppo, Fowler & Christakis 2009) and happiness (Fowler & Christakis 2008). These outcomes are, in part, therefore, the results of individuals' placements in community structures that they cannot hope to control. This community structure perspective is prominent in the theoretical work associated with Mark Granovetter in two foundational research articles concerned with the strength of weak ties (Granovetter 1973) and the extent to which economic relations are embedded in social relations (Granovetter 1985).

Despite the clear difference between these two research traditions, one emphasizing the strategic manipulation of close network relations (e.g., Burt 1992) and the other emphasizing the embeddedness of individuals within communities (e.g., Granovetter 1973; 1985), in theory and research concerning workplace interactions, this difference has proved elusive in recent research because of the overlap between structural hole and weak tie approaches. Structural hole theory has extended and reformulated the earlier emphasis within the weak tie approach on the strength of ties (Burt, 1992: 27-28). What is of importance from a structural hole perspective is not the quality of any particular tie but rather the way different, disconnected parts of networks are bridged by individuals for their own advantage. Thus, the benefits to the individual from bridging ties are decoupled from the average strength of those ties (Podolny, 2001: 34). But this still leaves weak tie and structural hole ideas as distinctively different core principles of how social networks relate to economic outcomes (Granovetter, 2005: 35).

3.1 Development of Structural Hole and Weak Tie Theory

Structural hole theory, like every generative social theory, has shown vigorous evolution since its earlier articulation in terms of the advantage of disconnected contacts (Burt 1980). In the earlier articulation the emphasis (borrowing from Simmel 1950) was on the extent to which actors achieved autonomy by occupying positions that had many conflicting group affiliations. Prefiguring the later emphasis on how diverse contacts reduced constraint, the autonomy argument emphasized how "the pattern of relations defining the network position 'frees' occupants of the position from constraint by others" (Burt, 1980: 922). In the later development of this argument as it affected interpersonal relations, the emphasis changed from structural positions (occupied by structurally equivalent actors – Burt 1980) to individual persons; and from freedom from constraint to the contrast between constraint on the one hand and control on the other (Burt 1992). More recently, the micro-macro dynamic has, following empirical results (Burt 2007), encompassed ego within the restricted focus of his or her direct contacts, thereby eschewing implications concerning the much wider community (Burt 2010).

There is also a developing emphasis on differences among individuals' ability to recognize and take advantage of structural hole positioning (Burt, 2005: 23). People display consistency across situations in whether they build closed or open social networks, and this consistency in networking style is suggestive of individual agency in network construction. Achievement is determined by the individual's role experience and the individual's role-specific network (Burt 2012). Note, however, that despite this developing emphasis on individualism, structural hole theory envisages companies benefiting from the activities of individuals who span across structural holes in the social fabric of the organization. These network brokers are "highly mobile relative to the bureaucracy" in providing faster and better solutions (Burt, 1992: 116).

Weak ties are those characterized by infrequent interaction, short history, and limited (emotional) closeness (Granovetter 1973). Weak ties are "ideal vehicles for access and exposure to very different thought worlds -- perspectives and approaches that are not only new to the actor but that are

fundamentally different from each other" (Baer, 2010: 592-593). In the weak-tie approach (Granovetter 1973; 1983), the emphasis is on bridging to distant clusters rather than on cementing relations with close friends or kin. To break out of the comforting entrapment of one's close circle of friends and family requires contact with a quite different social circle, contact that is unlikely to derive from a strong tie given that those with whom we maintain strong ties are likely to know the same people as ourselves. It is through weak ties (such as infrequent encounters between two people in the supply chain) that novel opportunities and resources are likely to become available. A key hypothesis in weak tie theory is: "the stronger the tie between *A* and *B*, the larger the proportion of individuals in *S* to whom they will *both* be tied" (Granovetter, 1973: 1362). This is a theory about how the relationship between two people can affect embeddedness in larger community structures and how community structure can affect the fates of individuals and of the clusters to which they belong. The micro-macro dynamic in weak tie theory encompasses not just the individual, the dyad and the local cluster to which individuals and dyads belong (as in structural hole theory) but also incorporates the ways in which individuals, dyads and clusters reciprocally relate to much larger community structures.

Structural hole theory among its many other contributions is valuable for pointing out that bridging ties – whether strong or weak – are key to understanding how individuals achieve advantage in situations in which information represents a scarce resource (Burt, 2005: 18). Structural hole theory is similar to and builds on weak tie theory's discussion of the benefits of diverse information. One of the valuable aspects of Burt's 1992's explication is the differentiation of these benefits into those of access, timing, and referrals (Burt, 1992: 13-15), benefits encompassed by both weak tie theory and structural hole theory. Briefly, in terms of access, some people are better positioned than others to use their networks to screen important news and opportunities. Similarly, some people have personal contacts who provide them with information before others receive it. And in terms of referrals, some people have personal contacts who make sure their names are mentioned at the right time in the right place so that opportunities are made available. All of this is compatible with weak tie theory although the emphasis in structural hole theory is on people "who can speak to your virtues" (Burt, 1992: 15)

prefiguring the more recent emphasis on benefits that flow from the immediate set of contacts around the individual rather than from secondary and more distant contacts. Thus, according to a recent treatment of structural hole theory, being connected to other well-connected people does not benefit ego (Burt, 2007; 2010). This more recent development of structural hole theory differentiates it from weak tie theory's emphasis on benefits flowing from afar.

3.2 Juxtaposing Structural Hole and Weak Tie Approaches

Differences between the two theories relate to the emphases on control, tie strength, traversing social distance, accuracy of social perception, and micro-macro links.

3.2.1 Control

Given the emphasis on weak ties as bridging social distance, weak tie theory highlights the extent to which the social network outcomes of individual workers are typically beyond their control: "The personal experience of individuals is closely bound up with large-scale aspects of social structure, well beyond the purview or control of particular individuals" (Granovetter 1973: 1377). How important are the control benefits to the distinctiveness of structural hole theory? The theory emphasizes that "the weak tie argument obscures the control benefits of structural holes" and states that "control benefits augment and in some ways are more important than the information benefits of structural holes" (Burt, 1992: 28). It is not just that the broker pursues a strategy of extracting benefits from the existing structure of the network (spanning across existing structural holes), but rather the broker also benefits from a strategy of actively intervening to manipulate situations: "... control benefits require an active hand in the distribution of information....The *tertius* plays conflicting demands and preferences against one another and builds value from their disunion" (Burt, 1992: 34). The activities of the broker extend to changing the network to undermine others in pursuit of gain, as this quotation makes clear concerning strategies to deal with a "truculent" boss: "the player could expand the network to include someone who could undermine the boss's control, perhaps a peer or

superior to the boss who could be played against the truculent boss in a *tertius* strategy" (Burt, 1992: 67-68).

More generally, in structural hole theory, brokers manufacture holes, withdraw from relationships that are constraining, and bring in new contacts to neutralize or disadvantage those that are constraining (Burt, 1992: 230-238). This emphasis on the strategic creation of structural holes has been carried forward by others who use structural hole theory to emphasize "a more competitive orientation" in which actors "attempt to segregate information, selectively building -- as well as undermining -- trust... to increase others' dependence on them and their power in the network" (Baum, Shipilov & Rowley, 2003: 704). Thus, in contrast to weak tie theory, the *tertius gaudens* strategy involves a broker not just passively receiving benefits because of his or her structural position in the network, but a broker who strategically controls the flow of information among two or more unconnected contacts, manufactures division among alters and exploits the conditions of uncertainty, on occasion, to undermine others for personal advantage. Recent theory identifies a *tertius separans* strategic orientation by individual actors toward keeping alters separate for the benefit of ego (Burt 2021).

Thus, a major distinction between the weak tie approach and the structural-hole approach concerns the extent to which the individual is in control of brokerage. In the weak tie approach, given unclear boundaries, lack of awareness of social structure, and the general flux of social interaction characteristic of everyday life in a boundaryless world (Direnzo & Greenhaus 2011), the individual benefits to a greater or lesser extent from chance encounters that have the possibility of connecting the individual to distant social worlds from which new knowledge and creative ideas are likely to flow. In the structural-hole approach, given its emphasis on local context within which the individual is centrally located, the emphasis is on the focal individual controlling information flow between alters. In the weak tie approach, given the emphasis on bridging to distant others, there is the possibility that low status actors will benefit from connections to those of higher status. In the structural-hole approach, there is an emphasis on ways in which the absence of connections among alters can be

exploited by social network brokers for personal gain even as the efficiency of organizational processes are enhanced through their coordination efforts.

3.2.2 Strength of Tie

Structural hole theory also differentiates itself from weak tie theory through an emphasis on the strength of ties between ego and alters necessary to ensure control. From a weak tie perspective, new pieces of information – such as news about job openings, market opportunities, and resource constraints – arrive through chance meetings, such as with prior colleagues and acquaintances. As Granovetter (1973: 1372) pointed out, "It is remarkable that people receive crucial information from individuals whose very existence they have forgotten."

The structural hole approach frequently (but not universally) incorporates a sophisticated measure of tie strength in the constraint measure. This feature of the constraint measure is useful in cases where researchers follow Burt (1992) in assessing structural-hole spanning across both positive relationships and negative relationships, encompassing, for example, both "the three people you have been with most often for informal social activities" and the people who have "made it the most difficult for you to carry out your job responsibilities" (Burt, 1992: 123). Empirically, the constraint measure is based upon core relations of the individual including people who are sources of frequent socializing, advice-seeking, and buy-in (Burt 1992; 2002; 2004), corresponding to Burt's (2010: 45) theoretical focus on brokerage opportunities among "ego's close, personal relationships." Different from weak tie theory is the emphasis (embodied in the constraint measure) on both core contacts and the extent to which individuals invest network time and energy in a single core contact or a concentrated group of interconnected core contacts. This insightful emphasis on how the individual's network can be controlled by an alter goes beyond weak tie theory's emphasis on closure through transitive triads.

It is important to note that structural hole theory recognizes the value of strong connections between the focal individual and alters on the one hand (to ensure control) and the inconsequential nature of

weak ties among alters on the other. For brokers who wish to access and control information, strong ties are emphasized, as in this explanation: "A structural hole indicates that the people on either side of the hole circulate in different flows of information. A manager who spans the structural hole, by having strong relations with contacts on both sides of the hole, has access to both information flows" (Burt, 1997: 341).

Thus, strong ties facilitate ego's access and control. And weak ties among the alters do little to diminish this access and control. According to expositions of structural hole theory in several places, structural holes are not necessarily completely free of bridging connections, rather they are free of *strong connections*: "the hole is the relatively weak connection between [clusters]" (Burt, 1997: 341). Similarly, in another exposition of structural hole theory, structural holes are defined as existing when social space is spanned by weak ties: "It is the weak connections (structural holes) between Robert's contacts that provide his expanded social capital" (Burt, 1998: 9). A weak tie across alters, therefore, is treated in these explanations of the theory as no connection at all. Note, however, that weak ties from ego to alters, as in weak tie theory, are recognized as weak-tie bridges (e.g., Burt, 2005:24) whose benefits may be worthy of further research (Burt, 2002: 339). There is, therefore, some ambiguity concerning strength of tie in relation to structural hole theory, despite the clear formalization of the theory in a constraint measure that includes strength of tie as one of its components (Burt, 1992: 50-81). This ambiguity is perhaps necessary given the wide-ranging nature and generative power of structural hole theory.

3.2.3 Traversing Social Distance

A third major difference from weak tie theory is the increasing emphasis within structural hole theory placed on brokerage opportunities across an individual's immediate local social network, that is, across the structure of relations among "ego's close, personal relationships" (Burt, 2010: 45). Although early versions of structural hole theory contemplated benefits deriving from structural holes among contacts of contacts (Burt 1992), the emphasis of the theory has moved progressively toward a

micro-focus on benefits deriving only from gaps among the individual's direct contacts in the workplace (Burt 2007). Invoking the idea of "sticky information" (von Hippel 1994), structural hole theory posits that when information is moved beyond an individual's local network, the information can lose its meaning and become misunderstood or miscommunicated (Burt 2010). Due to the characteristics of the information (e.g., tacit nature) or characteristics of the people processing the information (e.g., lack of shared understanding), information can be sticky to move. Brokerage is argued to be less successful once information has to be moved beyond the immediate circle of contacts in the workplace around the individual because an individual is less likely to share vocabularies, taken-for-granted understandings or routines with socially distant contacts. Secondhand brokerage – movement of information across the disconnected contacts of alters – has a negligible association with individual performance over and above the association of direct brokerage (Burt 2007). This emphasis on direct brokerage between the focal individual and his or her alters is different from the emphasis within weak tie theory.

From the weak tie perspective, a bridge between two individuals does not have to be the only social path connecting them. What is important is that the bridge functions as a vital link on the shortest path, contributing significantly to the ease with which people in distant parts of the network reach each other. An important insight of weak tie theory is that "long" spanning ties (i.e., ties that span between individuals far removed from each other in the social network) tend to be weak (Centola & Macy 2007) because strong ties, relative to weak ties, are at a higher risk of social closure. Presciently, weak tie theory in its earliest formulation (Granovetter 1973), linked Milgram's (1967) work on small-worlds to weak ties, noting how distant individuals are more likely to be reached through acquaintances than friends – an insight replicated in more recent small-world research (e.g., Dodds et al. 2003). In small-world terminology, "long-range shortcuts" (Watts, 1999: 511) tend to be weak ties, connecting what would otherwise be distant parts of a network involving long path lengths. It is this short access across social distance that gives rise to network advantage in terms of receiving distant information or influence (e.g., Lin et al. 1981; Montgomery 1992; Yakubovich 2005).

Whereas weak tie theory zooms out to emphasize distant connectivity beyond ego's immediate cluster of close relationships, structural hole theory zooms in to focus on the local social network surrounding ego. Emphasizing control benefits through brokerage, a bridge in structural hole theory is about spanning the missing relation between two alters rather than spanning social distance. The theme of planned, active maneuvering and negotiation to control the flow of resources across un-connected alters for personal benefits is strong in the structural hole approach (Burt 1992; Fernandez & Gould 1994), which stands out against the role of serendipity in the weak tie approach. Returns to strategic brokerage hinge on the ego-alter sharing of "concerns, unspoken assumptions and vocabularies" (Burt, 2010: 46) -- understandings more likely to be shared among direct close alters than socially distant alters; as such, secondhand brokerage fails to yield rewards since the lack of understandings inhibits the movement of information across socially distant alters (Burt 2007). Thus, weak ties connect the individual (and individual clusters of people) to distant social sources of distinctive information (Centola & Macy 2007) whereas in the structural-hole account, it is the local network surrounding the individual employee in which opportunity is there to be exploited (Buskens & van de Rijt 2008).

3.2.4 Acuity

Fourth, structural hole theory attributes to brokers a "vision advantage" (Burt 2004) such that brokers "are able to see early, see more broadly, and translate information across groups" (p. 354). Brokers, because of their network position, have greater acuity in network perception. Empirical research on network perception has shown that individuals who report experience spanning across structural holes are, indeed, more accurate in perceiving and remembering gaps in networks (Janicik & Larrick 2005). The weak tie approach, by contrast, assumes no such advantage. Rather, individuals tend to be embedded in their local clusters to the extent that they are unable to perceive community structures of relevance to their aspirations and futures (Granovetter 1973; 2005). It is precisely because of this embeddedness that weak ties are so valuable in potentially opening channels to hitherto unknown groups and sources of information and ideas.

Relative to the structural hole approach, therefore, there is less emphasis in weak tie theory on individuals accurately perceiving the structure of social networks in which they are embedded, an accuracy that would seem to be required for the manipulation and control of networks in the structural hole approach.

3.3 Micro-Macro Links: From Juxtaposing to Integrating the Two Theories

If advantage in the structural hole approach derives from brokerage in ego's immediate network of alters, then it is not surprising that its theoretical lens centers on local networks and local outcomes (Burt 2010). Central to weak tie theory, however, is the exploration of how local, micro relationships lead to global, macro patterns (Granovetter 1973). If weak ties are less prone to triadic closure and, thus, span greater social distance, then they are more likely to serve as the crucial informal connections helping to hold together separated business units within an overall collectivity. Formation or deletion of weak ties at the local level can therefore have significant consequences on structural integration or fragmentation at the global level. Local processes such as formation of weak ties, for instance, have been characterized as contributing to the formation of a small-world at the global level, where highly clustered groups are connected by short path-lengths (Dodds et al. 2003; Robins, Pattison & Woolcock 2005). Thus, a powerful contribution of weak tie theory is in explaining how local network changes shape global network connectivity, a point less emphasized in structural hole theory.

Weak tie theory has always had a double focus: a micro focus on the strength of the direct tie between the individual and that individual's contacts within and beyond the workplace; as well as a more macro focus on the structure of ties across the whole community of interests that constitutes the modern firm. It is this double focus that gives the theory much of its distinctiveness -- it is one of the few social theories that compellingly relates the activities of individuals to the fates of communities. Extending the theory to the situation of people within an organizational unit who develop strong ties

of cohesion among themselves, even in the face of pressures toward globalization, we can say that this internal bonding restricts the opportunities available to each employee of that unit. Relatedly, if each employee exclusively restricts himself or herself to strong tie attachments, then this reduces the resilience of the business unit in the face of unexpected jolts because the business unit will not have allies elsewhere in the wider organization or in the value chain (Krackhardt & Stern 1988).

The causal mechanisms in weak tie theory are different from those posited in structural hole theory. At the individual level, it is access to socially distant resources that provides the individual with advantage in the weak-tie account. At the community level, it is integration through weak ties across fragmented social groups that provides resilience in the face of threats to the social order and persistence of the community. But this is quite different from the active brokerage posited by structural hole theory that anticipates the individual controlling the flow of information between disconnected alters.

In sharpening the distinctions between weak tie approach and the structural hole perspective, we can ask the question: how do the classic themes of strategy and serendipity play out in the pursuit of advantage? What, for example, would a strategic approach involve from a weak tie perspective? One of the advantages of weak ties is that they require lower time commitments relative to strong ties, and, thus, increase the occurrence of serendipitous encounters (for which there is more time, and concerning which there is more likelihood). Thus, one possible weak tie strategy would be for individuals to develop many weak ties, not knowing which ones might or might not connect to socially distant sources of diverse information and opportunity. This "real options" approach helps hedge against uncertainty concerning how the network and the competitive landscape evolve (Gulati, Nohria & Zaheer 2000).

We have already discussed the emphasis within the structural hole approach on the strategic manipulation of ties, but we can say a little more in the way of clarifying theory. There is a consistent emphasis within structural hole theory on brokers as active agents striving for advantage, as

exemplified in this quotation: "people with networks rich in structural holes are the people who know about, have a hand in, and exercise control over, more rewarding opportunities" (Burt, 2005: 18). But structural hole theory also incorporates the likelihood that individuals in positions that span across structural holes are at risk of good ideas and rewarding opportunities even if they fail to recognize these ideas and opportunities or choose to pursue them. The emphasis on strategic agency does not rule out the possibility that agency can benefit from serendipity. Given the considerable churn in even the close ties of organizational members (Sasovova et al. 2010), this "pulsing swirl of mixed, conflicting demands" (Burt, 1992: 33) requires on the part of network brokers an active manufacturing of bridges: "Where structural holes do not exist, they can be manufactured, or their absence can be neutralized" (Burt, 1992: 230).

Further, structural hole theory advocates the principle of divide and rule, building on the work of Merton (1968: 393-394) and Simmel (1950: 185-186). From this perspective, the broker manufactures competition between alters to establish control by creating conflict where it otherwise might not exist: "Make simultaneous, contradictory demands explicit to the people posing them, and ask them to resolve their – now explicit – conflict. Even where it doesn't exist, competition can be produced by defining issues such that contact demands become contradictory and must be resolved before you can meet their requests…. if the strategy is successful, the pressure on you is alleviated and is replaced with an element of control over the negotiation" (Burt, 1992: 31). The promotion of latent conflict and competition and the guarding against possible collaboration by alters (Burt, 1992: 30-32) differentiates the structural hole approach from the emphasis on serendipity characteristic of weak tie theory.

The architecture of the ideal organizational network suggested by both weak tie theory (Granovetter 1973) and structural hole theory (Burt, 2005: 12-13) resembles a small world of cohesive clusters (that represent distinctive sources of knowledge, opportunity, and resources) connected by bridges across which knowledge, opportunity and resources can flow. However, because weak tie theory emphasizes information from afar, whereas structural hole theory emphasizes local control of

disconnected alters, there may be different implications depending upon which theoretical lens is adopted. To the extent that strong ties are the focus of structural hole theory, the implications of weak ties may be missed. Weak ties are not means through which ego controls alters, but they may well be pipes through which resources temporary or consistent flow (Hansen 1999). They may be present but unseen in networks exhibiting apparent structural holes, thereby limiting the information benefits to ego and reducing the extent to which control is possible.

An important difference between the two approaches, from a configuration aspect, is that the weak tie approach posits the possibility of information and resources flowing from afar across unclear boundaries, whereas the structural-hole approach seems to require a well-bounded social network within which the network broker can operate. Thus, structural hole theory has found a natural home in the analysis of social networks within bounded business units (Burt 2007), whereas weak tie theory has been applied to situations such as labor markets where the boundaries of opportunity from the individual's perspective are unclear (e.g., Montgomery 1992). In the boundaryless modern workplace, it may be possible for an updated weak tie theory to help us understand how careers develop and resources flow as vertical, horizontal, external, and geographical organizational boundaries are minimized, and as people pursue advantage both within and across current employers (Arthur & Rousseau 1996).

4. Social Network Research Methods

4.1 What Kind of Research Do You Propose?

As with any research initiative, a social network research endeavor can proceed according to different underlying assumptions. Being clear about the kind of research you are engaged in can facilitate progress and reduce misunderstanding among members of the research team. There are four basic types of research endeavor, organized according to questions concerning epistemology and ontology. The four approaches are illustrated in Figure 3 that poses two questions as you begin your research journey: Are you trying to move closer to the truth about the world? And: do you believe the theory

you are working with represents reality? Because the study of organizational social networks is a fertile research arena, in which new studies contribute to the sophistication of existing theoretical approaches in answering an evolving set of questions, knowing which epistemological approaches help answer these questions is fundamental for researchers to select the appropriate research methods to conduct their research. In this section of the book, we present the rationale behind the four approaches. Then, we discuss basic methodological choices that researchers interested in social network analysis must face.

[Insert Figure 3 here]

Figure 3. Four different approaches to social network research.

4.1.1 Structural Realism

First, if you are intent on uncovering basic truths about social network structure, then you are engaged in a structural realist pursuit and your answer to the two questions is in the affirmative as Figure 3 shows. Structural realism is exemplified in the mathematical social network research of Lorrain and White (1971) who discovered how complex crisscrossing patterns of relationships can reduce to simpler subsets to reveal unexpected similarities between people. Their discovery of structural equivalence provided the basis for blockmodel analysis which reduces relatively incoherent social networks into more readily interpretable patterns. For example, the patterns of inter-marriage and economic relationships among Florence's 92-family ruling elite during the 15th century can be simplified through block-modeling to reveal how the Medici family, and in particular Cosmo de' Medici, exploited network disjunctures to increase family power and control (Padgett & Ansell 1993). A much different use of the structural equivalence idea exemplified the snowball effect – the process by which employee turnover occurs in clusters of employees who see themselves as occupying similar informal roles in the workplace communication network (Krackhardt & Porter 1986). Structural realist research represents basic science and usually, as in the case of Lorrain and White (1971), involves a mathematical analysis.

4.1.2 Instrumentalism

A very different approach to research is identified in the bottom right corner of Figure 3 in the form of instrumentalism, also known as problem solving and pragmatism. For many people, the goal of science is to solve problems (Laudan 1977). Questions of the truth or falsity of theories are irrelevant. Scientific theories are useful instruments in helping predict events and solve problems (Cartwright 1983; Friedman 1953). As Rob Cross and colleagues explained, "Social network analysis can be an invaluable tool for systematically assessing and then intervening at critical points within an informal network" (Cross, Borgatti & Parker, 2002: 26). For example, the problem might be how to get ahead in the modern corporation. One answer would be to span across the gaps in the social structure to gain nonredundant knowledge (Burt 1992). Or, if you are manager of a subunit, you might be faced with the problem of how to gain access to sticky knowledge circulating within other subunits. The answer would be that weak ties are perfectly adequate for the transfer of standardized formulaic information, but strong ties are needed for the transfer of complex knowledge (Hansen 1999). These influential research endeavors provide specific and valuable answers to important questions.

4.1.3 Foundationalism

A third approach to the science of social networks is provided by foundationalism, captured in the bottom left-hand corner of Figure 3. Foundationalism emphasizes induction, that is, the surfacing of processes and structures otherwise invisible. Patterns emerge from the analysis of data according to this scientific approach. The possibility of gathering huge data sets and studying them with high-powered computers gives new impetus to this approach and has fueled the speculation of a post-theory scientific revolution (Spinney 2022). Social network researchers apply their tools to huge data sets that represent interactions on the World Wide Web and neurological networks (e.g., Dorogovtsev & Mendes 2003). These analyses of millions of connections are typically billed as exploratory, meaning that theory emerges from data (e.g., Ogle, Tenkasi & Brock 2020).

4.1.4 Paradigm Extending

The fourth approach, paradigm extending, in the top right-hand corner of Figure 3, differs in that theory drives the search for issues to study. This approach derives from the influential work of Thomas Kuhn concerning the extent to which mature sciences exhibit a distinctive set of taken-for-granted ideas, a community of interacting researchers, specialist conferences, and dedicated journals. Social network research has achieved paradigmatic status according to some leading figures (Hummon & Carley 1993). If your research endeavor involves working within the assumptions of a leading theory such as structural hole theory, then your work is paradigmatic. For example, perhaps the puzzle you address is whether social network brokers benefit from second order social capital, i.e., from spanning structural holes between contacts of your primary contacts? This effort helps refine and extend structural hole theory. Indeed, relevant research on this puzzle shows that returns to brokerage are predominantly derived from spanning primary structural holes, i.e., those that separate the people you are directly connected to (Burt 2007). But second-order social capital does matter, when these second-order contacts are with senior brokers (Galunic, Ertug & Gargiulo 2012).

Being clear concerning the purpose of your research facilitates the choice of theory, data, and methods. If your goal is to uncover the basic fabric of social network reality, then your choice of methods probably involves advanced mathematics. If your goal is to find patterns in mountains of data, then your goal is best served by atheoretical data mining associated with foundationalism. The pragmatic goal of solving an outstanding problem for an organization allows you to call upon any theory and any method that promises better predictability. But if you seek to contribute within the paradigm of existing theory, then the ideas and methods associated with that theory are to be preferred. In the next set of sections, we provide a guide to some of the basic tools and empirical approaches used by social network researchers, starting with the visual presentation of social networks.

4.2 Visualization Using Graphs

Imagine that your research project requires you to represent the friendship network among employees within an R&D department and to understand the connections between this network and the innovation activities of the firm. You have already thought through the theoretical approach that can help you approach your research question. Now, it is time to think about methods and visualization. How do you go about doing this? One intuitive way to represent any set of relationships among people is to draw a graph. Graphs have long been used for the visualization of social network relationships (e.g., Roethlisberger & Dickson 1939) but they also capture the data necessary for systematic analysis. The theory of graphs provides systematic vocabulary and mathematical operations to describe, denote, and quantify network structural features (Harary, Norman & Cartwright 1965). In this section, we illustrate basic graph theoretical concepts.

In a graph, *nodes* (or *points* or *vertices*) represent actors in a social network, e.g., Avery and Chris in Figure 4a. *Ties* (or *lines* or *edges*) between two nodes represent social relations, e.g., friendship in this case. Two nodes are *adjacent* if they are directly linked by a tie, and the number of adjacent nodes is called the *degree* of a node. For example, in Figure 4a, Jack is adjacent to Chris, Carol, and Michael. Jack has three connections, hence a network degree of three.

Ties within a specific graph represent a single type of relationship. For example, a friendship network is represented in Figure 4a, whereas Figure 4b represents a task communication network. Some types of social relations, such as *talks with*, tend to be reciprocated, whereas other types of social relations, such as *gives advice*, are directed from one person to another person without reciprocation. An example of a directed tie is represented in Figure 4c in which the one-way arrow from Avery to Jack shows the flow of advice. If two persons, such as Avery and Emily, advise each other, the tie is represented by a double-headed arrow.

[Insert Figures 4a, 4b, & 4c here]

Figure 4a. Friendship network.

Figure 4b. Task communication network.

Figure 4c. Advice giving network.

Some actors have no direct ties between them but can still connect via others. For example, in the communication network in Figure 4b, Avery and Jack are not connected, but information can still flow between Avery and Jack via Emily. Thus, Avery-Emily-Jack forms a *path*, namely a sequence of nodes without revisiting. This path is the shortest one between Avery and Jack and is defined as the *geodesic distance* (or *distance*) between them.

The information in graphs is captured mathematically in *adjacency matrices*. For example, Figure 5 contains the data represented in Figure 4c. In an adjacency matrix, nodes are represented by rows and columns. The tie from node *i* to node *j* is indicated by the entry in row *i* and column *j*. For example, Avery's advice-giving to Jack is indicated by "1" in Row 1, Column 4 in Figure 5. The matrix diagonal is filled with zeros by convention unless people's ties to themselves are well-defined.

The graphs and matrices capture the presence or absence of relationships between people either in binary terms – zeros and ones – or in more nuanced terms to indicate the relative strength of relationships. For example, in the matrix depicted in Figure 6, a higher number indicates a stronger tie in terms of higher frequency of advice giving. In a graph, there are also multiple ways of visualizing the features of social connections, such as adding value on top of lines, or adjusting tie width according to tie strength as shown in Figure 7.

[Insert Figures 5 through 7 here]

Figure 5. Matrix of binary advice-giving relationships.

Figure 6. Matrix of valued advice-giving relationships.

Figure 7. Advice giving network with values indicated by line thickness.

4.3 Research Design

4.3.1 Whole-Network Design

There are two different approaches to the collection of social network data. As our summary of philosophical approaches to research above reiterates, the type of social network data that you collect depends on the kind of research question that you want to answer. The *whole-network* (or *sociocentric*) approach requires collecting *all ties* among those included in the network (Borgatti, Everett & Johnson 2018). Under this design, actors in the network provide information concerning their social network connections with all other actors. For example, an analysis of the extent to which brokers who spanned between cliques were trusted involved the collection of two sets of data, one comprising students, and the other comprising hospital workers, as described by the authors (Tasselli & Kilduff, 2018: 808-809):

> ***Master's sample***. We surveyed 148 members of a full-time, two-year European business school master's degree program ….We presented people with a paper-based questionnaire during the third semester and 126 people (i.e., 85 percent) responded (average work experience = 2.31 years)….
>
> ***Hospital***. We surveyed 84 professionals employed in a critical-care unit of a publicly funded European hospital. Work involved diagnosis, surgical intervention, pharmaceutical care, and continuous checks of patients' health conditions. Seventy-five people (20 doctors, 39 nurses, 16 para-medical staff) responded to a paper-based questionnaire (response rate = 89 percent)….
>
> Across both samples, we used the roster method to collect network data (Wasserman & Faust, 1994: 46), an approach that reduces the likelihood that respondents forget important contacts (Marsden, 2011: 372). Each respondent was presented with a complete alphabetical list of all those in the relevant Master's or hospital network and asked to indicate the names of "people you consider as 'friends' – that is people with whom you frequently and regularly have friendly and pleasant relationships during classes and during your stay at the business school" (Master's sample) or "during your stay at work" (Hospital sample).

Whole network data can also be derived from archival sources as illustrated in this influential examination of embeddedness among 479 firms (Uzzi 1997: 685):

> Data on the network ties among all better dress apparel firms in the New York apparel economy were obtained from the International Ladies Garment Workers Union, which keeps records on the volume of exchanges between contractors and

> manufacturers.… The data describe (1) firm-to firm resource exchanges, (2) business group membership, and (3) a company's product lines, age, size of employment, and location. The data on resource exchange and social tie networks cover the full network of relations for each firm in this economy (e.g., the proportion of work that each firm "sends" and "receives" to and from its network partners and whether firms are linked by family, friendship, or shareholdings).

The whole-network design is useful not only for the examination of embeddedness, but also for the analysis of structural features of networks that include network *centralization*, i.e., the extent to which interactions are concentrated among a small number of actors (Freeman 1979); and network *density*, i.e., the extent to which actors in the network are connected to each other (Wasserman & Faust 1994). The whole-network design also provides information on the relative centrality or peripherality of each node. For example, the extent to which each node spans across structural holes is captured by *betweenness centrality* defined as the extent to which each person is on the shortest paths between other actors in the network (Freeman 1979). Whereas some research reports that central actors are more creative (e.g., Mehra et al. 2001), other research suggests that creativity derives from occupying a position between the core group of centralized actors and the set of peripheral actors loosely connected to the core. To test this latter hypothesis, the authors collected whole data on the Hollywood film industry as follows (Cattani & Ferriani 2008: 829):

> Our data consist of the entire population of core crew members who worked in at least one of the 2,137 movies distributed in the United States by the eight major studios—i.e., the seven historical majors (Universal, Paramount, Warner Bros, Columbia-Tristar, Disney, 20th Century Fox, and Metro-Goldwyn-Mayer) and Dreamworks—and their corresponding subsidiaries over the 12-year period 1992–2003.

Thus, whole network research captures the global patterns of connections among all actors, providing insights that are otherwise buried under the plethora of social relations; and whole network research allows for the analysis of micro-level phenomena such as the relative centrality of each member of the network.

Unless the whole network data can be assembled unobtrusively from archival or other sources (e.g., Uzzi 1997), this design requires that network members be identified, usually by name, so that respondents can report the presence or absence of ties to and from each other. Data can be collected confidentially but not anonymously. Researchers may have to make extra efforts to increase trust, provide assurances concerning confidentiality, and thereby increase participation. This will help avoid distorted results concerning network structure that can be caused by missing data (Borgatti, Carley & Krackhardt 2006).

4.3.2 Ego-Network Design

Different from the whole-network approach, the *ego-network* (or *egocentric*) design involves identifying each individual ego's direct contacts and the connections among the contacts (Wasserman & Faust 1994). People directly connected to ego are called *alters*. Under this design, information concerning alters' characteristics, ego-alter relations, and alter-alter relations can be supplied by ego (e.g., Burt 2004) or collected unobtrusively from employment records, for example (Burt & Ronchi 1990). This data collection approach helps answer questions concerning the network ties or networking behavior of egos in a social context.

Ego-network research, indeed, focuses on the local social networks surrounding egos, rather than the full set of relations among all egos and alters. Thus, ego network research primarily focuses on outcomes related to ego rather than structural features of whole networks. For example, controlling for the size of ego's network and for the extent to which ego's network features a rival who connects to many of ego's contacts, we can calculate the extent to which ego's alters are directly connected to each other with *network constraint*, a measure of social network brokerage that predicts speed of promotions and other advantageous outcomes (Burt 1992). Figures 8a and 8b below illustrate the ego networks for Avery and Carol. In these two ego networks, we see that Avery is a friend of Chris, Carol, and Emily, who are also friends of each other. By contrast, in Carol's network, some people, such as Jack and Emily, are not friends. Thus, Carol has a brokerage role whereas Avery does not.

[Insert Figures 8a and 8b here]

Figure 8a. The ego-network of Avery.

Figure 8b. The ego-network of Carol.

Ego-network research typically offers little insight regarding global patterns of connections (Perry, Pescosolido & Borgatti 2018) unless the researcher aggregates the different ego networks into a whole network (e.g., Burt 2004). Ego network research is particularly useful for accessing network data on individuals located in relatively large organizations. A whole network approach would burden each respondent with the necessity of recalling connections among hundreds or even thousands of alters. To achieve a balance between the completeness and the quality of data, researchers often limit the number of alters to be listed by egos (e.g., Brands & Mehra 2019). Missing data in an ego-network design is less problematic than in a whole-network design.

As mentioned above, ego networks can be combined to construct a whole network (Weeks et al. 2002). Even if ego network data are collected anonymously, alters listed by different egos may be identified and matched based on alters' attributes such as demographic information with the aid of software packages like SPIDER (Young & Hopkins 2015). But researchers should be cautious about possible errors in the process of identifying alters (Perry et al. 2018). And there are ethical and legal constraints on the identification of individuals that researchers must comply with.

4.3.3 Cognitive Social Structure (CSS) Design

Cognitive social structure research represents a different perspective to data collection from the two previous approaches in that individuals provide *perceptions* of whole networks within which they are situated (e.g., Kilduff & Krackhardt 1994). Each respondent provides a cognitive social network map, i.e., a complete picture comprising their view of all ties in the network. This allows researchers to compare each individual's perception of the network with the actual network of ties. Actual ties can

be defined as those that are verified by both people involved in the tie (e.g., Krackhardt 1987). That is, if John reports in his cognitive map that Avery claims friendship with Jane, then both Avery and Jane must agree that there is a one-way tie from Avery to Jane for this tie to be considered an actual tie rather than John's perception of a tie.

In reporting on positive ties such as friendship, people typically inflate their own centrality in the network relative to how others see them (e.g., Kumbasar, Romney & Batchelder 1994). People also tend to perceive both their own friendship relations and those of distant others as balanced (Krackhardt & Kilduff 1999), that is as both reciprocated and transitive, where transitivity refers to the perception that people who have a mutual friend are themselves friends (Heider 1958). We should note that the common research practice of symmetrizing friendship relations to simplify analyses ignores the evidence that reciprocity in friendship relationships is likely to be less than fifty percent in organizational settings (Krackhardt & Kilduff 1999).

Cognitive social structure research focuses not just on misperceptions concerning reciprocity and other structural features of networks (Brands 2013; Krackhardt 1987) but also on the outcomes related to these misperceptions. For example, an analysis of the effects of having actual versus perceived prominent friends showed that being perceived by others to have a prominent friend in an organization increased an individual's performance reputation, whereas having such a friend had no effect (Kilduff & Krackhardt 1994).

4.4 Sampling and Bounding Networks

The identification of social network boundaries is a critical step in network research (see Agneessens & Labianca 2022 for a discussion). Sometimes, a group has an easily-observed boundary, such as an organizational department (e.g., Kumbasar et al. 1994). In other cases, boundary specification requires compiling a list of the members of the population, collecting all the direct and possibly indirect ties of interest to the researcher (e.g., Powell et al. 1996), and establishing the period over which the data

will be collected. For example, a study of the spread of poison pills through the US intercorporate network used the Fortune 500 list of companies as the initial boundary set but had to exclude forty-two companies that featured missing data and thirty-two firms that were not publicly traded (Davis 1991). The time interval was fixed as between 1984 and 1989. The network measure of interest was a board interlock. These data on ties between companies had to be checked against standard directories even though initial data collection used computerized routines.

Similarly, with an ego-network design, participants and their alters need to be identified. One source of ego network data is the US 1985 General Social Survey (GSS), a national probability sample of 1395 adults. To investigate the extent to which, under job threat, status affects network recall, researchers reduced this sample to 806 people through the elimination of data from the non-employed and the exclusion from the sample of respondents for whom other necessary data were missing (Smith, Menon & Thompson 2012). The GSS ego network data were collected using the following name generator question and follow up probing:

> "From time to time, most people discuss important matters with other people. Looking back over the last six months—who are the people with whom you discussed matters important to you?" Interviewers probed for additional names when respondents named fewer than five people. Additionally, respondents described the presence or lack of relationship between each of the contacts named (Smith et al., 2012: 72).

In other cases, snowball sampling can help establish the boundary of the network beyond the initial sample of people identified by the researcher. The process involves collecting information on the contacts of the original sample members and continuing to collect information on the contacts of the contacts until few new names are added to the sample (Scott, 2000: 61). This process provides reasonable estimates of dyads and triads in the larger population of interest (Frank 1978; 1979).

4.5 Data Collection

4.5.1 Data Sources

If we are interested in understanding the communication networks within an organization, a straightforward way is to survey employees and ask them to report their networks (e.g., Burt & Wang 2021; Tasselli & Kilduff 2018; Soda, Tortoriello & Iorio 2018; Landis et al. 2018). We can also collect network data from archival sources (Burt & Lin 1977). For example, email exchange records can capture interpersonal social networks in organizations (e.g., Quintane & Carnabuci 2016; Kleinbaum, Stuart & Tushman 2013). Other archival data is either stored in organizations' databases or available online. For example, to construct the coach social networks in the National Football League (NFL) over thirty years, Kilduff and colleagues (2016) used the Record and Fact Book and cross-referenced other online archival data such as Pro Football Reference (www.pro-football-reference.com). Hand collecting and coding secondary data is often time-consuming but avoids problems related to obtrusive research methods (Webb et al. 1999).

Social network research can also involve the observation of interactions between people (e.g., Whyte 1943), the interviewing of people about their network relationships (e.g., Burt 1984), and the analysis of how people randomly assigned to different network setups interact with each other (e.g., Freeman, Roeder & Mulholland 1979). Contemporary network research often features a combination of types of studies including surveys and experiments thereby helping establish the validity and reliability of the research (e.g., Casciaro, Gino & Kouchaki 2014; Landis et al. 2018).

4.5.2 Data Collection Techniques

What methods are used in the collection of social network data? The answer depends, to some extent, on the research design. The *roster method* (Wasserman & Faust 1994) is widely used in whole-network research (e.g., Tasselli, Zappa & Lomi 2020; Kleinbaum et al. 2015; Tortoriello, Reagans & McEvily 2012). This method involves presenting research respondents with a complete list of people who are included in the pre-determined network boundary such as an organizational department. Then

respondents indicate their social connections with the people on the roster. For example, we could ask respondents to indicate those people on the roster whom they consider to be their friends (e.g., Tasselli & Kilduff 2018). This approach helps respondents recall their interactions with all relevant important contacts (Marsden 2011) thereby avoiding well-known problems with respondent recall (Freeman et al. 1987).

The other approach, *name generator* (or *free recall*, Wasserman & Faust 1994) is normally used in research with an ego-network design (e.g., Soda et al. 2018; Cross & Cummings 2004; Battilana & Casciaro 2012). Using this method, researchers construct egocentric social network data by asking respondents to freely recall and write down the names of people (i.e., alters) in the network. A name generator is used together with *name interpreters* to elicit the attributes of each listed alter, the network features (such as tie strength) between egos and alters, and the network features among alters (Perry et al. 2018).

An example of this egocentric technique is taken from an article on second-hand brokerage that involved the following procedure concerning the relationships among supply chain managers (Burt, 2007: 127). Managers were asked to describe their best idea for improving supply chain operations and then asked if they had discussed the idea with anyone. If yes, they were asked to name the person. Next, they were asked, "More generally, who are the people with whom you most often discuss supply-chain issues?" The respondent was then guided through a matrix in which the respondent's perceived relation between each pair of contacts was coded as "often," "sometimes," or "rarely" in regards to how often the two contacts discussed supply chain issues.

As well as being used in studies with an ego-network design, a name generator can also be used as a complement to the roster approach to identify relevant social contacts omitted from the roster due to the limitation of the pre-specified research boundary (e.g., Rodan & Galunic 2004).

4.6 Data Analysis

4.6.1 Characterizing Networks: Centrality

Social network analyses allow us to understand the structural characteristics of whole networks and the structural features of each individual's network position. In this section, we focus on one of the most important node-level properties in social network analyses: *centrality*. Centrality incorporates a set of concepts that indicate different aspects of individuals' structural importance in social networks (Borgatti 2005; Borgatti & Everett 2006). In undirected networks, the widely-used centrality measures include degree centrality, eigenvector centrality, betweenness centrality, and closeness centrality. We introduce each of these four measures below and summarize the equations and the interpretations of these measures in Table 2.

Degree centrality (Freeman 1979; Wang et al. 2014; O'Mahony & Ferraro 2007) can be thought of as an actor's popularity in that it comprises a count of each actor's ties. For example, in the idea-sharing network illustrated in Figure 9, Emily shares ideas with three persons, i.e., Avery, Chris, and Jack. Thus, Emily's degree centrality in this network equals three. Degree centrality indicates the extent to which an actor is visible in the network and the extent to which an actor is exposed to emotional support, work-related advice, gossip, disease, good ideas, and other influences (Borgatti et al. 2018).

[Insert Figure 9 here]

Figure 9. Idea sharing network.

*Betweenness centralit*y (Freeman 1977; e.g., Tasselli & Kilduff 2018) captures how often a given actor occupies a network position that falls on the shortest path between two other actors. This measure of centrality is interpreted as an actor's potential to play the role of a gatekeeper who can control flows through networks (Brass 1984). For example, actors with high betweenness centrality can filter or distort information flowing via them; and can separate or liaise between disconnected alters (Borgatti et al., 2013). As such, betweenness centrality can be used as a measure of brokerage if

the size of each individual's network is controlled for (e.g., Oh & Kilduff 2008). For egocentric research, the appropriate measure is *ego betweenness* which is specific to the set of actors directly connected to ego. Based on the equation in Table 2, Emily's betweenness centrality in the team's idea-sharing network is seven, whereas Carol's is four. Thus, compared with Carol, Emily has more control over the ideas flowing within this team.

[Insert Table 2 here]

Table 2. A summary of centrality measures.

Closeness centrality (Freeman 1979; e.g., Perry-Smith 2006; Tsai 2001) is often normalized in use and captures the distance between one actor and other actors in a network. It equals the reverse of the sum of geodesic distances between an actor and others. This value is then multiplied by *n-1* for normalization, with *n* representing the number of nodes in a network. A higher closeness centrality indicates that an actor can reach other actors quickly via a smaller number of links (Borgatti 2005). Based on the equation in Table 2, Chris's closeness centrality in the team's idea-sharing network is 0.42, whereas Jack's is 0.63. Thus, Jack is likely to hear new ideas shared in this network more quickly than Chris. Note that in networks that include two completely disconnected actors, the distance between them is not well-defined and closeness centrality cannot be calculated directly. A few options are available to address this issue, such as recoding the distance as the number of nodes (Freeman 1979) or setting the reverse distance as zero (Valente & Foreman 1998).

Eigenvector centrality captures the idea that some network contacts are more important than others. It is similar to degree centrality in terms of indicating actors' exposure to flows through the network, but it has been described as a type of "turbo charged" degree centrality (Borgatti, Everett & Johnson 2013). Unlike degree centrality that considers each actor connected with the focal actor equally, the eigenvector measure assigns a weight to each actor directly linked to the focal actor (Bonacich 1972; e.g., Jensen & Wang 2018; Shipilov, Greve & Rowley 2010). Specifically, a person's eigenvector centrality is a weighted sum of eigenvector centralities of this person's adjacent contacts. The

intuition behind this measure is that the centrality of an actor, for example, Avery, depends not only on how many actors Avery is connected to, but also on whether Avery knows influential others who are also central in the network (Bonacich 2007).

Eigenvector centrality is often interpreted as a person's status in a network. For example, in the idea-sharing network in Figure 9, Avery is connected to Emily, and Michael is connected to Carol. Thus, Avery and Michael's degree centralities are both equal to one. But Avery's single contact, Emily, is a prominent member of the network in that she has three connections. Thus, Avery has higher eigenvector centrality than Michael because of her link to the well-connected Emily.

Measuring centrality is more complicated in directed networks where relationships between two actors may be asymmetric. Whereas betweenness centrality can be used in directed networks, the other three measures require adjustments. The basic principle of these adjustments is to consider the network as having two versions, with each version representing one direction of the network. For example, for degree centrality, in the directed advice-giving network shown in Figure 4c, we could calculate Carol's *indegree* centrality, which reflects how much advice she receives from others, and *outdegree* centrality, which reflects how much advice she gives to others (Wasserman & Faust 1994). A similar approach applies to eigenvalue centrality and closeness centrality (Borgatti et al. 2018).

4.6.2 Network Structures

Network research is often referred to as structural analysis (e.g., Kilduff & Krackhardt 1994) in deference to its emphasis on discerning and analyzing structural features of the social world. In this section, we discuss some of the basic structures that feature in social networks.

A *dyad* consists of two actors between whom there is either a tie or an absence of a tie (Wasserman & Faust 1994). Figure 10 shows the three possible dyadic states: *null*, i.e., no tie; *asymmetric*, i.e., a one-way tie; and *reciprocated*, i.e., a two-way tie. An asymmetric positive one-way relationship such as

friendship or resource provision may provoke an impetus for the relationship to be reciprocated or disbanded to restore balance (Heider 1958; Wellman 1988). Across a social network, the extent of reciprocity can be measured as the proportion of reciprocated ties relative to all ties. For example, in the advice network displayed in Figure 4c, only the tie between Avery and Emily is reciprocated, meaning that overall reciprocity is 11%. Low reciprocity in a network may indicate status hierarchy, with some high-status actors receiving many nominations that they do not reciprocate.

[Insert Figure 10 here]

Figure 10. Three states of a dyad.

Triads. Long considered the building blocks of informal networks (Holland & Leinhardt 1977), triads involve three actors and the presence or absence of ties among them. Triads, relative to dyads, provide for the possibility of alliances (two against one), brokerage (one brokering between the other two), and the formation of majorities and minorities (Simmel 1950).

Balance theory (Heider 1958) alerts us to the importance of triadic *transitivity* in positive relationships such as friendship. Ignoring cases of vacuous transitivity involving, for example, three isolates, transitivity refers to whether the triad is complete. For example, if Ann regards both Bill and Colin as her friends, then the triad is transitive if Bill and Colin are friends with each other. The transitivity principle is important in weak tie theory, where a friendship group of three people in which the link between two is missing is labelled the *forbidden triad*, forbidden because of the assumption of strong pressure on two people who have a mutual friend to become friends (Granovetter 1973).

The members of a dyad embedded within a triad (i.e., Simmelian dyads – Krackhardt 1998; 1999) are constrained in their attitudes and behaviors because of their connections to a third party according to theory (Simmel 1950) and empirical research (Krackhardt 1998; Krackhardt & Kilduff 2002). But if a person is embedded in more than one such triad, the person may gain new ideas and access to resources by virtue of being a "multiple insider" – someone who benefits from the cohesion available

within closed groups and the non-redundancy that comes from being able to move across such groups (Vedres & Stark 2010).

A *clique* refers to a complete network in which every actor is directly connected to every other actor and has no common link to anyone outside the clique (Luce & Perry 1949). For example, Figure 11 illustrates the interaction network among 14 participants and four instructors at a National Science Foundation summer camp in 1992 (Borgatti et al. 1999). There are ten cliques in the camp. Cliques may emerge based on shared demographic characteristics such as gender and ethnicity (e.g., Mehra et al. 1998). People who bridge two or more cliques are *Simmelian brokers* (Krackhardt 1999) who may face paralyzing pressures to conform (Krackhardt, 1999: 206) or who may find themselves liberated to pursue innovative activities (Vedres & Stark 2010) based on how well their dispositions are matched to the brokerage challenge of moving between different closed groups (Tasselli & Kilduff 2018).

[Insert Figure 11]

Figure 11. Interaction networks and cliques in the National Science Foundation summer camp.

Centralization refers to the extent to which a network is centralized around one or a few actors. It is measured as a ratio of actors' centrality scores, most typically degree centrality scores (Freeman 1979). The nominator is the sum of the difference between the most central node's centrality and every other node's centrality, whereas the denominator is the maximum possible centralization score for that network. The maximum centralization occurs in a star network (one actor connected to all others with no other connections between actors) as illustrated in Figure 12. In the help network shown in Figure 13, the most central person is Carol, whose degree centrality is five. Thus, the nominator = 16: (5-1) + (5-2) + (5-2) + (5-2) + (5-2) + (5-5), whereas the denominator = 20: (5-1) + (5-1) + (5-1) + (5-1) + (5-1) + (5-5), and the centralization score = 16/20 = 0.8. By contrast, the camp social network in Figure 11 has no centralized actors so the centralization score is seven percent.

[Insert Figures 12 and 13 here]

Figure 12. A star network with six nodes.

Figure 13. Help network with six nodes.

As an important network structural feature, network centralization affects both individual and organizational outcomes. For example, in a longitudinal study that examined how social networks influenced the effectiveness of enterprise system implementation, researchers found that centralized structures made the implementation more likely to fail (Sasidharan et al. 2012). But at the individual level, employees with high indegree centrality reported implementation success even when they worked in centralized units. Thus, individual centrality and network centralization jointly affected peoples' self-perceptions of successfulness.

Networks can be assessed as to the extent to which they exhibit a *core/periphery* structure, which, in the extreme, features core members connected to everyone and periphery members connected only to core members and not to other members of the periphery (Borgatti & Everett 2000). In Figure 14, Emily, Chris, and Every are the core actors, whereas the other three are peripheral actors.

[Insert Figure 14 here]

Figure 14. A network with ideal core/periphery structure: graph and network matrix.

There are two ways of identifying core/periphery structures in social networks (Borgatti et al. 2018). The discrete method involves an optimization process: Actors are assigned to be either core or peripheral such that the correlation between the data matrix and the ideal matrix is maximized, indicated by a measure of fit. This optimization makes sure that the partition of core and peripheral actors maximizes the core-core ties and minimizes the periphery-periphery ties. Although this method matches the essential features of a core/periphery structure, it provides an oversimplified description of network structure.

The continuous method provides a more comprehensive picture of the extent of core/periphery structuring. This method generates a node-level coreness value by modelling the existence or strength of ties between a pair of actors i and j as a function of the coreness of each actor. If we use x_{ij} to denote the entry of row i and column j in a network matrix A* with an ideal core/periphery structure, and use c_i to denote the coreness of actors i, this method sets x_{ij} equal to f ($c_i c_j$). If both actors have high coreness, they are connected; and if both actors have low coreness, they are not connected. Then a least-squared procedure is implemented to identify coreness scores for each actor to maximize the correlation between the real data matrix A and the ideal matrix A*. For example, Figure 15 illustrates the interaction network among workers in negotiation for higher wages in a tailor shop in Zambia (Kapferer 1972) and the list of people with the highest and lowest coreness scores generated based on the continuous method.

[Insert Figure 15 here]

Figure 15. Interaction networks for workers in negotiation.

In organizations, core/periphery positions expose people to trade-offs between resource support and fresh ideas. Core people in organizations are likely to obtain resources and legitimacy that are essential to achieve success (e.g., Hargadon 2006). But peripheral people are theorized by some researchers as likely to generate new ideas because they face less pressure to conform to field norms (Perry-Smith & Shalley 2003). The creativity of peripheral actors was summarized by the polymath Michael Polanyi (1963: 1013) as follows: "I would never have conceived my theory, let alone have made a great effort to verify it, if I had been more familiar with major developments in physics that were taking place." An alternative view is that higher creative performance is found among people who occupy an intermediate core/periphery position in their organizations (Cattani & Ferriani 2008).

Small world networks are characterized by high local clustering and short average paths (Watts & Strogatz 1998). Local clustering means that actors in the network tend to be well connected within

several distinct clusters, and short average path length means that any actor in the network can reach any other actor via a small number of intermediate actors. Figure 16 illustrates an example of a small world network. In the classic small world research conducted by Travers and Milgram (1969), researchers invited 396 individuals in Nebraska and Boston to mail a folder directly to a person working in the Boston area as a stockbroker; or to mail the folder to a personal acquaintance who might know the stockbroker. In this study, 64 folders were successfully delivered to the stockbroker. The mean number of intermediaries for these delivery chains was 5.2. In similar follow-up research, 540 persons in Los Angeles were invited to generate acquaintance chains to either a white or a black-target person in New York. It turned out that 33 percent of persons completed the white-target chains and 13 percent completed the black-target chains (Korte & Milgram 1970).

[Insert Figure 16 here]

Figure 16. A small world network.

Small world networks are features of the real world, but also feature in people's perceptions of their networks. A cognitive social structure research effort showed that, given the difficulties in organizing and tracking even small social networks in organizations, people used small world principles in their perceptions of friendship networks. People perceived their work colleagues as interacting in dense clusters, with connections across the clusters between the most popular people within the clusters. The actual networks showed no features of small worldedness whereas the perceived networks exhibited small world features of clustering and connectivity (Kilduff et al. 2008).

To understand the extent to which a network displays small world properties, we calculate the *small world quotient* (Watts & Strogatz 1998) as illustrated in Table 3. The quotient is made up of two criteria: the extent to which the network shows much higher clustering than a random network of the same size, and the average path length. The *clustering coefficient* measures the average interconnectedness of ego's alters in a network. Take a friendship network for example, the clustering

coefficient equals the extent to which ego's friends are also friends of each other, averaged across all egos in the network (Watts 1999). The path length between two actors in a network equals the smallest number of ties that an actor needs to traverse to reach the other actor (Watts & Strogatz 1998). Taking the average of all individual path lengths between all connected individual actors generates the average *path length* in a network. The clustering coefficient and average path length values are then adjusted to account for the properties of a random network of the same size and density, because dense networks exhibit more clustering and shorter path lengths. In a random network with n nodes and k average ties per node, the *expected clustering coefficient* is k/n, and the *expected path length* is $\ln(n)/\ln(k)$ (Dorogovtsev & Mendes 2003). The *actual clustering coefficient* and *actual path length* are divided by the corresponding expected values, generating a *clustering coefficient ratio* and a *path length ratio*. The ratio of these two ratios then produces the small world quotient (e.g., Kilduff et al. 2008).

[Insert Table 3 here]

Table 3. A summary of centrality measures.

4.6.3 Duality of Network Structure: Two-Mode Networks

A two-mode network captures the intersection of persons within groups and of groups within individuals (Breiger 1974). For example, the Southern Women data set (Davis, Gardner & Gardner 1941) features 18 women's attendance at 14 events, data collected from newspaper records. Figure 17 shows the network matrix, with the rows representing the women and the columns representing the events. An entry of "1" means that the person attended the event, and "0" means non-attendance.

[Insert Figure 17 here]

Figure 17. Two-mode women-event dataset.

Two-mode network data can be converted to one-mode data to infer relationships among a single set of entities (Borgatti et al. 2018). In the women-event dataset example, we can construct a women-women network based on how many events two women both attended. Figure 18 shows the valued data matrix (with the first two letters representing the corresponding person in the column headings) and the graph (with the co-membership values reflected by the thickness of the lines). We can also construct an event-event network based on how many members are shared by two events, as shown in Figure 19.

[Insert Figures 18 & 19 here]

Figure 18. Converted women-women network matrix and graph.

Figure 19. Converted event-event network matrix.

Note that the women-women and event-event matrices are not independent of each other but involve duality: The tie that links two persons is a set of events forming the intersection of the persons' affiliations, and the tie that links two events together is a set of persons forming the intersection of the event's attendance (Simmel 1955; Breiger 1974).

Two-mode affiliation data are used in organizational research on topics such as interlocking directorates (e.g., Davis & Greve 1997) and project collaborations (e.g., Cattani & Ferriani 2008; Uzzi & Spiro 2005). Both actors and the places where they interact can be depicted in the same representation using correspondence analysis (e.g., Kilduff & Brass 2010).

4.6.4 Testing Hypotheses

Standard analytical models are useful if analyses involve network features (e.g., centrality, constraint) at the node-level (e.g., person, department, organization) as dependent or independent variables (Tasselli et al. 2020; Venkataramani et al. 2016; Tortoriello, McEvily & Krackhardt 2015). For example, one research effort examined coaches' career trajectories in the NFL over 31 years to test

whether having a workplace connection to a prestigious industry leader (i.e., an *acolyte* connection) affected a coach's probability of getting an initial promotion (Kilduff et al 2016). The independent variable, *acolyte status*, indicated the existence of such a social connection. The analysis used a standard random-effect logistic regression to analyze longitudinal data, where acolyte status was the independent variable and evaluative certainty (measured as the extent to which information was available concerning an individual's relevant work performance) acted as a moderating variable. The results showed that acolytes initially benefited, in terms of promotions, from loose linkages between their unobservable quality and signals offered by their industry-leader ties, but also suffered, after initial promotions, in terms of fewer further promotions or lateral moves and more demotions, as the unreliability of social network signals became evident.

Sometimes, however, network measures are not summarized at the individual level. The data exhibit systematic dependence. For example, research examined whether 170 members of an MBA class who were connected on one dimension, friendship, exhibited overlap on another dimension, namely similarity in the organizations they interviewed with for jobs (Kilduff 1992). The friendship and organizational similarity matrices contained 28,730 observations on all possible pairs of people. These observations were not independent of each other. Thus, the organizational similarity correlation between Chris and Carol was not independent of the organizational similarity correlation between Chris and Jack because both observations contained the same data from Chris. These kinds of data may exhibit autocorrelation that can generate biased estimations with ordinary-least-squares (OLS) tests.

A solution to the autocorrelation problem is the Quadratic Assignment Procedure (QAP) that estimates the significance of a correlation between matrices, and the Multiple Regression-QAP (MRQAP) that estimates the significance of beta coefficients from regression analyses (Huber & Schultz 1976; Krackhardt 1988; e.g., Brands & Kilduff 2014; Labianca et al. 2001; Pastor, Meindl & Mayo 2002). To estimate the significance of a correlation or a beta coefficient, these non-parametric procedures generate a reference distribution from the specific data that the researchers have collected.

This involves repeatedly permuting rows and columns of one matrix (the dependent matrix for MRQAP) in the analysis while keeping the other matrix or matrices constant to generate a reference distribution of correlations or coefficients against which the observed value can be compared (Borgatti et al. 2018).

Exponential Random Graph Models (ERGMs) also address analytical challenges arising from multiple dependencies in social network data (Daraganova & Robins 2013). ERGMs allow researchers to model characteristics of networks, such as reciprocated ties and triads, as outcomes of explanatory factors. ERGMs have been increasingly used in organizational research to model tie formation (e.g., Lomi et al. 2014; Rank, Robins & Pattison 2010). For example, building on ERGM analyses, Brennecke (2020) identified factors that explained the formation of dissonant ties in organizations, i.e., connections with colleagues who are difficult but who can help solve work-related problems. Unlike QAP and MRQAP that control away the network dependence, ERGMs model and interpret both structure and randomness in social networks, allowing researchers to specify the sources of dependence (Borgatti et al. 2018). ERGMs also allow researchers to investigate ties at multiple levels or across different networks (Wang 2013).

Social networks are dynamic in nature. Recently, more research attention has been paid to the interplay between individuals' psychological processes and network change (Tasselli & Kilduff 2021). This increasingly popular investigation focus has been facilitated by the development of analytical programs such as SIENA (Ripley et al. 2022) based on the Stochastic Actor-Oriented Modeling (SAOM) approach (Snijders 2001; 2005). This method allows researchers to examine how people's attributes, attitudes, and behaviors coevolve with structural features of social networks over time (Snijders, van de Bunt & Steglich 2010). SIENA has been applied to organizational research on network changes (e.g., Schulte, Cohen & Klein 2012; Baker & Bulkley 2014). For example, a study of social network position and turnover showed that people who thought more about quitting their jobs were likely to change their advice network and maintain their existing

friendship network; but the change of networks did not affect people's turnover attitudes (Tröster et al. 2019).

5. Current Debates

5.1 Agency and Structure: The Eternal Tension

Social network research currently strains to incorporate both the big data revolution involving networks with millions of nodes (e.g., Lee, Kim, Ahn & Jeong 2010); and a new emphasis on purposeful action and the pursuit of advantage by individuals (e.g., Burt 1992; Tasselli & Kilduff 2021). With big data, there is excitement over the possibility of examining the properties of very large networks as they evolve and change. Researchers in this tradition examine common features across heterogeneous networks including biological networks, co-citation networks, and the World Wide Web (e.g., Dorogovtsev & Mendes 2003). The emphasis is on examining the ways in which clusters develop, the processes by which highly connected actors develop even more connections (e.g., Newman 2002), and the extent to which networks exhibit resilience to attack (e.g., Moore & Westley 2011). Key questions in this structural configuration research include: How do structural features such as large components featuring millions of connected nodes affect flows across the network? And: does the network resemble a small world (i.e., a network characterized by a high degree of clustering together with short paths between any two actors -- Uzzi & Spiro 2005)?

On the side of individual agency, the publication of Burt's Structural Holes book (1992) with its description of the *tertius gaudens* broker who spans across gaps in the social structure brought a new focus on the ways in which people use social connections for advantage. In this world of competitive action between individuals, agency is ever-present: "The tertius plays conflicting demands and preferences against one another and builds value from their disunion" (Burt, 1992: 34).

A contrasting agentic approach is represented by the *tertius iungens* broker, the third who joins others to create collaboration among those who might not otherwise engage in work projects (Obstfeld,

2005). The tertius iungens research emphasis is on the *process* of bringing people into collaborative endeavors rather than on the *structure* of advantage that had been emphasized in some prior brokerage research (Obstfeld, Borgatti & Davis 2014).

The big data and agentic approaches to social networks pull against each other. The big data emphasis draws on the structural foundations of social network research to capture the lineaments of giant webs of interconnections; whereas the research on individual agency sees the structure of social networks as representing opportunities for individual actors to gain advantage through systems of relationships that can be forged, bridged, and broken (Burt, Kilduff & Tasselli 2013).

Thus, structure and agency represent two ways of looking at social networks. In examining the structure of a network, the focus is on the overall pattern of ties at different levels of analysis. At the individual ego network level, structure concerns whether the people to whom the individual is tied, i.e., the alters, are themselves connected to each other (e.g., Oh & Kilduff 2008). At the level of whole networks, structure is examined in terms of whether there is evidence of a core/periphery structure (e.g., Cattani & Ferriani 2008), or whether networks exhibit small-worldedness (e.g., Kilduff et al. 2008).

These structural emphases neglect the question of whether and how agentic actors create, reproduce and transform social structures in their own interests (Emirbayer & Mische 1998). Change in social networks from an agentic perspective is prompted by motivated people in pursuit of outcomes that are important at the collective (e.g., Obstfeld 2005) or at the individual level where social ties can be regarded as investments "in social relations with expected returns in the market-place" (Lin, 2001: 19).

The tension between agency and structure involves a dualism between individuality, representative of the 'push' factor of motivation from within, and social networks, representative of the 'pull' factor of structures of opportunity from without. Models of social action that incorporate both the motivations

and capabilities of individuals, and the constraints and opportunities provided by network structures are available (e.g., Tasselli et al. 2015) but are difficult to incorporate within a single study.

5.2 Network Volatility

Social network research has tended to privilege stability rather than change, with just 11 percent of social network papers published in the last two decades explicitly assessing network dynamics (for a recent review, see Chen et al. 2022). The argument for more research on dynamics is that network volatility is intrinsic in network research. Social networks are complex adaptive systems constituted both by established structures of relationships and by evolving patterns of expectations and perceptions (Kilduff et al. 2006). But many relationships, such as friendship, tend to be relatively stable as one study of MBA students' friendships observed: "Over the time period studied there was no significant change in homophily among the racial groups' networks, despite the explicit promotion of diversity in recruitment of students, formation of heterogeneous classes and teams, and active support by the MBA program administrators" (Mollica, Gray & Trevino, 2003: 123).

Early work by Barnard argued people in social contexts attract and repel each other like "components in a magnetic field" (Barnard, 1938: 75). The idea of repulsion and attraction, both in terms of homophily and propinquity, was also inherent in most foundational work on the dynamics of network relations. Newcomb (1961) observed the "acquaintance process" of initial strangers -- "seventeen men who were transferring from other institutions of higher learning to the University of Michigan" (Newcomb, 1961: 2) -- during the period of development and stabilization of their relationships. According to Newcomb's analysis, reciprocated relationships among strangers tended to stabilize over a period of about three weeks. But a closer examination of those results suggested a different view, showing that reciprocity often tended to fluctuate and some individuals "danced between friends" over the entire observation period of fifteen weeks (Moody et al. 2005: 1229).

Other famous foundational studies combined ethnographic enquiry and a network approach in investigating the evolution of network structures over time, including the "karate club" study conducted by Zachary (1977), which analyzed the structure of relationships in a karate club before and after its split into two different clubs. Due to the ideological conflict between the club president and the club instructor over both the price of karate lessons and the type of karate being practiced, the club was differentiated before the split in two highly centralized blocks around the two actors. Over time, these opposite pressures led the club to divide into two distinct clubs following the two leaders. Through the use of blocked matrixes and sociograms, Zachary's analysis suggests that a network aimed at achieving a goal will, in the presence of goal conflict, tend to form two groups differentiated on the basis of different goals.

A later approach to volatility emphasized the role of "shocks" in providing opportunities for actors to restructure their ties. External shocks can include technological change (Barley 1990; Sasovova et al. 2010) and industrial action (Meyer 1982), whereas internal shocks can include the potential distortive effects of new management (Burt & Ronchi 1990). Shocks can increase the degree of uncertainty experienced by individual actors, with efforts to reduce uncertainty resulting in a change of communication patterns between individuals and groups (e.g., Barley 1990).

More recent studies have addressed theoretical issues underlying patterns of volatility and stability inherent in network dynamics, with emphasis given to temporal antecedents and consequences of brokerage dynamics (e.g., Burt & Merluzzi 2016). In a study using four years of data on the social networks of bankers in a large organization, interpersonal bridges relative to other kinds of relationships showed faster rates of decay over time (Burt 2002), with nine out of ten bridges vanishing in the average period of a year. A more detailed analysis of these results, however, showed that decay varied according to an actor's experience in managing structural holes: slower decay was found in the networks of bankers experienced with bridge relationships, suggesting that social tends to accrue to those who already have it.

Dispositional forces, such as the individual's personality, contribute to the dynamic structuring of interpersonal connections, such that "individuals help (re)create the social network structures they inhabit" (Sasovova et al., 2010: 639). The social structures that individuals forge tend to maintain an overall inertia over time, even as the connections underlying those structures are shaped by the happenstance of individual choices and external events (Moody et al. 2005).

Overall, volatility and stability in network connections represent a duality characteristic of "boundedly rational actors creating and re-creating the social structures within which their opportunities and constraints evolve" (Kilduff et al., 2006: 1038). We lack evidence, however, on the advantages and disadvantages associated with the different degrees of volatility (and stability) that individuals experience in their networks of connections. Volatility can enhance opportunities for network advantage (Burt 2002). But volatility can also imperil individuals' career prospects in cases where the legitimacy necessary for the adding and cutting of relationships is absent (Burt 1992).

The research on network dynamics employs its own vocabulary and methods as summarized in the glossary provided in Table 4.

[Insert Table 4 here]

Table 4. Glossary of terms related to social network dynamics

5.3 Boundaries of Social Networks

Social network research has long focused on the advantages, constraints, and actions of focal individuals. Neglected in this focus have been the alters to whom individuals are connected. An alter-focused research endeavor has begun, however, with examination of ways in which alters affect

brokerage (e.g., Kleinbaum, Jordan & Audia 2015). But the question arises as to where to draw the boundary delineating possible influence on the individual. Should the boundary be restricted to individuals' direct contacts, or should it be extended to include indirect contacts of individuals' actors (i.e., the direct contacts of their contacts)? Research is conflicted on this question. Economic outcomes in organizations may be affected only by the set of direct contacts around the individual (Burt 2007), but this remains true only if the indirect ties of high-ranking colleagues are neglected (Galunic, Ertug & Gargiulo 2012).

The question of whether to include indirect connections in network research is relevant because longitudinal studies conducted in a variety of settings find significant effects linking direct and indirect ties to propensity to suffer from obesity, smoking cessation (Christakis & Fowler 2007), happiness in the workplace (Fowler & Christakis 2008), and social status and prestige (Lin, Ensel & Vaughn 1981). As yet unanswered are the effects of direct and indirect ties in relationships that are negative (Labianca & Brass 2006), conflictual (Klein et al. 2004), or emotional (Menges & Kilduff 2015). To what extent are people affected by experiences, cognitions, and feelings that are several connections removed?

5.4 Personality and Networks

Is network change driven by individual action, structural embeddedness, or by the coevolution of individual characteristics and behaviors and properties of network interactions (Tasselli et al. 2015)? Currently, we lack research that examines the dynamic patterns connecting individual identity and network configuration. Although personality variables have been treated by micro-foundational network research as independent (and immutable) predictors of network change (e.g., Sasovova et al. 2010), future work can investigate the possibility that the individual's personality itself changes as he or she experiences changing network positions. New research shows that relationship experiences, such as friendship and kinship, affect personality development (Mund & Neyer 2014). Previously, the discovery that personality in the form of self-monitoring influenced the occupation of advantageous

network positions (e.g., Mehra et al. 2001; Sasovova et al. 2010) challenged the structural hegemony of network research (Mayhew 1980). Now, the challenge is to build on the volume of work that shows the mutability of personality (Tasselli et al. 2018) to gauge the extent to which individuals change their dispositions in response to social network opportunities and constraints.

6. Future Research

6.1 Brokerage as Individual Advantage and Community Contribution

An individual view of agency (e.g., Lin 2001) emphasizes individual achievement through network connections whereas the embeddedness tradition (e.g., Granovetter 1973; 1985) focuses on social structure constraints and facilitation. These views compete on whether people or networks fuel social action. This tension is both reflected in and intrinsic to social network theory, but also gives opportunities for integration of competing views. Structural hole theory (Burt 1992; 1997), for example, depicts brokerage as a highly agentic activity in which people negotiate between the "pulsing swirl of mixed, conflicting demands" for their own advantage (Burt 1992: 33). Brokers are seen as network entrepreneurs who enable change (Burt, Jannotta & Mahoney 1998). At the same time, structural hole theory suggests that achievement accrues to those who provide value to the community of interacting participants by supplying good ideas (Burt 2004), mentoring junior colleagues (Burt 1992), and performing distinctive work (Burt 1997). Thus, there is an opportunity to bridge between the individual advantage and embeddedness approaches. Indeed, recent work indicates that successful social network brokers are those who engage in "punctuated brokerage," a pattern of interaction that features intermittent brokering with periods in which the broker retreats within a closed, rather than an open, network structure (Burt & Merluzzi 2016).

6.2 Network Cognition: From Bias to Opportunity

Implicit in the work on network cognition is the assumption that accurate perceptions of networks are advantageous in terms of future interactions and organizational outcomes (e.g., Brands, 2013: S93). Network accuracy is seen as helping individuals to scan the map of their social world in search of

opportunities and advantage (e.g., Krackhardt 1990). The alternative possibility is that misalignments in network perceptions are leading indicators of network change. Rather than seeking to correct individuals' mistaken network perceptions, therefore, as prescribed in prior research and practitioner advice (e.g., Krackhardt & Hanson 1993), individuals can be made aware of the possibility that environments can be enacted through purposeful efforts, so that actual relationships can catch up with perceptions. Network misalignment, therefore, could be re-categorized as a form of cognitive social capital that has the potential to be converted into actual social capital.

6.3 Past Ties

Research on ties that span temporal configurations suggests that it is not only current social capital that helps facilitate individuals' outcomes. Dormant ties (originated in the past and re-established in the present) - i.e., "former ties, now out of touch" – are repositories of vital and accessible help (Levin, Walter & Murnighan, 2011: 923). Given this, we envisage research aimed at analyzing the effects on present interactions of the legacy of past relationships. People forge and change ties in the present, but their actions may be embedded in networks of past ties, also referred to as "ghost ties" (Kilduff et al. 2006). Research on network memory shows the temporal effects of structural holes and closure on performance (e.g., Soda, Usai & Zaheer, 2004). Future research is needed to investigate the often-hidden influence of networks from the past on current networking patterns.

7. Conclusion

We have introduced and discussed key elements that drive the organizational social networks research program, including its historical foundations, distinctive ideas and theories, epistemological approaches and methods, current debates and future directions. The contribution of this book is threefold. First, we promote critical discussion of the core ideas and debates at the heart of the social networks research field. Organizational social network research, in our view, maintains theoretical and methodological consistency in answering questions that include: How do people forge and shape ties in organizations? How do network properties and structures emerging from these interaction

patterns explain individual and organizational outcomes? We have discussed theories and methods that help researchers answer these questions. Simultaneously, we are conscious that the social networks research program continues to evolve as it extends its generative capabilities.

Social network research is exemplary, in our view, in bridging micro and macro perspectives, bringing attention to how individual differences contribute to structural patterning, and also bringing attention to how the structure of networks influences individual actions and identities. From our perspective, the tension between individual agency and network structure continues to drive research opportunities of relevance to people's careers and lives. People generate and change over time the social network structures in which they live and work, but these structures affect in turn the way people, individually and collectively, think and behave. As an evolving research program, social network research combines both the intellectual vitality and the methodological flexibility required to tackle leading questions concerning individuals and organizations in the flux of transformation.

Tables

Table 1. Social network leading ideas.

	Key Citations
Social relationships: network research assumes the importance of relations that connect and divide individuals, groups, organizations, and other actors.	Freeman 2004; Tichy et al. 1979
Embeddedness refers to actors' preference for transacting with social network members; it also refers to the preference for forging, extending, and renewing social ties within and through the existing social network.	Granovetter 1985; Uzzi 1996
Structural patterning: network research examines patterns of clustering, connectivity, centralization, small-worldedness, and other structural features of social networks.	Wellman & Berkowitz 1988; White et al. 1976
Social network outcomes: network connections constitute the social capital that facilitates outcomes of importance to individuals and groups.	Burt 1992; Nahapiet & Ghoshal 1998

Table 2. A summary of centrality measures.

Measure	Equation	Interpretation
Degree centrality	$d_i = \sum_j x_{ij}$, where d_i is the degree centrality of actor *i*, and x_{ij} is the value in row *i* and column *j* of the adjacency matrix.	Popularity and exposure to flows through the network; direct opportunity to influence or be influenced
Betweenness centrality	$b_i = \sum_{h<j} \frac{g_{hij}}{g_{hj}}$, where b_i is the betweenness centrality of actor *i*, g_{hij} is the number of geodesic paths that link *h* and *j* via *i*, and g_{hj} is the total number of geodesic paths that link *h* and *j*.	Control over things flowing through the network (gatekeeping; brokering)
Closeness centrality (normalized)	$c_i = (n-1)/[\sum_j d(i,j)]$, where c_i is the closeness centrality of actor *i*, *n* is the number of nodes in the network, *and d(i, j)* is the geodesic distance from *i* to *j*.	The speed at which an actor receives things flowing through the network
Eigenvector centrality	Let *X* be the adjacency matrix of a network, λ the largest eigenvalue of *X*, and **e** the eigenvector: $X\mathbf{e} = \lambda\mathbf{e}$, Thus, $\mathbf{e} = \frac{1}{\lambda} X\mathbf{e}$ Then the i_{th} component of **e** gives the eigenvector centrality of actor *i:* $e_i = \frac{1}{\lambda}\sum_j x_{ij} e_j$, where e_i is the eigenvector centrality of actor *i*, and x_{ij} is the value in row *i* and column *j* of the adjacency matrix.	The well-connectedness of each actor, often interpreted as status

Table 3. Formula for small world quotient.

Variable	**Formula**
Clustering coefficient (CC)	$\frac{\sum_{i=1}^{n} C_i}{n}$, where $C_i = \frac{A_i}{k_i(k_i-1)}$ and A_i is the actual number of ties between node i's k_i adjacent nodes
Expected network clustering coefficient ($CC_{expected}$)	k/n, where n is the number of nodes in a network and k is the average number of ties per node
Clustering coefficient ratio (CC_{ratio})	$CC/CC_{expected}$
Path length (PL)	$\frac{2}{n(n-1)} \sum_{i=1}^{n} \sum_{j=1}^{n} L_{min}(i,j)$, where L_{min} is the minimum path length connecting node i and node j
Expected network path length ($PL_{expected}$)	$\ln(n)/\ln(k)$, where n is the number of nodes in a network and k is the average number of ties per node
Path length ratio (PL_{ratio})	$PL/PL_{expected}$
Small world quotient (SW)	CC_{ratio}/PL_{ratio}

Table 4. Glossary of terms related to social network dynamics

Term	Description
Churn	Connotes continual change (e.g., Sasovova, Mehra, Borgatti & Schippers 2010) often applied to changes in a node's ego network (e.g., Siciliano, Welch & Feeney 2018).
Network trajectories	Primarily used in the context of nodes, it refers to change in the composition ties, or in the node's social capital (e.g., Kilduff & Tsai 2003). Another usage: the pattern of change of a whole network over time. For example, the trajectories of one network becoming more cohesive, another becoming more decentralized (Borgatti, Everett & Freeman 2002).
Network patterns	The stratification of network structures and configurations in a given social system. Over time, network patterns define the social space of a given system (e.g., Burt 1982).
Endogenous network change	Used to describe changes in the network that can be modeled without data on node characteristics (e.g., gender, or age) or without other kinds of ties (e.g., friendship when studying advice) (e.g., Amati, Lomi & Mira 2018). In other contexts, it refers to change caused by factors internal to a group, such as a team or an organization (e.g., Lomi et al. 2014).
Exogenous network change	Used to describe change in the network generated by or associated with an external jolt (for example, the introduction of a new technology in the organization -- Sasovova et al. 2010).
Network equilibrium	A state in which forces of change counteract each other such that network patterns stay the same even though some ties may be in flux (e.g., Moody, McFarland & Bender-deMoll 2005).
Network evolution	Refers to a process of network emergence, formation, reconfiguration, decay, and dissolution, (e.g., Burt 2002; Zheng, Zhao, Liu & Li 2019).
Network oscillation	A pattern of network change characterized by periods of activity and periods of stability. For example, effective brokers oscillate between periods of spanning across structural holes and retreating within closed networks (Burt & Merluzzi 2016).

Network orchestration/ governance	Activities performed by central actors in the network to coordinate, influence, and direct other actors (e.g., Heidl, Steensma & Phelps 2014; Nambisan & Sawhney 2011)
Network multiplexity	The presence of multiple types of relationships between the same actors (Shipilov et al., 2014: 450) at both interpersonal levels, and intra- and inter-organizational levels. For example, two firms have a multiplex tie if they are connected by a board interlock and a strategic alliance (Sytch & Tatarynowicz 2014). At the individual level, it can describe the presence of different relationships between two people such as friendship and advice giving (Clarke, Richter & Kilduff 2021). Recent research examined the dynamics of temporal multiplexity, i.e., the overlaying of ties of different duration (Operti, Lampronti & Sgourev 2020).
Network dynamics	An umbrella term that incorporates concepts ranging from network change to the occurrence of relational events, influence and flows (e.g., Ahuja, Soda & Zaheer 2012)
Network change	This term defines change in (a) dyadic states, or (b) higher order constructs such as centralization. It can also define (c) changes in whole-network properties, such as density. Like 'network dynamics,' it is also used to reference changes happening at the network level over time (e.g., Kim, Oh & Swaminathan 2006)
Network stability	It can define lack of change or patterns of stasis before or after patterns of change. A network is described as stable if it does not change (e.g., Oh & Jeon 2007); but a network can also be described as stable if it is experiencing a moment of stasis between periods of change (e.g., Burt & Merluzzi 2016).
MRQAP	(Multiple Regression – Quadratic Assignment Procedure). In cases where network data exhibit systematic autocorrelation, this procedure generates a reference distribution from the data against which regression coefficients can be assessed for significance (e.g., Kilduff & Krackhardt 1994).
ERGMs	(Exponential Random Graph Modelling). These procedures model the interdependences between different types of network ties. Specifically, they model the

	probability that a tie from i to j exists as a function of predictors, where each predictor corresponds to an actor-specific factor or a local configuration of ties (e.g., Robins, Pattison & Wang 2009; Snijders et al. 2006). The ERGMs family also includes MERGMs (Multilevel Exponential Random Graph Models), a class of logit models for network data (Wang et al. 2013); and STERGMs (separable temporal exponential random graph models) that account for longitudinal change in network relational structures, testing the probability of a new tie forming over time (e.g., Krivitsky & Handcock 2014).

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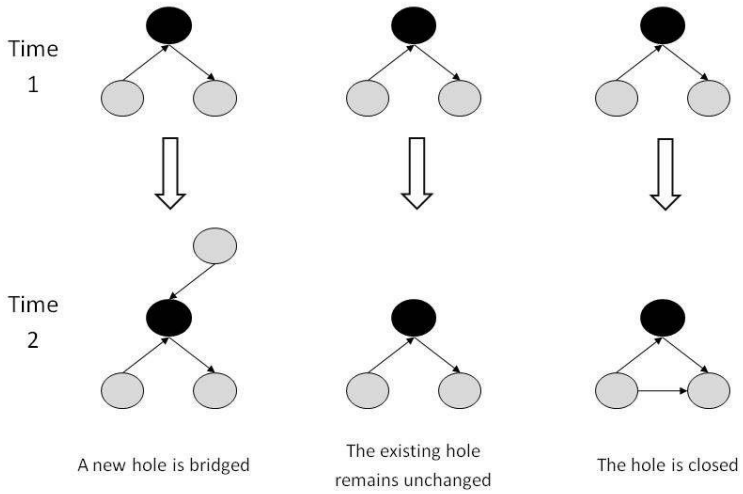


Figure 1. Brokerage opportunities change or remain the same over time.

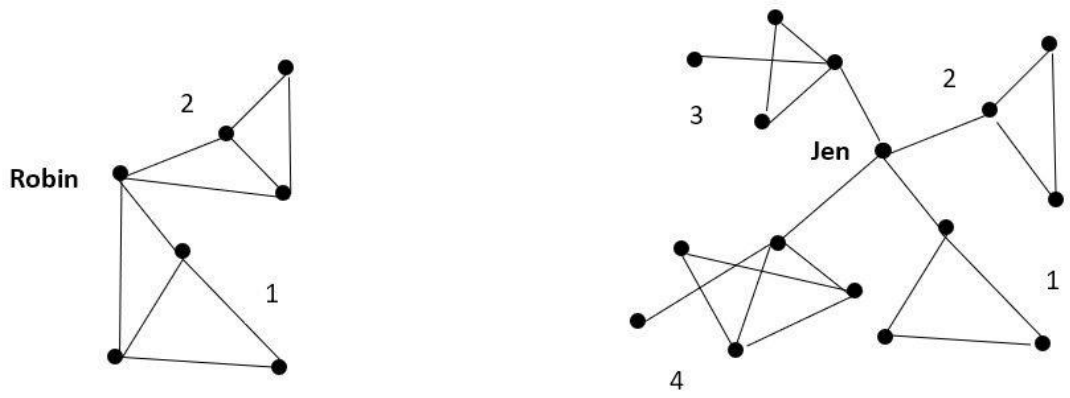


Figure 2. Managing structural holes between groups.

		Epistemology	
		Social network research gets closer and closer to the truth?	
		Yes	No
Ontology Social network theories represent reality?	Yes	*Structural Realism* Uncover basic structural properties of networks (e.g., Lorrain & White 1971).	*Paradigm Extending* Work within a dominant social network theory to address anomalies, puzzles (e.g., Burt 2007).
	No	*Foundationalism* Analyze big data to uncover new social network processes (e.g., Dorogovtsev, Dorogovtsev & Mendes 2003).	*Instrumentalism* Address an empirical problem using social network tools (e.g., Cross, Borgatti & Parker 2002).

Figure 3. Four different approaches to social network research.

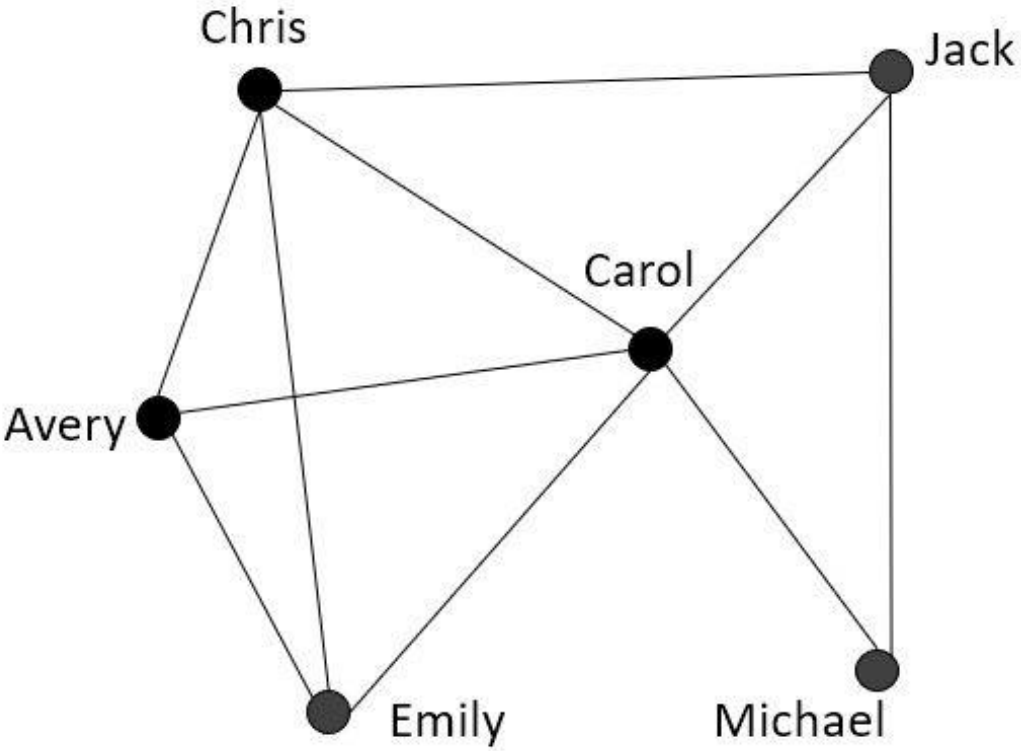


Figure 4a. Friendship network.

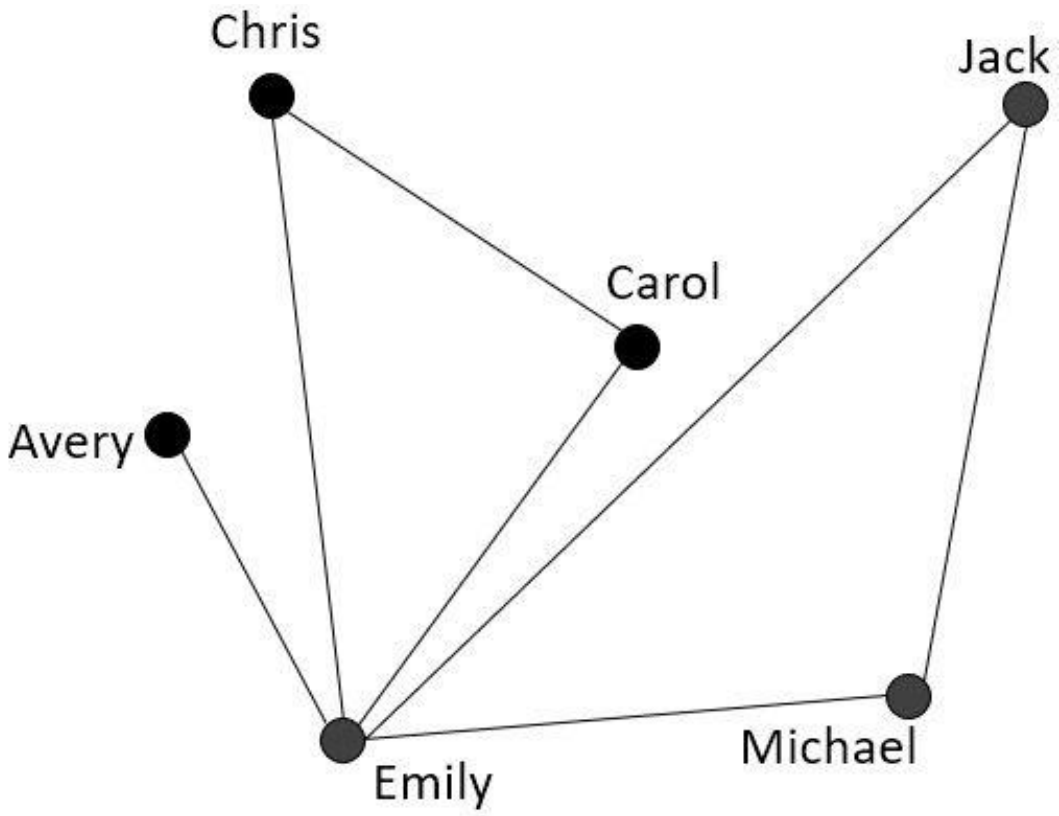


Figure 4b. Task communication network.

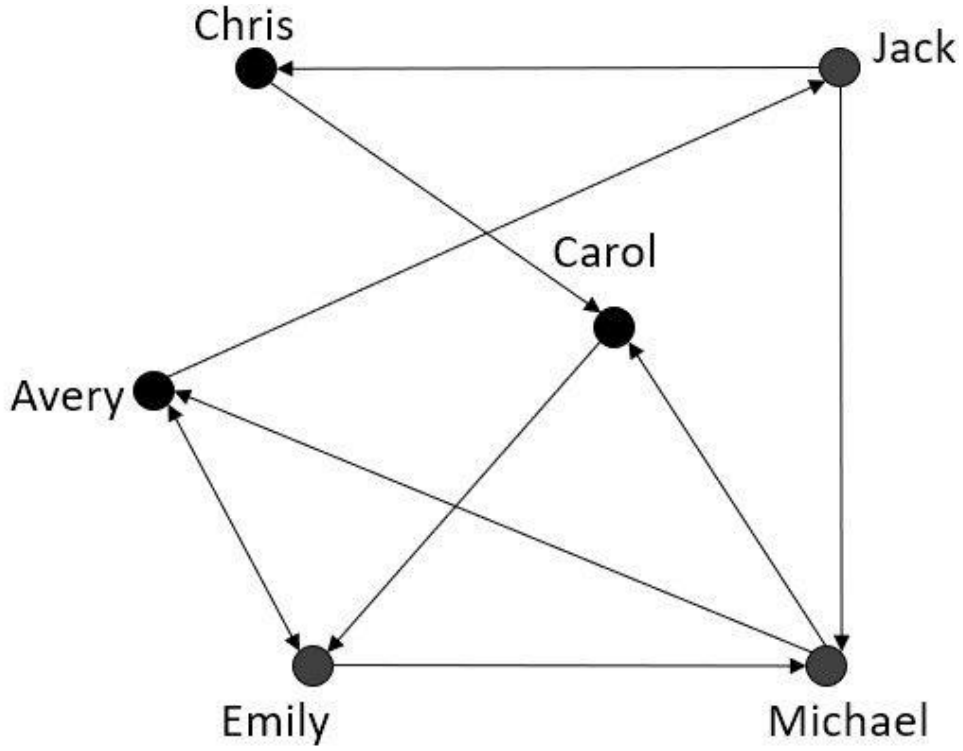


Figure 4c. Advice giving network.

	Avery	Chris	Emily	Jack	Michael	Carol
Avery	0	0	1	1	0	0
Chris	0	0	0	0	0	1
Emily	1	0	0	0	1	0
Jack	0	1	0	0	1	0
Michael	1	0	0	0	0	1
Carol	0	0	1	0	0	0

Figure 5. Matrix of binary advice-giving relationships.

	Avery	Chris	Emily	Jack	Michael	Carol
Avery	0	0	1	1	0	0
Chris	0	0	0	0	0	1
Emily	1	0	0	0	3	0
Jack	0	2	0	0	1	0
Michael	1	0	0	0	0	1
Carol	0	0	2	0	0	0

Figure 6. Matrix of valued advice-giving relationships.

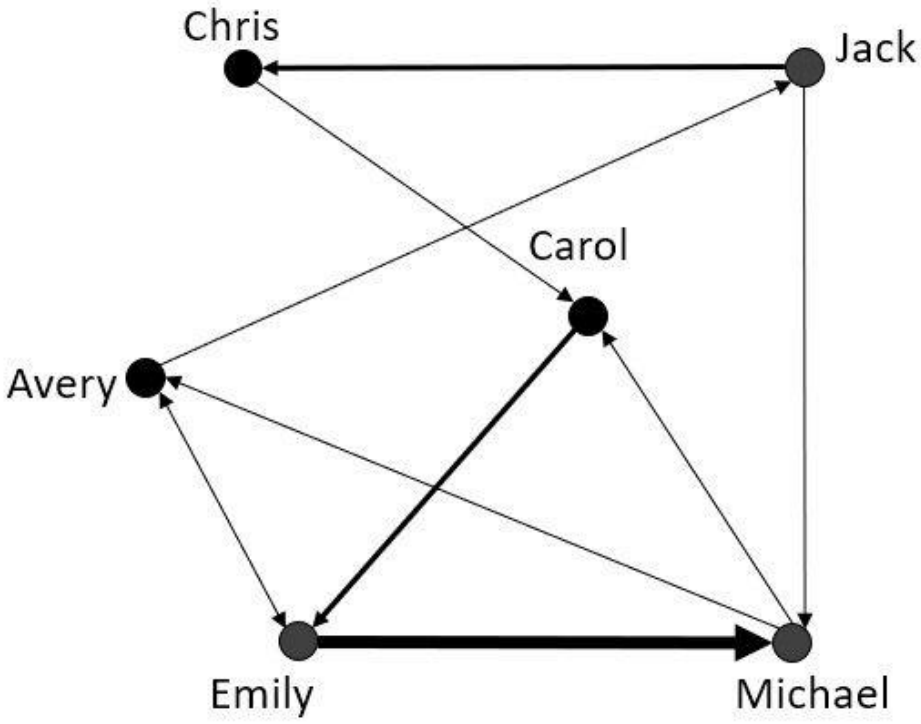


Figure 7. Advice giving network with values indicated by line thickness.

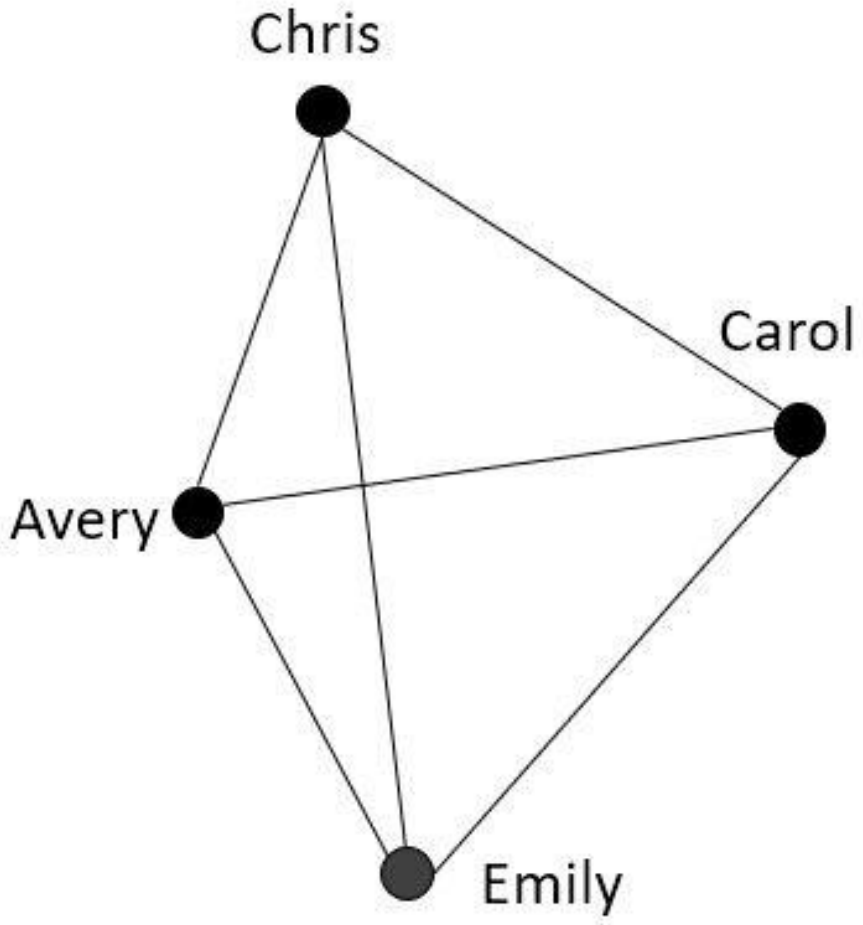


Figure 8a. The ego-network of Avery.

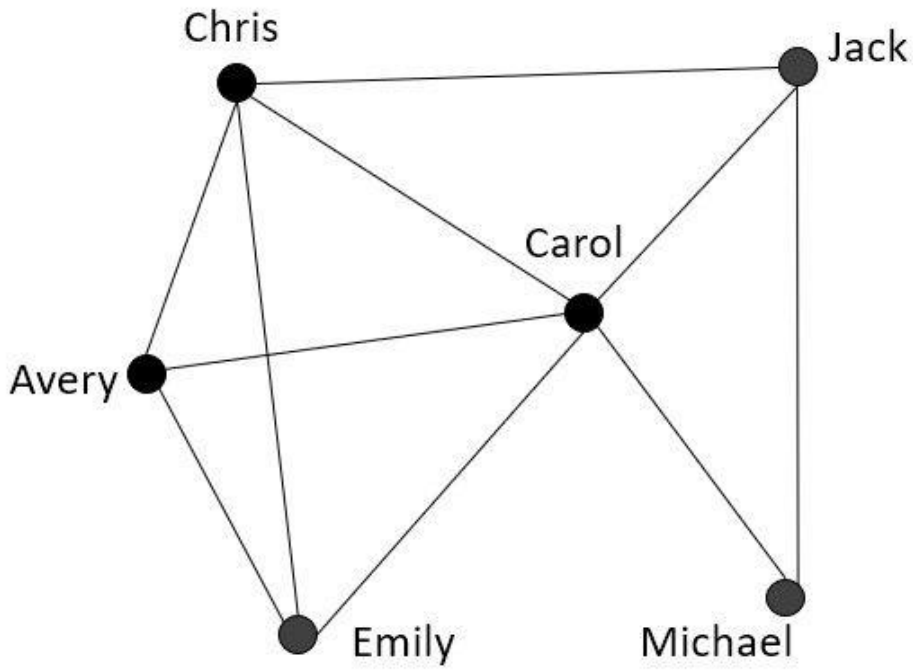


Figure 8b. The ego-network of Carol.

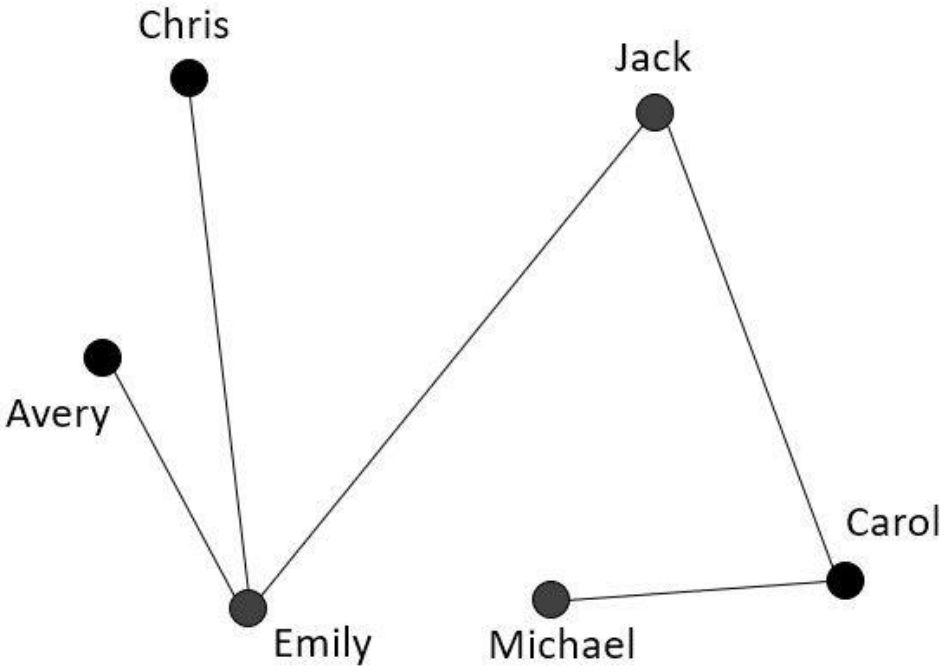


Figure 9. Idea sharing network.

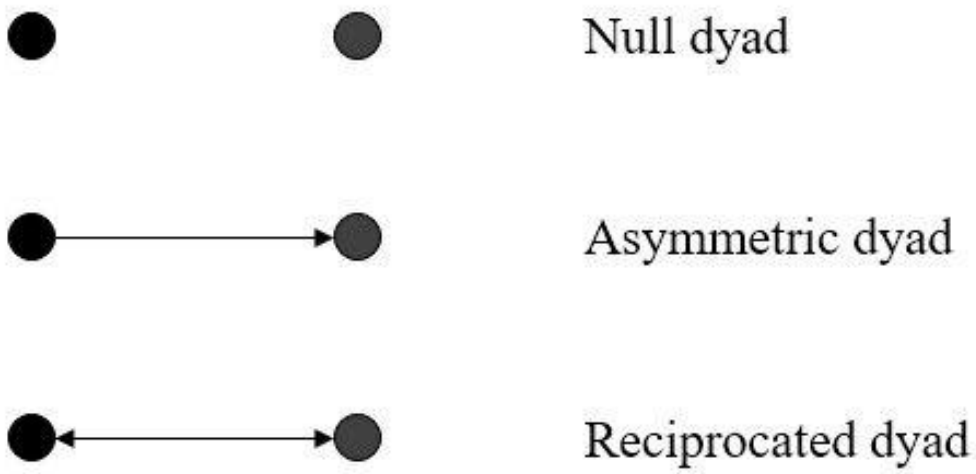
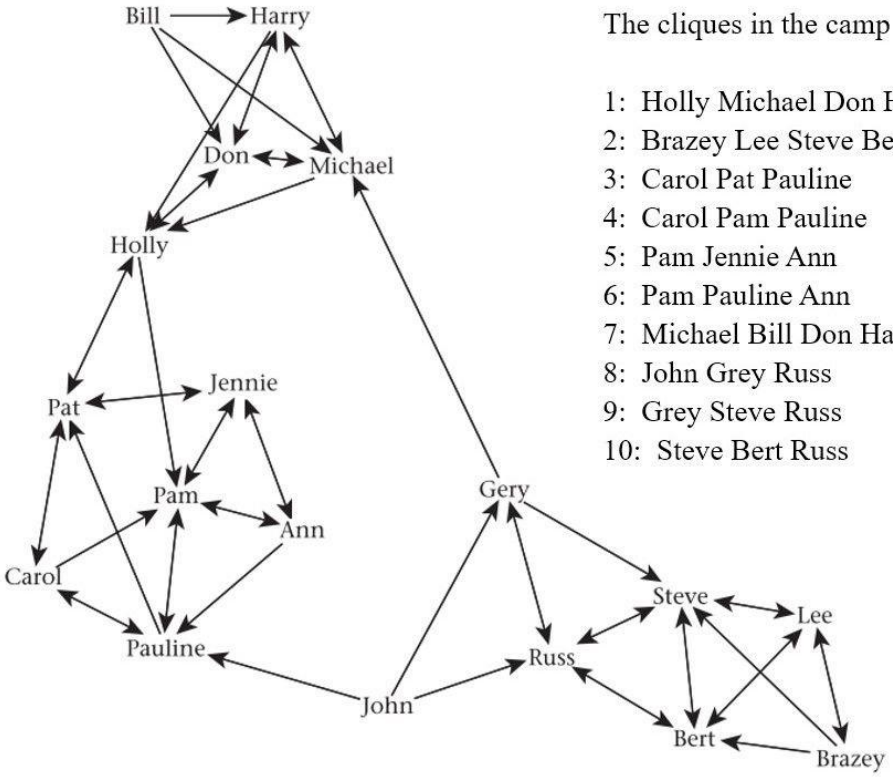


Figure 10. Three states of a dyad.



The cliques in the camp network:

1: Holly Michael Don Harry
2: Brazey Lee Steve Bert
3: Carol Pat Pauline
4: Carol Pam Pauline
5: Pam Jennie Ann
6: Pam Pauline Ann
7: Michael Bill Don Harry
8: John Grey Russ
9: Grey Steve Russ
10: Steve Bert Russ

Note: In this figure, an arrow from A to B means that A has chosen B as one of his or her top three interaction partners

Figure 11. Interaction networks and cliques in the National Science Foundation summer camp.

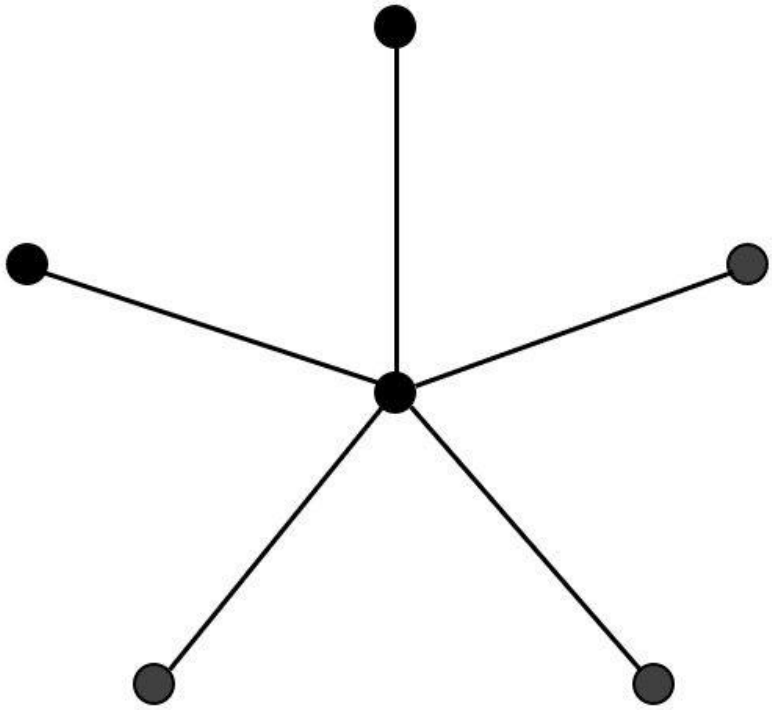


Figure 12. A star network with six nodes.

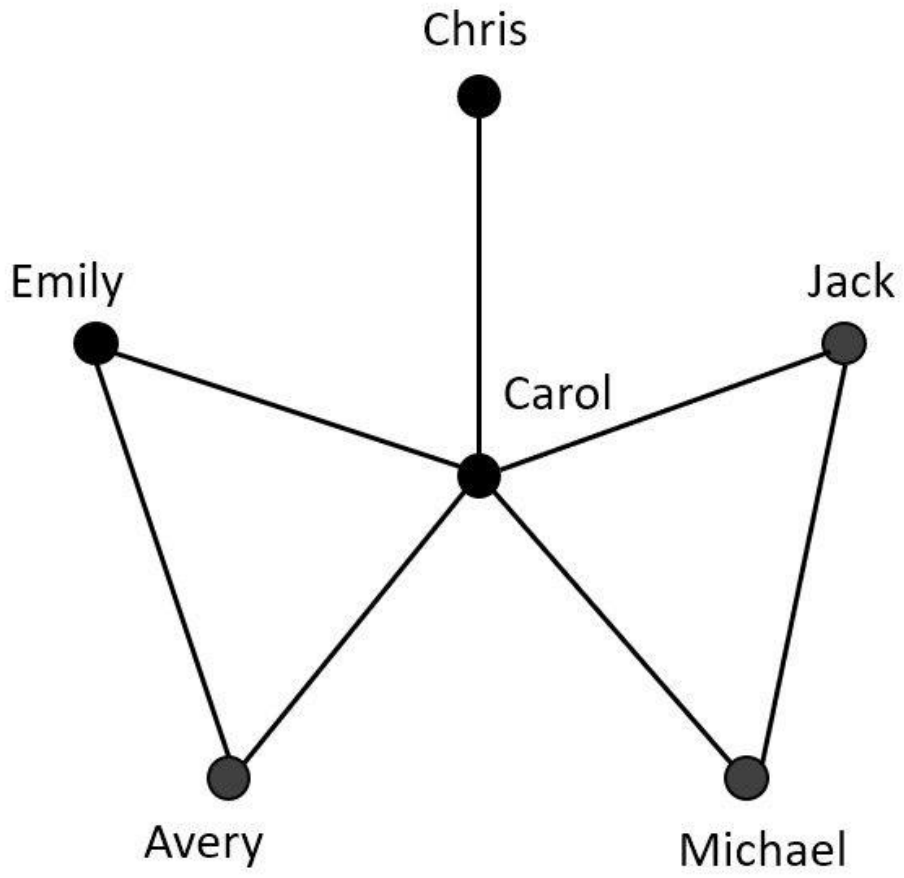
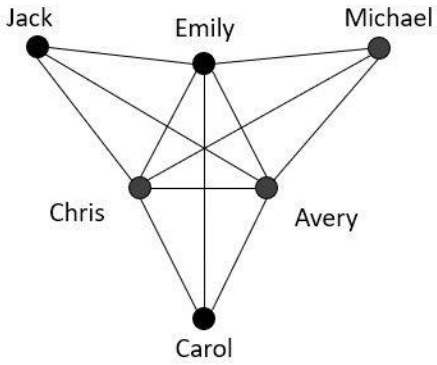
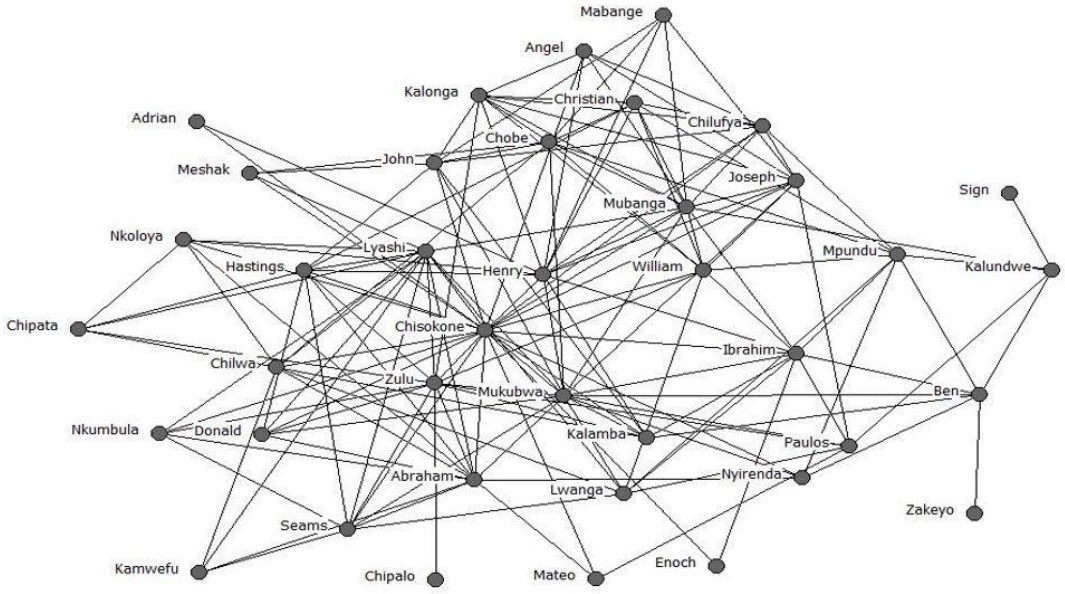


Figure 13. Help network with six nodes.



	Avery	Chris	Emily	Jack	Michael	Carol
Avery	1	1	1	1	1	1
Chris	1	1	1	1	1	1
Emily	1	1	1	1	1	1
Jack	1	1	1	0	0	0
Michael	1	1	1	0	0	0
Carol	1	1	1	0	0	0

Figure 14. A network with ideal core/periphery structure: graph and network matrix.



Core actors	*Coreness*
Chisokone	0.36
Mukubwa	0.29
Lyashi	0.25
Mubanga	0.24
Henry	0.23

Peripheral actors	*Coreness*
Adrian	0.06
Enoch	0.05
Chipalo	0.02
Zakeyo	0.01
Sign	0.01

Figure 15. Interaction networks for workers in negotiation.

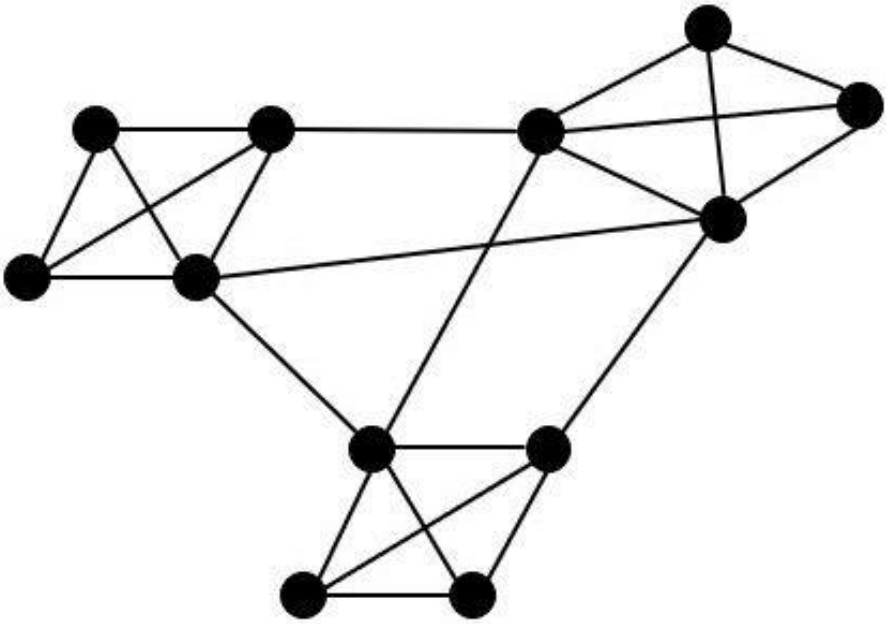


Figure 16. A small world network.

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14
Evelyn	1	1	1	1	1	1	0	1	1	0	0	0	0	0
Laura	1	1	1	0	1	1	1	1	0	0	0	0	0	0
Theresa	0	1	1	1	1	1	1	1	1	0	0	0	0	0
Brenda	1	0	1	1	1	1	1	1	0	0	0	0	0	0
Charlotte	0	0	1	1	1	0	1	0	0	0	0	0	0	0
Frances	0	0	1	0	1	1	0	1	0	0	0	0	0	0
Eleanor	0	0	0	0	1	1	1	1	0	0	0	0	0	0
Pearl	0	0	0	0	0	1	0	1	1	0	0	0	0	0
Ruth	0	0	0	0	1	0	1	1	1	0	0	0	0	0
Verne	0	0	0	0	0	0	1	1	1	0	0	1	0	0
Myrna	0	0	0	0	0	0	0	1	1	1	0	1	0	0
Katherine	0	0	0	0	0	0	0	1	1	1	0	1	1	1
Sylvia	0	0	0	0	0	0	1	1	1	1	0	1	1	1
Nora	0	0	0	0	0	1	1	0	1	1	1	1	1	1
Helen	0	0	0	0	0	0	1	1	0	1	1	1	0	0
Dorothy	0	0	0	0	0	0	0	1	1	0	0	0	0	0
Olivia	0	0	0	0	0	0	0	0	1	0	1	0	0	0
Flora	0	0	0	0	0	0	0	0	1	0	1	0	0	0

Figure 17. Two-mode women-event dataset.

	Ev	La	Th	Br	Ch	Fr	El	Pe	Ru	Ve	My	Ka	Sy	No	He	Do	Ol	Fl
Evelyn	8	6	7	6	3	4	3	3	3	2	2	2	2	2	1	2	1	1
Laura	6	7	6	6	3	4	4	2	3	2	1	1	2	2	2	1	0	0
Theresa	7	6	8	6	4	4	4	3	4	3	2	2	3	3	2	2	1	1
Brenda	6	6	6	7	4	4	4	2	3	2	1	1	2	2	2	1	0	0
Charlotte	3	3	4	4	4	2	2	0	2	1	0	0	1	1	1	0	0	0
Frances	4	4	4	4	2	4	3	2	2	1	1	1	1	1	1	1	0	0
Eleanor	3	4	4	4	2	3	4	2	3	2	1	1	2	2	2	1	0	0
Pearl	3	2	3	2	0	2	2	3	2	2	2	2	2	2	1	2	1	1
Ruth	3	3	4	3	2	2	3	2	4	3	2	2	3	2	2	2	1	1
Verne	2	2	3	2	1	1	2	2	3	4	3	3	4	3	3	2	1	1
Myrna	2	1	2	1	0	1	1	2	2	3	4	4	4	3	3	2	1	1
Katherine	2	1	2	1	0	1	1	2	2	3	4	6	6	5	3	2	1	1
Sylvia	2	2	3	2	1	1	2	2	3	4	4	6	7	6	4	2	1	1
Nora	2	2	3	2	1	1	2	2	2	3	3	5	6	8	4	1	2	2
Helen	1	2	2	2	1	1	2	1	2	3	3	3	4	4	5	1	1	1
Dorothy	2	1	2	1	0	1	1	2	2	2	2	2	2	1	1	2	1	1
Olivia	1	0	1	0	0	0	0	1	1	1	1	1	1	2	1	1	2	2
Flora	1	0	1	0	0	0	0	1	1	1	1	1	1	2	1	1	2	2

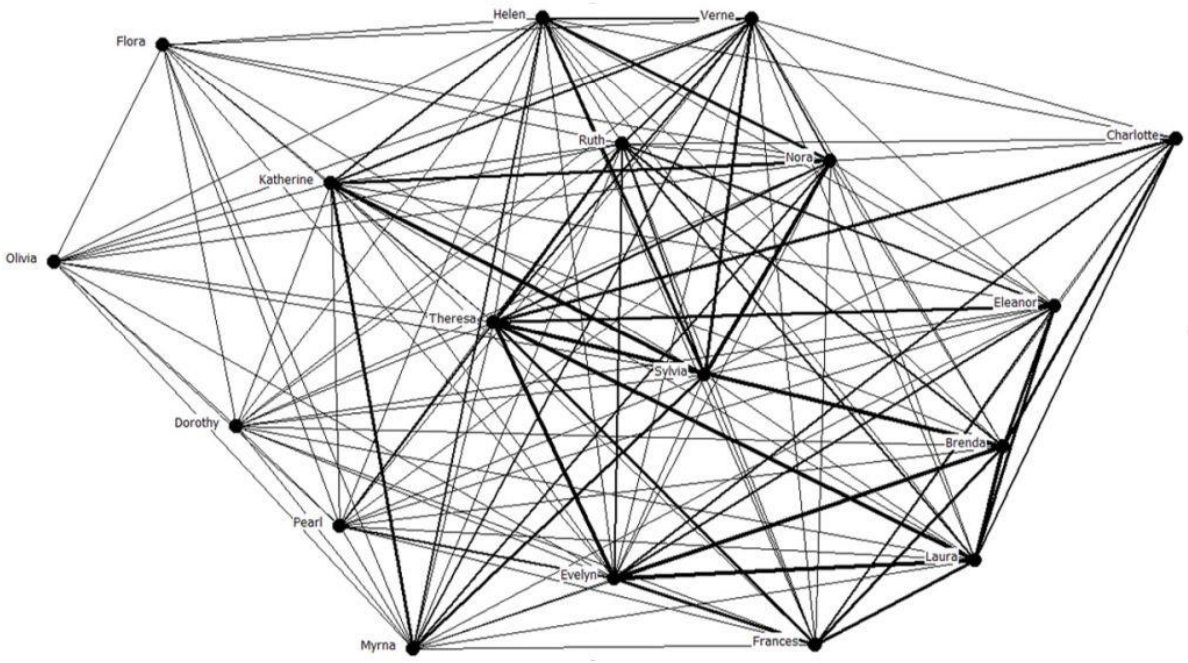


Figure 18. Converted women-women network matrix and graph.

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E1	E1	E1	E1	E1
E1	3	2	3	2	3	3	2	3	1	0	0	0	0	0
E2	2	3	3	2	3	3	2	3	2	0	0	0	0	0
E3	3	3	6	4	6	5	4	5	2	0	0	0	0	0
E4	2	2	4	4	4	3	3	3	2	0	0	0	0	0
E5	3	3	6	4	8	6	6	7	3	0	0	0	0	0
E6	3	3	5	3	6	8	5	7	4	1	1	1	1	1
E7	2	2	4	3	6	5	10	8	5	3	2	4	2	2
E8	3	3	5	3	7	7	8	14	9	4	1	5	2	2
E9	1	2	2	2	3	4	5	9	12	4	3	5	3	3
E10	0	0	0	0	0	1	3	4	4	5	2	5	3	3
E11	0	0	0	0	0	1	2	1	3	2	4	2	1	1
E12	0	0	0	0	0	1	4	5	5	5	2	6	3	3
E13	0	0	0	0	0	1	2	2	3	3	1	3	3	3
E14	0	0	0	0	0	1	2	2	3	3	1	3	3	3

Figure 19. Converted event-event network matrix.