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The Role of Space in the Formation of Social Ties

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Abstract

Recent years have seen a resurgence of interest in the relation between networks and spatial context. This review examines critically a selection of the literature on how physical space affects the formation of social ties. Different aspects of this question have been a feature in network analysis, neighborhood research, geography, organizational science, architecture and design, and urban planning. Focusing primarily on work at the meso- and microlevels of analysis, we pay special attention to studies examining spatial processes in neighborhood and organizational contexts. We argue that spatial context plays a role in the formation of social ties through at least three mechanisms, spatial propinquity, spatial composition, and spatial configuration; that fully capturing the role of spatial context will require multiple disciplinary perspectives and both qualitative and quantitative research; and that both methodological and conceptual questions central to the role of space in networks remain to be answered. We conclude by identifying major challenges in this work and proposing areas for future research.

INTRODUCTION

To get a sense of how much technology has changed the process through which people form ties, consider two statements that, until recently, would have been deemed to be truisms. First, for people to form ties they must first interact socially; second, all social interaction must take place in a physical space (Blau 1977). The first has been and will continue to be true for the foreseeable future. The second is dramatically untrue in the age of the Internet (Rainie & Wellman 2014). While people have been able to interact without being copresent at least since the invention of the telephone (Fischer 1992), today physical copresence is so unnecessary to many network processes that some have been tempted to assert that space no longer matters.

In this article, we critically assess a body of research that, on the contrary, asserts that physical space plays a central role in the formation of social ties. The general literature on how space shapes social relationships is long-standing, including work in network analysis, geography, organizational science, neighborhood research, architecture and design, and urban planning (e.g., Park et al. 1925; Festinger et al. 1950; Goffman 1963; Whyte 1980; Fischer 1982; Hillier & Hanson 1984; Lefebvre 1991; Latané & Liu 1996; Small 2009, 2017; Butts et al. 2012; Doreian & Conti 2012; Spillane et al. 2017; for *Annual Review of Sociology* articles, see Baldassare 1978, Gieryn 2000, Logan 2012). Major researchers concerned with how space shapes social relations have included sociological thinkers such as Simmel (1997) and Blau (1977), urban observers such as Jacobs (1961) and Whyte (1980), space theorists such as Lefebvre (1991) and Hillier & Hanson (1984), and network analysts such as Feld (1981) and Festinger et al. (1950).

Recent years have seen a resurgence of interest specifically on the relation between space and networks. Several research programs have developed new perspectives and methods (e.g., Hillier et al. 1993, Butts 2003, Liben-Nowell et al. 2005, Daraganova et al. 2012, Butts et al. 2012, Hipp et al. 2012, Sailer & McCulloh 2012). Multiple scholars have authored thematic, conceptual, or instructional papers (e.g., Latané & Liu 1996, Butts & Carley 2000, Butts & Acton 2011, Luo & MacEachren 2014). And several journals have published special issues—e.g., *Social Networks* (adams et al. 2012), the *Journal of Economic Geography* (Glückler & Doreian 2016), and *Environment and Planning B* (Ye & Liu 2018).

This work, ranging widely across disciplines, is fertile ground for sociologists interested in the formation of social ties. The range of ideas far surpasses what can be covered in one review—e.g., several reviews could be written on the methodological work alone (Peponis et al. 1997a,b; Butts & Acton 2011). For this reason, we select studies strategically, favoring works that are particularly innovative, undercited outside their fields, or central to the three forms of spatial context we discuss. We also point readers to relevant additional reading.

In what follows, we argue that spatial context plays a role in the formation of social ties through at least three mechanisms, spatial propinquity, spatial composition, and spatial configuration. We show that fully capturing the role of spatial context will require multiple perspectives and both qualitative and quantitative research and that important questions in the study of space and networks remain to be understood. We first place our review within the large extant bodies of work; it largely centers on work at the meso- and microlevels of social interaction. Next, we review a selection of research on how spatial propinquity, composition, and configuration shape the formation of social ties. Then, we identify core critiques of spatial approaches to the formation of social ties, including their mixed evidentiary basis. We conclude by briefly identifying promising areas for future work.

BACKGROUND AND SCOPE

Tie Formation—Individuals and Dyads

The general question of how people form ties has inspired a large and diverse literature (e.g., Lazarsfeld & Merton 1954, Newcomb 1961, Verbrugge 1977, Hallinan 1978, McPherson et al. 2001, Rivera et al. 2010, Snijders et al. 2010, Butts et al. 2012). The literature is diverse in, among other things, the studies' units of analysis: the individual, the dyad, the triad, the whole network, the organization, the neighborhood, the city, and the nation. Accordingly, it is methodologically diverse, involving qualitative and quantitative studies and multiple analytical traditions, including both ego-centric and socio-centric works within network analysis and alternative perspectives in other fields. Because of this heterogeneity, the literature is also diverse in the language used to conceive the process: friendship formation, association, edge probability, triadic closure, transitivity, marginal probability of a social tie, change in density, and more. These differences reflect substantially different assumptions about the ontology of networks and actors and the epistemological perspective from which they should be studied. For example, an ego-centric study might assume that the process ultimately hinges on actors' decisions, and thus focus on how, given their opportunities and constraints, individuals decide to befriend or associate with others; in contrast, a socio-centric study might assume that the process ultimately hinges on the properties of the network, and thus focus on how the network evolves over time, distinguishing random fluctuations from fundamental structural processes. While the various perspectives are not necessarily in contradiction, they do ask fundamentally different questions.

Given their range, we cannot do justice to all these perspectives in one article. We focus primarily on work at the individual and dyadic units of analysis and adopt the corresponding language of tie formation (see Rivera et al. 2010). Nevertheless, we also selectively discuss studies of network evolution, of community formation, and of neighboring, when these focus on the decisions of individuals or behavior of dyads, or when they are important or methodologically notable. Recent reviews covering tie or network formation broadly are those of McPherson et al. (2001) and Rivera et al. (2010). For work on space within networks research at structural levels of analysis, readers are directed to the articles by Butts & Acton (2011) and Butts et al. (2012).

Meeting and Mating

Researchers on tie formation at the individual and dyadic levels largely agree that the probability that two strangers form a tie depends on two separate processes: coming into contact and deciding to associate. The first calls attention to the importance of opportunities for social interaction. As Blau & Schwartz (1997, p. 29) put it (their emphasis), "*rates of social association depend on opportunities for social contact*…the extent of contact opportunities governs the probability of associations of people, not merely of casual acquaintances but even of intimate relations, like those of lovers" (see also Blau 1977, p. 90). Marsden (1990, p. 397) referred to this idea as the "supply-side" perspective of friendship, wherein "the composition of individual social networks will reflect the…opportunity structure for the selection of associates." Gans (1961, p. 135) referred to it as "contact" based on ecology. Verbrugge (1977, p. 577), who adopted an explicitly dyadic approach to friendship formation, argued that "pairs of strangers have varying probabilities of ever meeting each other" and referred to this set of probabilities as the "meeting" process. Consistent with this notion, much of our review focuses on how spatial context affects opportunities for social interaction.

The second process calls attention to the decision, given the opportunity, to form a tie. Marsden (1990, p. 397) referred to it as the "demand-side" perspective, which "interpret[s] variation in

network composition as the result of differing levels of individual preference for associates of particular kinds." Gans (1961, p. 137) conceived of it as a "choice" based on mutual interest. Verbrugge (1977, p. 577) put it differently. For a pair of strangers, there are "varying probabilities of developing a close friendship if they do meet," a set of probabilities she called the "mating" process. We also examine how, consistent with this notion, spatial context affects the frequency and nature of interaction once contact has been established (Sacerdote & Marmaros 2006, Conti & Doreian 2010, Reagans 2011, Frank et al. 2013).

Defining Spatial Context

Space is everywhere. Given the many disciplines examining how space affects social relations, the terms "space" and "spatial" have been used in diverse ways. For our purposes, spatial context is the natural or built physical environment in which social interaction takes place. We use "space" strictly in the physical sense, not in the metaphorical sense at times used in network analysis, as when social relations are conceived of existing in a "space" of vertices and edges (see adams et al. 2012, pp. 1–2). Thus, when we speak of "proximity," we are referring to physical propinquity, or the number of feet, blocks, miles, etc., that separates two actors, rather than "network proximity," or the number of intermediaries between two nodes; a "neighborhood" refers to a physical place—the collection of blocks, streets, and organizations in a city—rather than a set of nodes in network (as in, e.g., Pattison & Robins 2002). Limiting the designation of space-related terms to the physical realm helps avoid confusion as we translate works across disciplines.

Spatial Scales

We narrow our scope by focusing on the lower scales of spatial context. Spatial context has been studied at the macrolevel of cities and regions, at the mesolevel of neighborhoods and organizations, and at the microlevel of streets or parks (within neighborhoods) and rooms or cubicles (within organizations) (e.g., Blau 1977, Festinger et al. 1950, Conti & Doreian 2010). The research at the macro scale includes the large literature on the role of spatial proximity in opportunities for contact (Blau 1977). Researchers have examined the spatial distribution of people of different backgrounds across regions and cities to understand issues such as the racial composition of personal networks. Butts and colleagues have developed a series of models to examine how the distribution of a population across a region affects various aspects of its network structure (Butts 2003, Butts et al. 2012; also Liben-Nowell et al. 2005). Research at this large geographic scale has grown rapidly in recent years and has generally uncovered that geographic variability alone can account for much of the structure in large-scale networks.

Instead, our focus is a lower level of analysis. Consistent with our focus on individual and dyadic relations, we center on spatial context at the meso- or microlevels, specifically on neighborhoods and organizations and on the places within them. Note that our focus is the spatial context of neighborhoods and organizations—the physical features of their built environments. Since a neighborhood is not merely the sum of its physical features, our discussion largely excludes other ways neighborhoods can affect the formation of social ties, such as through their demographic composition. Similarly, since organizations are more than their physical features—and indeed may even lack a physical footprint altogether—our discussion largely excludes other ways organizations may affect tie formation, such as through their administrative hierarchies.

Three Forms of Spatial Context

Even within these constraints, there are multiple ways of understanding the relationship between spatial context and tie formation. We argue that three mechanisms are especially important: spatial

propinquity, or the degree of physical proximity between actors; spatial composition, or the presence of fixed places, such as parks, restaurants, or lobbies, that make interaction possible or likely; and spatial configuration, or the segmentation of space into subunits with physical boundaries and pathways between them. We discuss each in turn.

SPATIAL PROPINQUITY

The most widely studied issue in spatial network analysis is the role of physical proximity in social relations. This focus reflects what Tobler (1970, p. 236) called the first law of geography: "everything is related to everything else, but near things are more related than distant things." In sociology, early thinking on proximity may be found in the work of Simmel (1997), who believed that the physical distance between people affected their psychological and emotional relations (see also Simmel 1971). Blau (1977, p. 90) believed that "physical propinquity exerts a pervasive influence on human relations," affecting "not merely…casual acquaintance but also…friendship and marriage." Simply put, "the greater the physical propinquity between persons, the greater is the probability of associations between them" (Blau 1977, p. 91; Blau & Schwartz 1997).

The importance of propinquity to tie formation has been uncovered empirically many times. In a suggestive early study, Bossard (1932) examined whether residential proximity affected how people found their spouses, based on 5,000 consecutive marriage license applications in Philadelphia that listed the two applicants' addresses. Examining the number of blocks between the addresses, he found a "marked decline in the percentage of marriages as the distances between the contracting parties increase" (Bossard 1932, p. 222; see also Marches & Turbeville 1953). In their classic study, Festinger et al. (1950) examined several hundred residents in an MIT housing complex for married war veterans and asked them who they most saw socially among others on the complex; respondents were more likely to report neighbors who lived closer. Many early studies reported similar findings (Caplow & Forman 1950, Athanasiou & Yoshioka 1973, Nahemow & Lawton 1975, Ebbesen et al. 1976).

Both traditional and contemporary studies have varied widely in their approach to measuring propinquity. Some studies have simply used binary measures that capture adjacency. For example, Segal (1974) and Conti & Doreian (2010) studied friendship formation among police academy trainees and measured proximity based on adjacency in the trainees' assigned seating. Other studies have used indirect proxies for propinquity, such as coresidence in the same housing unit (Erbe 1966) or neighborhood (Sigelman et al. 1996), or work in the same university (Van Vliet 1983), floor (Reagans 2011), department (Dahlander & McFarland 2013), or chamber (Liu & Srivastava 2015). These measures capture proximity either indirectly or very generally.

Many studies have developed more precise measures of propinquity. For example, Festinger et al. (1950) counted the number of units between each pair of potential associates among the four housing units on each floor of the buildings of the MIT housing complex. Greenbaum & Greenbaum (1985, p. 58), in a study of friendship ties among about a hundred women in four neighborhoods, used two measures, one an indicator of copresence in the face-block, the other a measure of successive 150-foot distance zones between the parties. In fact, quite a few studies have measured propinquity as distance in feet, meters, or miles (e.g., Erdogan et al. 1996, Habinek et al. 2015, Spiro et al. 2016, Kabo 2017). Occasionally, studies examine multiple measures at different scales (Kleinbaum et al. 2008). For example, Caldeira & Patterson (1987) studied the effect of proximity on friendships among Iowa legislators, based (at the microlevel) on the seating proximity in the chamber—whether pairs of legislators were within one seat of each other in any direction—and (at the macrolevel) on the number of miles between the county seats of each pair.

More precise conceptions of propinquity have made possible more fine-grained analyses. With multiple measures and at multiple scales, researchers have consistently found a nonlinear relation between propinquity and either friendship, communication, or association, with evidence of rapid decay as distance increases (Latané et al. 1995, Preciado et al. 2012). (Geographers have long studied such phenomena at the macrolevel under the distance decay rubric, e.g., Eldridge & Jones 1991.) For example, based on a small study ($n \sim 80$) of residents in different kinds of dwellings in Decatur and Peoria, Illinois, Sudman (1988) reported that, of those living in single-family units, about 80% knew their next door neighbors, about 50% knew the neighbors two doors down, and about 10% knew the neighbors behind them (see also Greenbaum & Greenbaum 1985). In an early study of communication patterns among more than 5,000 workers in seven research and development laboratories, Allen & Fustfeld (1975) examined the relationship between the distance between the desks and frequency of communication. The association between distance and communication decayed rapidly, reaching an asymptotic level near zero by about 25 or 30 m. A later study based on research on additional organizations reported the figure at about 50 m (Allen 2007, p. 26). Using nationally representative data on adolescents from the National Longitudinal Study of Adolescent to Adult Health (Add Health), Mouw & Entwisle (2006) found that the effect of residential propinquity on within-school friendship nominations was limited to a distance of within 1/4 km, after which there was no impact on the probability of a tie between respondent and alter. And a recent study based on data on several hundred teens in a Swedish town found that the log odds of friendship "decrease[d] smoothly with the logarithm of distance" between the two adolescents' households (Preciado et al. 2012, p. 18; see also Latané et al. 1995).

Similar nonlinearities have been found in studies focused on other outcomes related to social interaction, such as knowledge sharing among coworkers (Appel-Meulenbroek et al. 2017) or relationship maintenance among friends (Carrasco et al. 2008; see also Verbrugge 1983, Mollenhorst et al. 2011). For example, Mok & Wellman (2007) used data from 29 of the respondents of Wellman's (1979) East York study to examine how the number of miles between people who knew one another was associated with face-to-face contact; they found marked declines after 5 miles, after about 50, and again after about 100.

SPATIAL COMPOSITION

Though propinquity is probably the most studied and least surprising spatial variable to affect tie formation, proximity alone may not ensure interaction. In fact, other dimensions of spatial context are no less important. One of these is what we refer to as spatial composition, or the presence or absence of fixed places that make social interaction possible or likely. Note that, strictly speaking, propinquity is not a characteristic of space; it is a characteristic of two or more people that manifests itself in space. Spatial composition is a core characteristic of space itself. At the neighborhood level, spatial composition refers to the presence or absence of parks, plazas, community organizations, cafés, bars, barbershops, religious institutions, child care centers, and similar places where social interaction takes place (Oldenburg 1989, Small 2009, Small & Feldman 2012). At the organizational level, it refers to the auditoriums, water cooler stations, cafeterias, lobbies, classrooms, and similar places in the buildings where social interaction takes place (Blau 1955, Davis 1984, Kabo 2017).

Such fixed places are two things at once. First, they are locations that make social interaction possible. A pair of neighbors may have difficulty interacting in the absence of restaurants, grocery stores, or barbershops in their vicinity; a pair of workers in the same large corporation may never come into contact in the absence of cafeterias or other common spaces where interaction may take place.

But fixed places do not only make interaction possible; they may also encourage it by focusing attention. They are not just locations but also foci. While some aspects of this question have concerned architects for generations (e.g., Alexander et al. 1977), as a sociological matter, this idea has roots in thinkers such as Simmel (1997), Feld (1981, 1982), and Whyte (1956, 1980).

Simmel (1997, p. 146) proposed that one of the most important aspects of space was the possibility of "fixed" locations, immobile places that serve as a "pivot point" for social interaction. People do not move about randomly in a space; they orient their activity toward fixed locations. He offered the example of the church: "This fixed point in space becomes a pivotal point for the relationships and the cohesion of the faithful, so that communal, rather than isolated, religious forces are developed" (Simmel 1997, p. 147). The church building is important because it orients social activity toward a single place, giving people a reason to gather in one location. Fixed locations actually structure social interaction and may, in fact, be indispensable to the latter.

Decades later, Feld (1981, 1982) proposed that foci of activity were important to the formation of social ties. He argued that foci, which "may be many different things, including persons, places, social positions, activities, and groups" (Feld 1981, p. 1018), serve as a point toward which people's activity is oriented, resulting in the formation of connections. Around the same time, Whyte (1980) made a similar argument, based on his systematic observational study of the factors affecting interaction in small urban spaces. He noted that when two actors interact around a single focus, the phenomenon may be termed "triangulation;" he described it as "the process by which some external stimulus provides a linkage between people and prompts strangers to talk to each other.… The stimulus," he noted, "can be a physical object or a sight" (Whyte 1980, p. 94). Thus, fixed places in space may not just provide opportunities for social interaction (meeting); they may encourage relations (mating).

Evidence of the importance of spatial composition has accumulated at the mesolevel of the parks, plazas, and establishments within neighborhoods, and at the microlevel of the lobbies, halls, and public spaces within organizations. Moreover, spatial composition at both levels has been shown to shape the role of propinquity. We begin by focusing on neighborhood analyses.

Neighborhood Level

Urbanists have long argued that parks, plazas, and establishments in cities and neighborhoods contribute to social interaction among strangers (see, e.g., Jacobs 1961, Whyte 1980, Katz 1993, Mehta 2007)—an idea borne out in multiple empirical studies.

Some studies have focused on the impact of parks and plazas. Whyte's (1980) systematic study of plazas and other small urban spaces made clear that plazas regularly brought strangers into contact. That relationship has not weakened with time. Whyte confirmed that these places encouraged contact among strangers based on careful video recordings of such places in New York, Boston, Philadelphia, and other cities. In a unique replication study, Hampton et al. (2015) returned to those sites three decades later, video-recorded social interactions systematically, and compared their results to Whyte's. They found a similar pattern (in addition, more of the people visiting the locations were doing so in groups than in the past, and a greater proportion of the visitors now were women). Lund (2003) surveyed residents in eight urban and suburban neighborhoods and found that rates of unplanned interaction were higher in neighborhoods with walkable access to parks. Abu-Ghazzeh (1999) both surveyed and conducted in-depth interviews of residents in a large community in Jordan and found that the opportunity to interact in small public spaces, but not the presence of large open spaces, was associated with increased social interaction and friendship formation.

Some studies have focused on establishments and shown that, by facilitating interaction, they encourage tie formation. In a widely cited book, Oldenburg (1989) argues that places such as coffee shops, beauty parlors, and bars were not merely establishments for the purchase of coffee, hair products, or alcohol; they were primarily sites of sociable, noninstrumental interaction (see also Anderson 2011). Both commercial establishments and local community organizations have been shown by many ethnographic studies to contribute to the formation and maintenance of social ties; examples include bars (Anderson 1978), neighborhood restaurants (Duneier 1992), hair salons (Furman 1997), churches (McRoberts 2003), and child care centers (Small 2009). Studies focused not on tie formation but on other outcomes that depend on social interaction have reported similar findings (e.g., Klinenberg 2002, Sampson et al. 2005).

Other studies of establishments have focused not on the establishments themselves but on individuals as the unit of analysis. In an early descriptive study, Farberman & Weinstein (1970) surveyed more than 400 residents of St. Paul, Minnesota, about the establishments they frequented, such as hairdressing locations, car repair shops, and clothing stores, and the friendships they formed there. They found a steady relationship between the proportion of respondents patronizing an establishment who reported forming friendships there and both the intensity and the frequency of interaction in it. For example, 34% of those patronizing barbershops or hair salons, where interaction is repeated and intense, had formed ties there; but only 5% of those patronizing hardware stores, where interaction is infrequent and brief, had done so. Along these lines, Small (2009) showed that child care centers are often visited by parents both frequently (for drop-off and pickup) and intensely (for volunteer activities). Using nationally representative data on US mothers, he found that most mothers who enrolled their children in centers had made friends there, and as a result had more close friends, ~4.5 versus ~3.5, than comparable mothers who did not enroll their children in centers (Small 2009, p. 38). Other studies have found that participation in establishments is associated with the characteristics of the ties formed. For example, Mollenhorst et al. (2008a,b), using nationally representative survey data in the Netherlands, found that people who met in contexts such as school, work, or clubs (but also via family) were more likely to be homophilous to friends and partners (see also Verbrugge 1979, Kalmijn & Flap 2001).

Some works have specifically examined the idea that focused activity is part of how establishments and similar fixed locations contribute to tie formation. Small found that activities such as parent meetings, field trips, and spring cleanings in child care centers focused the activities of parents, providing "opportunities and inducements" for parents to connect to one another (Small 2009, p. 51). Abdulkarim & Nasar (2014) sought specifically to test, in a laboratory setting, Whyte's ideas that seats, food vendors, and sculptures attract and keep people in plazas. In an experiment, the authors showed participants pictures of plazas and asked how willing they were to visit, stop at, or spend time in these; the plazas were randomly assigned to either have or lack digitally entered but realistic seats, food vendors, or sculptures. The researchers found that plazas with any of these elements were scored higher than those without these elements—sculptures and similar elements, the findings suggest, attract the attention of passersby. An early observational case study based on three playgrounds found a different kind of evidence of the importance of focused activity (Hayward et al. 1974). Based on systematic observation, the authors found that though children interacted socially in all three, they spent more than twice as much time (about 75 min) in a playground fitted with materials for children to devise their own play—an especially intense focused activity—than in more traditional playgrounds with swings, seesaws, or tunnels (Hayward et al. 1974). A recent community-based intervention in three Portland, Oregon neighborhoods created amenities or fixed foci of activity such as kiosks, benches, and art walls. To evaluate the consequences for tie formation and civic engagement, Semenza & March (2009, p. 22). interviewed more than 300 residents within two blocks of the three project sites; after the intervention, "30%

mentioned increased social interactions, 13% revealed an enhanced sense of place, [and] 43% described neighborhood participation." Many of these studies are small in scale and, though highly suggestive, far from dispositive. As we discuss below, both evidentiary and methodological challenges remain.

Organization Level

Architects and designers have long argued that communal places such as waiting areas and conference rooms, and their elements such as benches and tables, can contribute to social interaction and cohesion (e.g., Alexander et al. 1977, Davis 1984, Appel-Meulenbroek et al. 2017, Kabo 2017). Though much of this work has been produced by architects and designers rather than planners and urbanists, the differences between these types of studies of spatial composition are less in kind than in degree. In essence, similar kinds of questions, often under different rubrics, are studied at a more microlevel of analysis.

In fact, some of the work is explicitly a more microlevel approach to questions typically studied among neighborhoods. Rather than studying whether elements such as cafés contribute to interaction in neighborhoods, they examine whether elements such as open outdoor seating contribute to interaction in cafés. For example, Mehta & Bosson (2010) examined what Oldenburg (1989) termed "third places" to determine the physical characteristics that shaped their effectiveness at stimulating social interaction. The authors identified three high-traffic neighborhoods in Cambridge, Brookline, and Somerville, Massachusetts; collected systematic data on 120 first-floor businesses; and conducted in-depth interviews. The authors examined several factors, including whether the business provided outdoor seating and shelter from the elements (see also Sommer 1966a,b; Whyte 1980; Abdulkarim & Nasar 2014). In matched comparison tests, they found that successful third places ["identified as a community-gathering place by the people who lived or worked in the neighborhood" (Mehta & Boston 2010, p. 788)] provided significantly more seating and shelter from the elements than comparable establishments. Others have studied similar questions in other contexts, such as whether houses have front porches (Brown et al. 1998, Al-Homoud & Tassinary 2004, Wilkerson et al. 2012) or whether dormitories have communal spaces (see Heilweil 1973). Readers interested in additional studies with a sociological, rather than only architectural, orientation may find especially useful the *Journal of Planning Education and Research*, *Environment and Behavior*, and *Environment and Planning* (particularly *Environment and Planning B: Urban Analytics and City Science*, formerly *Environment and Planning B: Planning and Design*).

An important aspect of organizations is that they are not only places for social interactions but also institutions with sets of rules and norms that govern social interaction (Small 2009, 2017). Within a school, a physical classroom makes interaction among students possible, but institutional rules about class assignment determines which students actually occupy it at a given time (Hallinan 1976, 1979). As a result, much of the sociological evidence on the role of fixed places within organizations is bound up with research on institutional rules, particularly those that separate people into rooms. For example, an early study of Air Force soldiers that examined the role of their arrangement into bays within barracks found that soldiers were more likely to report "best buddies" among those with whom they shared sleeping bays (Loether 1960). School and college studies have often reported similar kinds of findings (Hallinan & Tuma 1978, Hallinan & Sørensen 1985, Moody 2001, Van Duijn et al. 2003, Frank et al. 2008). For example, Frank et al. (2013) used Add Health data to examine whether taking multiple courses in common affected friendship formation. They found that students who took clusters of courses together were 1.77 times more likely to form a friendship than students who took different clusters, even after adjusting for standard factors.

Spatial Composition and Propinquity

The spatial composition of neighborhoods or organizations can either mediate or moderate the effects of propinquity. The use of local establishments may affect how often people living near each other interact. For example, in a small study ($n = 54$) of relations among residents in Bloomington, Indiana, Campbell (1990) found that those living adjacent to a grocery store or a church had denser neighbor networks than others. The finding provides indirect evidence that such fixed locations matter—and that their presence undercuts the negative effects of distance. In a survey-based study of relations among neighbors in a new urban community with multiple subdivisions, Cabrera & Najarian (2015) examined the extent to which people had connections to those in other subdivisions. Propinquity research would suggest the distance between homes in separate subdivisions was too far to ensure interaction. The authors found that "respondents who made use of the local shops and businesses (foci such as the yoga studio, fitness center, café, etc.)" had significantly more ties to residents in subdivisions other than their own than those who did not (Cabrera & Najarian 2015, p. 259). Similarly, in their study of friendships among Swedish adolescents, Preciado et al. (2012, p. 29) found that which school students attended strongly moderated the effect of propinquity: "for those going to different schools, living nearby [was] more important than for those going to the same school." In fact, for students attending the same schools, propinquity largely only had an effect if the distance was fewer than 350 m. The effects of propinquity may depend on the composition of the space itself.

SPATIAL CONFIGURATION

We refer to spatial configuration as the arrangement of physical barriers and pathways that result in the segmentation of a space. At the neighborhood level, spatial configuration refers to the arrangement of streets, blocks, and other elements that segment the space and thereby encourage interaction among some while discouraging it among others (e.g., Suttles 1968). At the organizational level, it refers to the hallways, floors, cubicles, and other aspects of a building that have the same consequence (e.g., Sailer & Penn 2009, Kabo et al. 2014).

Spatial configuration has two dimensions. One is the segmentation of space by boundaries and pathways. The importance of such segmentation was noted by Simmel, who argued that a "quality of space" that "has a fundamental effect on social interactions, lies in the fact that for our practical use space is divided into pieces which are considered units and are framed by boundaries" (Simmel 1997, p. 141). Years later, Blau (1977, p. 90) made a similar observation: "Physical barriers—be they prison bars or oceans or long distances—naturally impede social associations." Since then, researchers have differed in whether they have emphasized boundaries or pathways. Those focused on boundaries have studied, e.g., walls, rivers, and highways, and have used various names to describe them, including space enclosures (Al-Homoud & Tassinary 2004), fixed boundaries (Small 2004), and wedges (Hipp et al. 2014). Those focused on pathways have usually studied roads, streets, and hallways (e.g., Grannis 1998, Spillane et al. 2017). The key is that boundaries undermine contact between two segments of a space; pathways facilitate it. By structuring movement, they both shape social interaction.

The other dimension is the position of boundaries and pathways relative to one another in the city, neighborhood, or organization (Hillier & Hanson 1984, Kabo et al. 2014, Wineman et al. 2014). In recent years, the work of Hillier and Hanson has been essential (Hillier & Hanson 1984; Hillier et al. 1987, 1993). The authors have proposed what they call a "space syntax" approach to study how people's movement across space responds to its configuration. In a useful discussion, Hillier et al. (1993) contrast their focus on spatial configuration to others' focus on what we have called spatial composition. In reference to the idea that fixed places are what bring people together,

the authors write, "We might call this the *attraction* theory of pedestrian movement: movement is seen as being *to and from* built forms with differing degrees of attraction, and design is seen as coping with the local consequences of attraction" (Hillier et al. 1993, p. 29; italics in original). The authors believe that this primary focus on places that attract people is undeserved: "Attraction theories say little about the spatial configuration of the urban grid, that is, about the way in which the spatial elements through which people move—streets, squares, alleys, and so on—are linked together to form some kind of global pattern" (Hillier et al. 1993, p. 29). The "space syntax" project is both theoretical and methodological, a graph-theoretic approach to the elements of a space that allows for the representation of city, neighborhood, and building layouts as a particular kind of network map. The heart of this work is the notion that the relation among the boundaries and pathways in a space shape the natural movement of people across it, and, thus, their opportunities for social interaction.

Both aspects of spatial configuration, the segmentation of space by boundaries and pathways and the position of these elements relative to one another, have received great attention, under many diverse rubrics, at both the neighborhood and the organizational levels. Many researchers have focused on one or the other of these elements, rather than both. And as we discuss, the work has also made clear that spatial configuration must be part of any understanding of propinquity.

Neighborhood Level

Many neighborhood studies have shown that the configuration of space shapes opportunities for social interaction. Several of these have focused on the impact of boundaries. In a classic study of how boundaries affect social interaction, Suttles (1968) examined the small Addams area of Chicago, composed of several small neighborhoods with residents of different ethnic composition. Suttles (1968, p. 225) noted that the relations were characterized by "ordered segmentation": "Within each neighborhood, each ethnic section is an additional boundary which sharply restricts movement. Adults cross ethnic boundaries to shop or go to work, while children do so in running errands or attending school." Beyond these encounters, there was little interaction across the neighborhood boundaries (but see Anderson 1990). In an ethnographic study based in Boston's South End, Small (2004, ch. 5) reported that one main street served as a "fixed boundary" between low-income and affluent residents, such that within each side of the street the blocks were socioeconomically homogeneous. This segmentation was such that each socioeconomic group largely stayed within its side of the street, rarely interacting with those across it (see also Raman 2010).

Others researchers have examined the role of what we have called pathways. For example, in his analysis of Park Forest, Illinois, the suburb he studied as part of his examination of "organizational man," Whyte (1956) noted that the neighborhood was laid out such that routes from houses to the play areas seemed to structure friendships. The importance of pathways to social interaction was at the heart of the New Urbanists' objection to the cul-de-sac street form and their support for more traditional urban grids, although some studies have suggested that the quiet and safety of cul-de-sacs promotes neighborliness (Cozens & Hillier 2008). Some studies have focused not on social interaction but on related outcomes. In an important series of papers, Grannis (1998, 2005) has suggested that the connections among tertiary streets, which are small pedestrian-focused streets, matter more than either larger streets or other aspects of the spatial composition of cities for their extent of residential segregation.

A number of studies have taken a different approach. Rather than studying the configuration of the space, they have focused on how the individual's position within that configuration affects social interaction or tie formation. Whyte (1956, p. 330) also adopted this approach in some of the work, and put the issue well: "Despite the fact that a person can pick and choose from a vast

number of people to make friends with, such things as…the direction of a street often have more to do with determining who is friends with whom." For example, he noted that the location of one's house made a difference: "The more central one's location, the more social contacts one has" (Whyte 1956, p. 346). Similarly, Campbell (1990), in the aforementioned study, found that those living in the center of the block had denser networks than other residents (see also Caplow & Forman 1950). Festinger et al.'s (1950) aforementioned study examined several aspects of the configuration of the studied space. For example, some residents lived in two-story, 10-unit buildings whose second floors were accessible only through external staircases; residents of the units near the staircases had far more friendships than others. Brown & Werner (1985) examined a somewhat different issue, whether the house was on a street likely to encourage social interaction among neighbors. In one neighborhood, they interviewed 139 female heads of household, 40 living on cul-de-sacs and 99 on through streets, and found that the former showed higher levels of neighboring behavior.

The studies above focused on pathways. Studies focused on boundaries have also adopted individual-level perspectives. Hipp et al. (2014) combined surveys of 4,351 residents of Brisbane, Australia, with land use data to examine, among other things, how boundaries such as rivers and highways affected neighboring behavior, community attachment, and perceived neighborhood cohesion. They found that the total number of kilometers a river occupied in a neighborhood— thus, the extent to which it divided the neighborhood—was strongly and significantly associated with lower outcomes in all three measures, even after standard household and neighborhood controls. One study in the Tasmanian town of Hobart, Australia, used the natural experiment of the collapse of a bridge—the only means of transportation between the city's eastern and western sides—to measure the impact of physical boundaries on short-term and long-term social ties. It found that households decreased contact with friends and family on the other side of the river and increased contact with ties on their own side of the river, and that some portion of these changes persisted after the bridge was reconstructed (Lee 1980).

Organizational Level

The role of configuration at the organization level, particularly within offices, has long been a preoccupation of researchers. This literature generally lies at the intersection of design and management research, and centers on the role of office layouts in interaction-dependent outcomes such as collaboration or innovation (e.g., Toker & Gray 2008, Chan et al. 2007 and associated special issue; for reviews, see Wineman et al. 2009, Davis et al. 2011). Though often not centered on tie formation, the work is centrally concerned with the relationship between spatial configuration and interaction.

Many early studies documented such associations, often focusing on the role of physical boundaries and their impact on actors' ability to interact, hear, or even see one another (e.g., Appel-Meulenbroek et al. 2017). For example, Gullahorn (1952) examined, within the floor of a firm, a set of workers seated in rows that were separated from one another by file cabinets, over which the workers could speak to others but not easily. Among 1,558 conversational interactions observed passively over two weeks, 78% were within, rather than across, rows. Blake et al. (1956) studied how the arrangement of military recruits into barracks with open or closed cubicles affected their friendships. The cubicles were similar except that "the closed cubicle barracks had walls enclosing each unit of six bunks, with entrances from which doors had been removed" (Blake et al. 1956, p. 134). Soldiers were randomly assigned to type of cubicle. The authors found "that closed cubicles significantly increase[d] relationships with others in the same cubicle and reduce them with others located in the same barracks but living in different cubicles" (Blake et al. 1956, p. 137).

The notion of comparing boundaries in open versus closed spaces has persisted. In a study of nearly 100 workers in two high technology firms, Hatch (1987) examined the number of participant-logged minutes respondents spent in activities involving interactions with others, depending on whether they worked in open or closed spaces. "Enclosure by partitions (or walls) and a door was found to be positively associated with the amount of time individuals reported working with others. Partition height was also positively related to reported amounts of meeting time" (Hatch 1987, p. 396). Over the course of a few weeks, Boutellier et al. (2008, p. 377) observed all communications among workers in two office environments in the same company, an "'activity based' layout with low partition heights and high visibility versus 'individuum based' layout with high partition heights and low visibility." Workers communicated far more often, though for shorter periods, in the space with low-partition heights and high visibility. In recent years, researchers have developed more advanced measures, such as the "fragmentation index" to capture the extent to which a space has been segmented "by means of partitions or by deformations of shape" (Peponis 1985, p. 360; see also Hillier & Hanson 1984, Peponis 1997).

Nevertheless, much of the most innovative new work has focused less on boundaries alone than on either pathways or the relation between boundaries and pathways (Hillier & Hanson 1984)—as a result, the work has ultimately focused on reshaping our understanding of distance and propinquity.

Spatial Configuration and Propinquity

Spatial configuration necessarily structures the role of propinquity. A measure of distance as the line between two points as the crow flies fails to capture that the configuration of space makes the experienced distance, the amount of time required to travel from one space to another, longer. Researchers have used the concepts of functional distance and functional proximity to refer to this idea and have developed increasingly refined ways to measure it (Festinger et al. 1950; Peponis 1985; Grannis 1998, 2005; Sailer & McCulloh 2012; Kabo et al. 2014, 2015).

The measures have grown rapidly. Peponis (1985, p. 360), working expressly in the spatial syntax tradition, proposed a series of measures to capture how the relation between pathways and boundaries shapes movement across space: the "depth of one space *A* from another space *B*," which is "the minimum number of spaces that must be crossed to reach *A* from *B* or *B* from *A*;" the control value of a space, which "increases in proportion not only to the number of connections [to immediate neighbors] but also…to the extent that each of the neighbor spaces is itself poorly connected;" and the relative number of rings, which is "the number of circulation loops as a proportion of the maximum number of loops possible." In this work, spaces are nodes and the pathways between them edges, with the analysis and measures bearing self-evident analogs to conventional social network analysis.

A recent example sought to bring spatial syntax to formal network analysis. Sailer & McCulloh (2012, p. 56) expressly developed multiple separate measures of distance, including "the number of steps in an axial line topology [a formal representation of an area in terms of possible movement routes between spaces], the number of steps in a more refined segment topology [a more fine-grained version of the former]," and "path length in meters and the degree of angle change." Multiple measures of distance based on spatial configuration resulted in a configuration-based approach to propinquity.

Kabo et al. (2015, p. 62) proposed an important "functional overlap" measure that transcends the limits of even these refined measures of distance. The authors acknowledged that "walking distances between the primary spaces (e.g., offices) that individuals occupy offer more salient

conceptions of distance than do straight line measures." They argued that, nevertheless, "point-to-point walking distances still miss aspects of space that shape the likelihood of passive contacts in the course of normal daily activity." For example, the occupants of two offices within a few yards of walking distance from one another may nonetheless have little contact if separate stairs to the ground-floor exit are adjacent to each office. Conversely, the occupants of two distal offices may encounter each other regularly if one must pass the other on the way to the elevator. In several papers, Kabo and colleagues have developed measures that capture the degree of overlap in the functional zones of two actors in a dyad (Kabo et al. 2014, 2015; Wineman et al. 2014). One important basic measure is path overlap, or the "length of overlap in feet of the paths in the functional zones of the two people in the dyad" (Kabo et al. 2015, p. 73). Another is "the extent to which an individual's workstation is on or near spaces that are on the shortest path (based on metric distance) when moving from all professionals' workstations (within the study unit) to all others" (Wineman et al. 2014, p. 1105). This approach has made the analysis of space amenable to researchers used to social network methods.

This literature has uncovered associations between increasingly refined measures of spatial configuration and social interaction. For example, Kabo et al. (2015), in a study of more than 200 researchers working in two biomedical research buildings, found that a 100-ft increase in path overlap was associated with either a 15% or 30% increase, depending on the building, in a multi-item measure of research collaboration, after dyadic and spatial controls (see also Kabo et al. 2014). Spillane et al. (2017) used data on staff at 14 elementary schools in the United States to understand how space affected patterns of help-seeking, examining, among other things, the functional zone. They defined the functional zone as "the path that connected that staff member's workspace (classroom or office) with two of the following locations: the principal's office, staff restrooms, photocopier location, student lunchroom, and nearest entrance/exit to the building" (Spillane et al. 2017, p. 156). They found that staff "whose paths likely cross[ed] more frequently in their day-to-day work within the school building [were] more likely to talk with one another about their work" (Spillane et al. 2017, p. 149). This sampling of recent studies makes clear that new measures of spatial configuration have created opportunities for much more sophisticated work, far beyond the simple notion that proximity increases opportunities for social interaction.

CHALLENGES AND LIMITATIONS

Though research on spatial propinquity, composition, and configuration has grown rapidly, important challenges remain. These represent both obstacles to progress and opportunities for innovation, both theoretically and empirically. We note three related challenges.

First, the evidence in support of each of these contextual effects remains incomplete. In fact, numerous studies have found either no spatial effects or conflicting evidence. For example, using surveys of 183 residents of a residential development in Irvine, California, to examine the relationship between spatial layout and the probabilities of being liked and disliked, Ebbesen et al. (1976, p. 505) found that "the probability of being chosen as a disliked individual was even more dependent upon physical distance (more disliked than liked individuals lived close to the subjects)." Kahn and McDonough surveyed more than 500 managers in electronic industries to examine the consequences of colocation, an indicator of propinquity, on standard performance measures: "Contrary to the findings of prior studies, we found no significant direct relationship between colocation and performance" (Kahn & McDonough 1997, p. 175). In fact, "the overall results of the present study suggest that colocation does not necessarily have a uniform, beneficial effect on interaction, collaboration, performance, and satisfaction" (Kahn & McDonough 1997, p. 175). Studies

have also found contradictory evidence when examining spatial configuration. An early study of whether cul-de-sac, curvilinear, or linear street forms in Tulsa, Oklahoma, for more than 300 respondents shaped interaction among neighbors found that neighbor familiarity was only weakly correlated with street form (Mayo 1979). More recently, Rashid et al. (2006) collected spatial and behavioral data in four large offices, analyzed them from a spatial syntax perspective, and found mixed results: "spatial layouts [had] consistent effects on movement, but inconsistent effects on visible copresence and face-to-face interaction" (Rashid et al. 2006, p. 825); in fact, "in all four offices studied, there were no consistent relationships between the spatial variables and interactions" (Rashid et al. 2006, p. 842; see also Sailer & McCulloh 2012). Results of these and other studies make clear that the evidence base on the role of space in social interaction has not yet been fully reconciled.

Second, establishing a causal effect convincingly will likely remain a challenge (see Morgan & Winship 2015). For example, though Cabrera & Najarian (2015) found evidence that use of local establishments such as yoga studios and cafés was associated with certain kinds of tie formation, it is just as possible that highly friendly people frequent those places and would have developed the ties through other means anyway. Both early and recent studies have exploited random assignment in dorms and barracks (e.g., Blake et al. 1956) or quasirandom assignment in police academy seating (e.g., Segal 1974, Conti & Doreian 2010) to eliminate selection bias as a factor in friendship formation. Studies of this kind have provided powerful evidence of the importance of space. However, many such studies have been possible because their measures of spatial context have been some form of simple proximity, colocation, or adjacency. As measures of spatial variables have become more complex, the ability to rely on such straightforward natural experiments to study the formation of new ties has decreased. Most studies applying more complex measures are based on observational data collected at a single point in time on a small number of contexts in which the spatial conditions do not vary (but see Coradi et al. 2015). Finding multiple longitudinal contexts and collaborating with planners and organizations in natural settings will likely become important (e.g., Branas et al. 2018).

Third, coupled with the empirical inconsistencies and gaps is the fact that many conceptual issues remain unresolved, even about the basic operation of propinquity, composition, and configuration. For example, the importance of homophily to the effect of propinquity at meso- and microlevels has probably been understated (but see Lazarsfeld & Merton 1954; Small 2017, ch. 5). As Reagans (2011, p. 835) put it, "putting an older person and a young person in the same office cubicle will not improve their relationship if they are not interested in developing it. Being in close proximity could make their interactions even more problematic." In an early critique of enthusiastic ideas about propinquity among urban planners, Gans (1961) made a similar critique about the potential importance of homophily, suggesting that many of the propinquity effects observed in new communities were only observed because the places were demographically homogeneous. In the context of spatial composition, May (2014) made an analogous point. Studying social interaction in the nightclub neighborhood in a city in Georgia, he found what he described as integrated segregation, wherein people of different races went to the same street corners in the evenings but stuck to their own groups. Nevertheless, homophily is only an example. The point is not merely that homophily may moderate spatial effects; it is that making sense of the evidentiary inconsistencies in research on spatial context and tie formation requires developing more refined theories about why people respond to proximity, composition, and configuration of spaces as they do. Whether and how these spatial factors matter in any given context will depend on network structure and other conditions that remain to be understood. At this juncture, the needs are as much empirical as conceptual.

CONCLUSIONS

We have shown that there is a robust, diverse, and growing literature related to how spatial context shapes social interaction, and argued that not only spatial propinquity but also spatial composition and spatial configuration play central roles in the opportunities for social interaction essential to the formation of social ties. The literature on this question has been qualitative and quantitative, observational and experimental, and methodological and substantive; it has produced a rich corpus. The empirical and theoretical challenges in the literature point to the need for future work within sociology, rather than only in sister disciplines.

We conclude by noting three areas where such work may be especially fruitful. One is the relation between spatial and online networks. Spatial factors will generally matter less to network processes to the extent that the domain in question increasingly involves online social interaction. For example, romantic mate selection increasingly happens online (Rosenfeld 2017). Nonetheless, online interaction may not have radically undermined face-to-face contact in meaningful relations. For example, online dating itself is still remarkably local, making clear that propinquity continues to matter (Bruch & Newman 2018). In fact, in a study of interpersonal relations comparing East York residents studied in the 1970s and again in the 2000s, the authors found that "email has only somewhat altered the way people maintain their relationships. The frequency of face-to-face contact among socially close friends and relatives has hardly changed between the 1970s and the 2000s, although the frequency of phone contact has slightly increased. Moreover, the sensitivity of these relationships to distance has remained similar, despite the communication opportunities of the Internet and low-cost telephony" (Mok et al. 2010, p. 2747). At this juncture, the research calls for a more sophisticated approach to the question, one that examines how spatial and nonspatial contexts interact to shape tie formation, use, and maintenance (e.g., see Eagle et al. 2009, Takhteyev et al. 2012, Lane 2016).

A second area is the relation between spatial context and perception. Though one may be tempted to see spatial factors as fixed, immutable, objective, or exogenous, how actors perceive a space may affect their movements throughout and interaction within it, regardless of its composition or configuration. For example, neighborhood spaces perceived as violent or dangerous have been shown to affect how people approach friendship formation with neighbors (Harding 2009, Chan Tack & Small 2017, Branas et al. 2018). Organizational spaces perceived as exclusive may have little effect on social contact, regardless of how well positioned or otherwise spatially amenable.

A third area is the relationship between spatial context and the mating process. Much of the work centered on how space structured opportunities for contact. But we have seen that once people have come into contact, the composition and configuration of a spatial context may affect how frequently, for how long, how comfortable, and how focused their social interaction is. These meso- and microlevel processes are ripe for theoretical, methodological, and empirical attention.

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