How Networks Form: Homophily, Opportunity, and Balance

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Abstract

Owing to rapid advances in available data and methods, social network analysis has recently been propelled into a new era: Instead of documenting patterns in static network structures, we are increasingly able to pinpoint the principles governing the evolution of these structures as well as how they emerged in the first place. In this essay, I trace the contours of this new trend. First, I describe foundational research on three mechanisms of network generation that have received particular attention in the literature: homophily, opportunity constraints, and structural balance. Next, I outline cutting-edge research that has built on this foundation. In just the past several years, scholars have broadened prior approaches into larger, encompassing analytic frameworks; disentangled the various underlying processes that give rise to observed patterns in network structures; and distinguished between attribute-driven network change and network-driven attribute change—all largely thanks to advances in modeling tools that have overcome prior obstacles and enabled theoretical progress. Finally, I discuss three directions for future research. While recent scholarship has revolutionized our understanding of network dynamics, our grasp of how tie-generating mechanisms operate and interact remains comparatively shallow; counterintuitive divisions exist between major sites of relational research and there remains much room for comparative work; and for all the promise of computational social science, there is risk that this movement will return us to the descriptive techniques of prior days but on a much larger scale.

INTRODUCTION

The study of social networks has a rich interdisciplinary history (Freeman, 2004). In contrast to standard quantitative social science—which has been described as a "sociological meatgrinder" because its tools typically require that all respondents in a sample are independent of one another, thus stripping individuals from their social contexts (Barton, 1968)—it is precisely these interdependencies among respondents that are the focus of network research. Traditional network studies have examined patterns of

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relationships across a staggering array of settings: from interactions among monks (Sampson, 1968) to friendships among fraternity housemates (Newcomb, 1961), business ties among Renaissance Florentine families (Padgett & Ansell, 1993) to social event coattendance among southern socialites (Davis, Gardner, & Gardner, 1941). And while the network approach to social science has been gaining momentum since the "renaissance" of the 1970s (Freeman, 2004), this movement has progressed particularly rapidly—and taken a particular shape—in just the past decade: Instead of documenting the characteristics of static network structures, advances in available data and methods have enabled contemporary network analysts to study how these structures evolve as well as how they emerged in the first place.

This new frontier of research has returned network analysts to questions at the heart of the sociological enterprise: What are the interpersonal affinities and antagonisms that characterize a given social structure (Laumann & Senter, 1976)? In other words, if we recognize that patterns of human relationships reflect both the deliberate choices of individuals as well as the constraints in which these decisions are made, the "choice" part of this equation provides direct insight into the structure of intergroup boundaries: who is willing and unwilling to affiliate with whom, and therefore the strength of various social cleavages. Unfortunately, disentangling the role of choice from the role of constraint—the classic sociological distinction between agency and structure—has not always been so easy.

FOUNDATIONAL RESEARCH

Contemporary research on the genesis and evolution of social networks tends to draw on three primary traditions of research. Each tradition corresponds to a distinct *mechanism* whereby social ties are created and maintained. Interestingly, the three traditions developed somewhat independently of one another, and it has only been relatively recently that these strands have been integrated into a more comprehensive analytic framework.

Homophily

Arguably the most well-known principle in the networks literature is that of homophily: the notion that "birds of a feather flock together" or "similarity breeds attraction." Homophily has been studied across a striking array of settings, relationships, and attributes. This research was deftly reviewed by McPherson, Smith-Lovin, and Cook (2001)—a paper that continues to be one of the most-cited works in sociology today. The motivating principle behind this research is simple: Insofar as similar individuals seek out one

another and dissimilar individuals avoid one another, the ensuing patterns of relationships have powerful implications for the information we receive, the attitudes we form, and the interactions we experience (McPherson *et al*., 2001). Importantly, as mentioned, the strength of this tendency itself can be used as a barometer of social relations: Rather than asking individuals about intergroup prejudices using various forms of social distance measures (e.g., Bogardus, 1947), we can instead infer these prejudices from observed patterns of social ties (e.g., Kalmijn, 1991).

One noteworthy feature of this body of research is the surprising degree of ambiguity and inconsistency regarding what the label of "homophily" signifies in the first place. Literally, the term *homophily* is derived from the Greek words *homoios* (equal, similar) and *philia* (friendship, love, affection; see Skopek, Schulz, & Blossfeld, 2011, note 1). In other words, homophily refers to a *preference*—the enhanced degree of psychological attraction between two similar birds—rather than a *pattern*—the actual observed tendency for similar birds to flock together more frequently than dissimilar birds. However, the term homophily is often confusingly applied to both. In addition, regardless of whether the focus is preference or pattern, an important question is how exactly to measure this phenomenon; and in particular, what is the baseline degree of attraction/affiliation that should be used as a basis for comparison. In other words, what level of homophily should we expect merely as a consequence of chance? This discussion leads naturally to the next mechanism of tie formation—a mechanism that recognizes there is at least one important reason to expect similar birds to flock together that has nothing to do with their preference to do so.

Opportunity

Social networks are hardly structured by individual preferences alone. Rather, these preferences operate, most basically, within the constraints of who is *available* to affiliate with in the first place. Let us imagine we were to acquire a list of who is dating whom at a certain high school—and we discovered that, lo and behold, every single romantic couple on this list is composed of two students who both have brown eyes. One possible explanation for this finding is that brown-eyed students display a strong degree of preference for one another (brown-eyed student homophily). Another possibility, however, is that the entire school is simply full of brown-eyed people—in which case the pattern we observe tells us nothing about students' preferences and everything about the limited pool of dating partners from which each student had to choose.

In order to accurately assess the role of homophily in governing the selection of social ties, therefore, we must first account for the *opportunity structure*

from which these ties were selected; and as a baseline expectation without *any* role of homophily, we would expect that patterns of interpersonal affiliation would naturally reflect the patterns of characteristics in a population. This basic, intuitive insight—one that, surprisingly, remains ignored in many studies of social networks today—was developed and tested in two foundational texts by Blau (Blau 1977; Blau & Schwartz, 1984). Importantly, Feld (1981, 1982)'s concept of *social foci* provides an additional, more precise theoretical tool for examining the impact of opportunity structures on social networks. Drawing on Homans' (1950) social elements of activity, interaction, and sentiments, Feld defines a social focus as "a social, psychological, legal, or physical entity around which joint activities are organized"—as a consequence of which, individuals whose activities are organized around the same focus will be much more likely to form a social tie (Feld, 1981). In other words, "opportunity structures" of potential contacts are not distributed randomly in physical space; rather, they are concentrated at areas of joint activity.

Balance

As noted by Feld (1981), foci posit a "sociological" explanation for why proximity breeds affiliation: Two individuals are much more likely to become connected if they share a social context in common. A complement to this approach is the "psychological" explanation provided by balance theory—where two people who share a friend in common are more likely to become friends themselves.

Balance theory was originally formulated by Heider (1946), formalized by Cartwright and Harary (1956), and further developed by Davis (1963). Its central insight is that certain configurations of relationships (namely, "unbalanced" configurations) produce psychological strain for all parties involved and tend to be avoided. It is very uncomfortable, for instance, to be friends with two people who intensely dislike each other—and so the only options for alleviating this strain (and restoring "balance" to the triad) are for the focal individual to abandon one or the other of the friendships (i.e., to take a side) or to try to get the two friends to make amends and start liking each other. The upshot of this process is that "unclosed triads" in social networks (configurations where A is friends with B and B is friends with C but A and C are not themselves friends) are extremely rare (Davis, 1970), because there are psychological pressures that induce A and C to become friends (thereby "closing" the triad). It is important to note that the scope of structural balance predictions is not limited to configurations of three people, but extends also to more or fewer persons (as well as to configurations with nonhuman objects about which two people may have attitudes). Another regularity in social networks, for instance, is the tendency for the psychological strain

produced by asymmetric ties (situations where A is friends with B but B is not friends with A) to be avoided: If B does not eventually reciprocate the tie, A is likely to withdraw it (e.g. Hallinan, 1978).

CUTTING-EDGE RESEARCH

While research on each of the above mechanisms—homophily, opportunity, and structural balance—has progressed for nearly a century, it is only relatively recently that scholars have developed integrated theoretical frameworks involving all three. This development is due, in large part, to recent advances in available methods for analyzing cross-sectional and longitudinal social network data.

Theoretical Developments

Theoretical advances in recent years have developed along three fronts: first, expanding the above-mentioned three mechanisms into a broader, encompassing framework; second, differentiating between observed patterns and underlying processes and disentangling the unique role of various processes in generating these patterns; and third, expanding focus to include fixed as well as endogenously changing individual attributes.

Broader Analytic Framework. In an important, recent contribution, Rivera, Soderstrom, and Uzzi (2010) provide a thorough review of the various possible mechanisms that lead to the formation and persistence of social network ties. They classify these mechanisms under three headings: assortative, proximity, and relational mechanisms. This framework is a natural extension of the three processes described earlier—homophily is but one assortative mechanism, social foci are but one proximity mechanism, and structural balance is but one relational mechanism—but there are other mechanisms of each type, as well. For instance, in addition to seeking similarity in a partner, there are various reasons—often in collaborative settings (e.g., Moody, 2004)—for preferring dissimilarity in interaction partners, or heterophily. Physical proximity influences not just the creation of ties through meeting opportunities but also the likelihood of ties being maintained over long distances (e.g., Martin & Yeung, 2006). And "structural" mechanisms that have nothing to do with individual attributes include not only reciprocity and triadic closure but also dynamics of repetition (the tendency for interactions to be repeated) and degree (the tendency for individuals with many ties to accumulate new ties at a faster rate than individuals with fewer ties, or "preferential attachment").

Disentangling Underlying Processes. There is a pervasive tendency in research on social networks—and on homophily in particular—to assume that observed patterns in network structures directly parallel the underlying processes that generated them. In other words, if certain types of individuals (e.g., from the same racial background) tend to be connected in a social network, this must be because individuals from the same racial background prefer to connect with one another (i.e., racial homophily). In much the same way that similarity among network affiliates could be produced by either homophily or opportunity constraints, recent research has begun to acknowledge that the relationship between underlying processes and observed outcomes is still more complex. This work is not without its forbears: Granovetter (1973), for instance, noted that triadic closure could equally plausibly result from structural balance, homophily, or opportunity mechanisms; Feld (1982) noted that social foci bring together disproportionately homogeneous sets of people, leading to the appearance of homophily; and Rivera *et al*. (2010) note that work on each mechanism tends to progress in relative isolation, and we know relatively little about the relative strength of various network-generating factors (see also Kalmijn, 1998).

Building on these leads, a handful of recent papers have not only mapped a number of theoretical relationships between different underlying processes and the same observed pattern; they have statistically disentangled and quantified the relative contribution of each process, as well. Goodreau, Kitts, and Morris (2009), for instance, consider the relationship between three underlying processes (sociality, selective mixing, and triadic closure) and three observed outcomes (a network's degree distribution, mixing pattern, and level of transitivity). Kossinets and Watts (2009) investigate the origins of "homophily" in a large university community, and show that even a modest degree of homophilous preference can be compounded over many "generations" of interaction due to triadic and focal closure. Meanwhile, Wimmer and Lewis (2010) distinguish between racial "homophily"—the preference for a racially similar partner—and "homogeneity"—the pattern of racial similarity in social networks—and show that the importance of racial homophily is distorted unless alternative mechanisms of tie formation (ethnic homophily, sociality, and structural balance) are also taken into account.

Network and Behavioral Coevolution. A final source of theoretical progress in fact has to do with another mechanism that can generate observed similarity between partners in a social network—but only with respect to characteristics that, unlike racial background, potentially change over time. In other words,

just as network "homogeneity" in certain characteristics can be produced by homophily, opportunity, and structural balance, so too can homogeneity be generated by *peer influence*—the tendency to adopt the characteristics and behaviors of our peers. In other words, are friends similar to one another because similar people become friends or because friends become more similar over time? While the puzzle of social selection and peer influence has been a focus of research for decades (e.g., Kandel, 1978), a number of methodological issues (Lyons, 2011; Noel & Nyhan, 2011; Shalizi & Thomas, 2011) have plagued traditional and contemporary work on this topic; and it is only relatively recently that methodological advances (e.g., Steglich, Snijders, & Pearson, 2010) have enabled a clearer answer to this longstanding theoretical puzzle. Perhaps unsurprisingly, results vary tremendously based on the context, relationship, and attribute at hand: While Mercken, Snijders, Steglich, Vartiainen, and de Vries (2010) find that selection as well as influence processes play an important role in adolescent smoking behavior and de Klepper, Sleebos, van de Bunt, and Agneessens (2010) show that students adjust their own military discipline to that of their friends, Lewis, Gonzalez, and Kaufman (2012) find that peer influence among friends on Facebook is virtually nonexistent.

Methodological Advances

The above-mentioned progress was largely enabled by unprecedented developments in available methods for analyzing social network data. While network analytic tools have rapidly advanced on a number of fronts (see review in Snijders, 2011), of particular note here are two methods that are capable of statistically disentangling the various underlying mechanisms that give rise to observed patterns: one, exponential random graph modeling, which uses cross-sectional network data to understand how observed social networks were generated (Robins, Pattison, Kalish, & Lusher, 2007); and the other, stochastic actor-based modeling, which uses longitudinal network data to understand how observed social networks evolve over time (Snijders, van de Bunt, & Steglich, 2010). While these are certainly not the only techniques available for examining the complex underlying processes governing social network emergence and evolution, they do provide several distinct advantages compared to prior approaches (e.g., Steglich *et al*., 2010); feature recently developed model terms and estimation techniques that help overcome the limitations of prior specifications (e.g., Robins, Snijders, Wang, Handcock, & Pattison, 2007); and are increasingly featured in mainstream sociological publications (e.g., Schaefer, Kornienko, & Fox, 2011; Srivastava & Banaji, 2011; Wimmer & Lewis, 2010).

KEY ISSUES FOR FUTURE RESEARCH

As a consequence of the advances described, recent scholarship has built on the foundation created by decades of prior work to advance social network analysis to a new level. Rather than describing patterns in social networks and inferring from these patterns the underlying processes that generated them, the relationship between process and pattern is itself increasingly scrutinized—leading to knowledge that is genuinely explanatory rather than descriptive. Still, there is room for progress in three directions.

Depth

First, our grasp of the processes governing network formation and evolution remains relatively shallow—a necessary consequence of tackling comparatively "superficial" issues first (e.g., what is the relative importance of various mechanisms) before plunging deeper (e.g., what are the interactions between these mechanisms and how does their importance vary over time). For instance, does the strength of triadic closure vary across racial groups? What types of social foci are particularly conducive to friendship development and maintenance? And how does the importance of each mechanism vary over time as networks emerge and evolve (cf. Rivera *et al.*, 2010)? Greater depth can also be achieved by returning to the basics of how network analysts approach their data and the assumptions implicit in much of our theory and methods. How is the process of tie formation different from that of tie maintenance—not to mention tie dissolution? How do these dynamics vary when we are dealing with valued, rather than dichotomous, social relationships? Transcending such distinctions altogether, future research would benefit from greater integration of qualitative and quantitative approaches focused on the meaning of ties, nodes, and groups (e.g., Fuhse, 2009; Pachucki & Breiger, 2010; Yeung, 2005), and even by returning to longstanding, taken-for-granted mechanisms such as homophily and acknowledging how little we actually know about how they work in practice (see DiMaggio & Garip, 2012, p. 111).

Breadth

Second, while our understanding of network dynamics has quickly expanded to new settings and relationships, curious gaps—and the potential for still further improvement—remain. For instance, social network analysis is fundamentally concerned with the study of interpersonal relationships, of which there is arguably no more important example than romantic ties. However, the literature on romantic relationships (which has largely focused on marriage due to the importance of the marriage

relationship and the availability of accurate, nationally representative data) has developed largely independently from the broader literature on social networks. This division is understandable due to the unique nature of "marriage" as a network tie (individuals can have, at most, only one "alter" at any given time, making for a rather uninteresting social network) as well as the unique nature of marriage data (while complete social network data provide information on ties as well as non-ties, marriage records, for instance, include only the former, precluding the application of many network analytic techniques). On the other hand, this division has also stymied progress because each line of research has been slow to take advantage of the theoretical insights developed by the other. More generally, there is great room for comparative work across networks with multiple types of relationships in multiple types of settings, as well as the development of additional analytic techniques that can handle multiple types of ties in the *same* setting, that is, network multiplexity (McPherson *et al.*, 2001).

Scale

Finally, there is increasing enthusiasm for a movement commonly referred to as "computational social science"—in which network analysis will almost certainly play a central role. Owing to the ubiquity of electronic communication—and especially the explosion of social network sites such as Facebook—digital traces of human interaction are available to researchers in unprecedented quantities. While traditional network datasets (such as those cited in the introduction) consisted of networks on the order of tens of nodes, we are now seeing available network datasets on the order of hundreds, thousands, and sometimes millions of nodes—leading some to term this the moment of "big data" in social science. The promise and obstacles such a movement entails have been discussed (and foreshadowed) elsewhere (e.g., Lazer *et al.*, 2009; Rogers, 1987). What has received less attention is the tension this situation has created for forward-thinking network analysts. We have reached a stage of rapid methodological development in which we are able to do more today with the same data than we have ever done in the past. However, this methodological development has not yet caught up with the scale of available data—leading to situations in which available methods are applied beyond their intentions (and worse, beyond their assumptions); or, more commonly, they are not applied at all. Ironically, then, for all of its promise, the movement of computational social science risks pushing us back to the very type of descriptive analyses that characterized foundational research on social networks—because we simply do not yet have the tools available to do anything else.

Perhaps the most promising area for future development, then, is striking a productive compromise between the two: acknowledging what we can and cannot do with the massive quantities of data that are increasingly available and ensuring that explanatory breadth and depth are not sacrificed because our reach exceeds our grasp. The three mechanisms of homophily, opportunity, and balance will surely continue to be central to our understanding of how networks form and evolve. But particularly at a time when an increasing proportion of human interaction occurs digitally and technology is used as much to maintain social ties (Ellison, Steinfield, & Lampe, 2007) as to create them (Rosenfeld & Thomas, 2012), the next great advance in social network thinking and research remains to be seen.

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