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ORIGINAL ARTICLE

Making Big Communities Small: Using Network Science to Understand the Ecological and Behavioral Requirements for Community Social Capital

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Abstract The concept of social capital is becoming increasingly common in community psychology and elsewhere. However, the multiple conceptual and operational definitions of social capital challenge its utility as a theoretical tool. The goals of this paper are to clarify two forms of social capital (bridging and bonding), explicitly link them to the structural characteristics of small world networks, and explore the behavioral and ecological prerequisites of its formation. First, I use the tools of network science and specifically the concept of small-world networks to clarify what patterns of social relationships are likely to facilitate social capital formation. Second, I use an agent-based model to explore how different ecological characteristics (diversity and segregation) and behavioral tendencies (homophily and proximity) impact communities' potential for developing social capital. The results suggest diverse communities have the greatest potential to develop community social capital, and that segregation moderates the effects that the behavioral tendencies of homophily and proximity have on community social capital. The discussion highlights how these findings provide community-based researchers with both a deeper understanding of the contextual constraints with which they must contend, and a useful tool for targeting their efforts in communities with the greatest need or greatest potential.

Keywords Agent-based model · Diversity · Simulation · Small world · Social capital · Social network

Introduction

The concept of social capital is becoming increasingly common in community psychology and elsewhere. About one-in-six papers published in the *American Journal of Community Psychology* since 2000 mention social capital, and as Fig. 1 illustrates, its use there is growing. But, what is social capital? This is a difficult question because multiple conceptual and operational definitions have been offered. In some cases, social capital refers to social relationships, while in other cases it refers to the consequences of those relationships (e.g. trust), which risks logical circularity (Portes 1998). Similarly, in some cases social capital refers to a phenomenon arising from or yielding cohesion within groups (e.g. bonding; Collins et al. 2014), while in other cases it refers to a phenomenon arising from or yielding mixing between groups (e.g. bridging; Todd 2012), which risks ambiguity about the particular kind of social capital an author has in mind. These ambiguities limit the usefulness of "social capital" as a conceptual tool and its ability to be measured empirically.

The goals of this paper are to clarify two forms of social capital (bridging and bonding), explicitly link them to the structural characteristics of small world networks, and explore the behavioral and ecological prerequisites of its formation. By unpacking the concept of *capital*, I explore what scholars implicitly have in mind when invoking the concept of *social capital*. Similarly, drawing on the tools of network science, I show how the within-group (bonding) and between-group (bridging) types of social capital can be united under a single conceptual framework rooted in a community's pattern of

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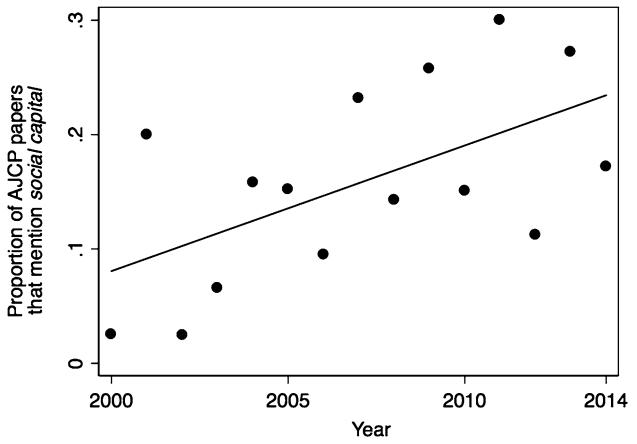


Fig. 1 References to "social capital" in the American Journal of Community Psychology, 2000–2014

social relationships. Building on this network-based framework, I use an agent-based model that simulates the formation of community social networks to explore how two behavioral tendencies (homophily and proximity) and two ecological characteristics (diversity and segregation) combine to facilitate or hinder the development of community social capital. The results suggest diverse communities have the greatest potential to develop community social capital, and that segregation moderates the effects that the behavioral tendencies of homophily and proximity have on community social capital.

The paper is organized in four sections. In the background section, I begin by reviewing the range of ways the concept of social capital has been used in community psychology and elsewhere. I then introduce network science and small-world networks as a way of measuring a community's potential for developing social capital, and conclude by offering some hypotheses about the ecological and behavioral requirements for community social capital. In the methods section, I develop an agent-based model to simulate the formation of relationships in communities, and explain how the potential for social capital within these simulated communities can be measured. In the results section, I present the findings from a series of experiments conducted using this model that are designed to identify the ecological and behavioral requirements of community social capital. I conclude, in the discussion section, by focusing on how the results of the simulation analysis can guide interventions designed to build communities with sufficient social capital to address their local issues.

Background

What is Social Capital?

The term "social capital" has a long history beginning with its first use describing the role of schools in society by Dewey (1900), and subsequently by Hanifan (1916) who initially defined social capital as "goodwill, fellowship, mutual sympathy and social intercourse among a group of individuals and families who make up a social unit, the rural community, whose logical center is the school" (p. 130). Many other definitions have been offered in the intervening 100 years (see Portes 1998). Here, I focus on two conceptual confusions that arise when attempting to define the concept: causes versus effects of social capital, and within-group versus between-group types of social capital.

Some authors use the concept of social capital to describe the positive effects of a community with strong relationships (e.g. Poortinga 2006). However, this forces us to ask, where do these effects come from? Accordingly, other authors use social capital to describe the specific types of relationships that lead to these outcomes (Granovetter 1973; Coleman 1988; Burt 2001). Moreover, Portes (1998) accused Putnam (2001) of using the concept in both ways, creating a logical tautology by arguing that social capital leads to positive outcomes like community economic development, but inferring the existence of social capital by observing community economic development.

One way out of this causes-versus-effects confusion is to return to the more fundamental concept of capital. Capital refers to a type of resource that facilitates action, but there are many different varieties of capital that each facilitates different kinds of action. In his classic and unambiguously titled work, Marx (1867) focused on *physical* capital, and specifically on the ownership of factories and equipment. Those in possession of physical capital (i.e. the capitalists, or bourgeoisie) could use these resources to achieve a desired goal: the manufacture of goods to be sold at a profit. Becker (1964) focused on *human* capital, which includes the skills and talents that individuals are born with or acquire through education, and that can subsequently be used to obtain employment and contribute to society. Bourdieu (1973) described *cultural* capital as the type of local knowledge that can be used to obtain access to or buy-in from exclusive groups. For example, knowing how to select an appropriate wine for dinner may be necessary to participate in elite social circles. Following the same logic that has been used to define other varieties of capital, *social* capital can be used to refer to a type of resource (social relationships) that facilitates action (e.g. cultivating trust, sharing information). Tseng and Seidman's (2007) theory of settings helps to illustrate how social capital is particularly unique. Their theory holds that the potential intervention targets include both a setting's social processes and a setting's resources, which are normally conceptually distinct. For example, the social process of employment is distinct from a setting's financial resources; one could intervene on the process by hosting a job fair, or on the resources by offering transfer payments (e.g. unemployment insurance).

But, social capital is a unique type of setting resource because it is indistinguishable from the process of social interaction; social capital is both a process and a resource.

However, this raises a second kind of ambiguity: precisely what type of social relationships facilitate such outcomes as cultivating trust or sharing information, and thus counts as social capital? Two varieties of social capital, each rooted in a specific type of social relationship and leading to a specific outcome, are distinguished in the literature, but they masquerade under many different names (see Table 1). One type views between-group relationships as a kind of resource that facilitates one's access to other resources, such as information. In his study to understand how individuals learn about job opportunities, Granovetter (1973) described these types of relationships as "weak ties" because they often occur between casual acquaintances. Referring to the same type of relationships, Putnam (2001) used the term "bridging" to highlight their role in bridging relational gaps between otherwise socially disconnected groups, while Burt (2001) used the term "brokerage" to highlight their importance in brokering the flow of resources from one group to another. Examples of this type of social capital are seen throughout the community psychology literature. For example, Todd (2012) describes how two different religious networking organizations used bridging relationships between congregations to mobilize resources and facilitate information sharing. Similarly, Hughey and Speer (2002) explain how a project aimed at targeting substance abuse in a small Kentucky community was stalled by the insularity of a network of professional-class coalition members and a separate network of police. The project ultimately found success when a bridging tie between these groups was forged by "a retired newspaper executive turned philanthropist" who served as a broker (p. 81).

A second type views within-group relationships as a kind of resource that facilitates the cultivation of mutual trust, cooperation, and a sense of community among group members. Granovetter (1973) calls these "strong ties" because they often are intense and long-term relationships between close friends and family members, while Putnam (2001) uses the term "bonding" to highlight the feeling of togetherness such tightly knit communities often have. Highlighting a different feature of these relationships, Coleman (1988) and Burt (2001) use the term "closure" because their inward-focus is what defines the boundaries of a group and distinguishes it from other groups. Collins et al. (2014) found that this type of social capital mediated the relationship between individual-level civic engagement behaviors and community-level collective efficacy, serving to coalesce or bond many individual "I"s into a collective "We." Perhaps hoping to capitalize on the efficacy-promoting benefits of bonding social capital, some members of the religious organizations described by Todd (2012) wanted their organizations to focus on organizing within-congregation events, and stopped participating when their organizations pursued a between-organization bridging social capital strategy instead.

Social Capital and Network Science

There is a tension between the bridging and bonding varieties of social capital. The more intense a community's inwardly focused bonding relationships, the more insular it becomes. This facilitates the cultivation of a strong internal sense of community, but potentially at the expense of its members' ability to interact with and access resources in other communities through bridging relationships. Likewise, the more intense a community's outwardly focused bridging relationships, the better connected it is to other communities. This facilitates the exchange of ideas and perspectives, but potentially at the expense of its members' ability to develop a shared identity through bonding relationships. Hughey and Speer (2002) have suggested that "navigating [this] tension between internal cohesion and external relationships…is the central challenge of community psychology" (p. 76). However, they are clear that the tension does not imply an either-or proposition in which we are focused to choose between bridging and

Table 1 Two varieties of social capital

	Type I	Type II
Location of relationship	Between-group	Within-group
Expected outcome	Facilitate access to other types of capital	Facilitate trust and promote a sense of community
Authors and terms—		
Granovetter (1973)	Weak ties	Strong ties
Putnam (2001)	Bridging	Bonding
Burt (2001)	Brokerage/structural holes	Closure
Examples in the Community Psychology literature—	Hughey and Speer (2002)	Collins et al. (2014)
	Todd (2012)	Neal and Neal (2014)
	Townley et al. (2011)	Townley et al. (2011)

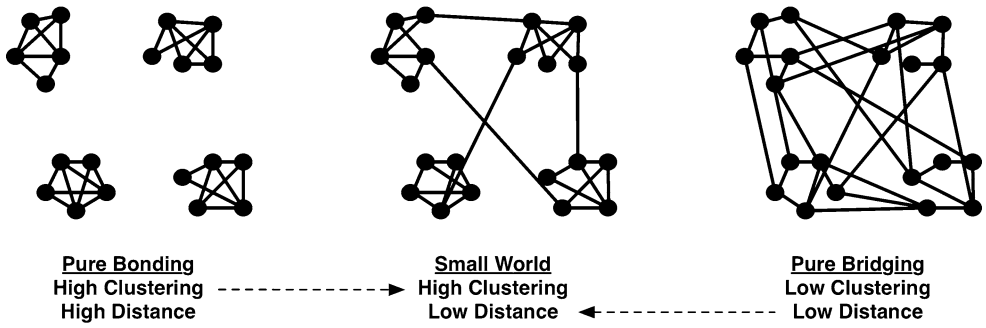


Fig. 2 Bonding, bridging, and small-world networks

bonding social capital. The real challenge for community psychology lies not in picking the "right" kind of social capital, but rather in finding ways that communities can benefit from both varieties simultaneously.

Some recent insights from network science (Watts and Strogatz 1998) can provide a map for understanding and navigating this tension. Two structural characteristics of networks correspond closely to these two varieties of social capital. First, a characteristic known as *clustering* captures the type of within-group relationships associated with bonding social capital and the cultivation of sense of community (Neal and Neal 2014). In a highly clustered network, each person's (or organization's) contacts also have relationships with one another, or more concretely, all of my friends are also friends with each other (Newman 2010). The left panel of Fig. 2 illustrates a highly clustered network. The people in such a network have plenty of bonding social capital, but no bridging capital. As a result, each of the four readily identifiable groups can cultivate a strong internal identity and sense of community, but it is impossible for resources like information to be shared across these groups.

A second characteristic, the *average path length* or network distance between a pair of individuals (or organizations), captures the type of between-group relationships associated with bridging social capital and the ability for information and other resources to be shared rapidly and efficiently. In a network with a low (i.e. short) average distance, resources can pass from one individual to another easily because direct (or short, indirect) opportunities for interaction exist (Newman 2010). The right panel of Fig. 2 illustrates a network with low average distance. The people in such a network have plenty of bridging social capital, but very limited bonding social capital. As a result, information and other resources can be shared among them, but it is nearly impossible for subgroups with distinctive identities or a sense of community to form. In this example, because *none* of my friends are friends with each other, everyone is on their own.

These two cases—pure bonding social capital with high clustering and pure bridging social capital with low distance—represent extremes on a continuum. Starting with only bonding relationships and converting some into bridging relationships like Hughey and Speer (2002) described in Kentucky (i.e. moving from the left to center panel in Fig. 2) might seem to yield a community with a little bonding social capital and a little bridging social capital. Likewise, starting with only bridging relationships and converting some into bonding relationships, for example by bringing people together in schools and community centers (Hanifan 1916; Neal and Neal 2012; i.e. moving from the right to center panel in Fig. 2), might also seem to yield a mix of bridging and bonding social capitals. However, Watts and Strogatz (1998) demonstrated, somewhat counterintuitively, that certain types of networks can simultaneously have high clustering (i.e. lots of bonding social capital) and low distance (i.e. lots of bridging social capital). Networks with this type of structure are known as small-world networks[1] and provide a theoretical foundation for Hughey and Speer's (2002) claim that communities need not choose between bridging and bonding social capital, but can aim to have both.

When and Where does Social Capital Develop?

While the formal structural properties of small-world networks remain an active area of research for network science, of greater concern for community-based researchers is the question of how to create such networks so that communities can benefit from the simultaneous advantages of bridging and bonding social capital. Understanding the ecological and behavioral conditions under which bridging and bonding social capital are more or less likely to develop could provide community-based researchers with both a deeper understanding of the contextual constraints with which they must contend, and a useful tool for targeting their efforts in communities with the greatest need or greatest potential.

[1] The label, small-world network, is an homage to Milgram's (1967) study of the small-world problem. He sought to understand how almost any two random people could be linked to one another through a relatively short chain of mutual acquaintances. His findings gave rise to the notion of "six degrees of separation," but the underlying mechanism remained unexplained until the discovery of small-world network structures by Watts and Strogatz (1998).

Social relationships do not form randomly between people, but rather are guided by behavioral tendencies that make some relationships more likely to form than others. *Homophily* refers to the tendency for relationships to form between people with something in common more often than between people who differ, and is captured by the aphorism that birds of a feather flock together. Homophily is almost universally observed in human communities along many different dimensions including race, religion, and social class. It can emerge from attitudes of prejudice, but also from more benign sources: homophily along musical tastes arises because jazz fans have more to talk about with other jazz fans, than with fans of modern rock or some other genre. Common interests facilitate relationship formation because it allows individuals to "speak the same language" (Fu et al. 2012; Kleit and Carnegie 2011; Lazarsfeld and Merton 1964; McPherson et al. 2001; Mouw and Entwisle 2006; Rivera et al. 2010). *Proximity* refers to a tendency for relationships to form between people who live nearby more often than between people who live far apart. Proximity is also nearly always observed in human communities, driven by the fact that those who live nearby have more opportunities to encounter one another by chance, and subsequently to form a relationship (Festinger et al. 1950; Hipp and Perrin 2009; Hipp et al. 2012; Rivera et al. 2010). Although decades of research has demonstrated that homophily and proximity shape the formation of community social networks, recent research even suggests that these forces play a role in the development of online social ties (e.g. Huang et al. 2013).

Although tendencies toward homophily and proximity both shape the formation of relationships, they may vary in intensity by community, or by type of relationship. For example, in a community with a history of racially motivated violence and oppression, the intensity of homophily along racial lines might be quite strong, while in other places race-based homophily may be weaker. Likewise, Hipp and Perrin (2009) demonstrated that the effect of proximity is stronger for the formation of "close ties," while the effect of homophily is stronger for the formation of "weak ties." When tendencies for homophily or proximity are intense, community members build relationships with one another around shared characteristics or spaces, thus facilitating the emergence of bonding social capital. Likewise, when these tendencies are weak, community members build relationships with one another without considering whether they share a characteristic or space in common, thus facilitating the emergence of bridging social capital. In the simulations reported below, I make no assumptions about how strong or weak the forces of homophily and proximity are, but rather explore the consequences of a range of different plausible intensities. Accordingly, these different possibilities reflect network formation in different types of communities, and composed of different types of relationships. A central question in this study is, what combinations of homophily and proximity allows communities to build relationships that bond residents into groups that share a characteristic or space, but that also bridge across these groups?

The formation of community relationships does not occur in a vacuum, but rather unfolds within an ecological setting with its own unique characteristics. Although community ecologies can vary in many ways, *diversity* (i.e. who is around?) and *segregation* (i.e. how are they organized?) are among the most widely studied. These two ecological characteristics, while often conflated, are quite different. Diversity refers to the relative sizes of different social or demographic groups in a setting. A community is most diverse when each group is represented in equal proportions, and becomes progressively less diverse as some groups outnumber others. In American cities, levels of diversity vary widely, from heterogeneous cities like Vallejo, CA where five major racial/ethnic groups are represented in near-equal proportions, to homogeneous cities like Laredo, TX, whose population is more than 95 % Hispanic (Lee et al. 2012). Segregation, in contrast, refers to the spatial clustering of these groups in the setting. A community is most segregated when individuals live near only other members of the same group, while a community is most integrated when individuals live near both members of their own group and members of other groups. Levels of segregation also vary widely in American cities, from Detroit where 86 % of residents would need to move to achieve complete integration, to Albuquerque where only 32 % would need to move (Frey n.d.).

The ecological characteristics of diversity and segregation may influence the roles that behavioral tendencies play in network formation. For example, in a diverse community, even if the tendency toward homophily is strong, everyone will be able to find a pool of potential contacts who are similar to themselves. In contrast, in a non-diverse community where the tendency toward homophily is strong, majority members will easily find suitable contacts and build large social networks, while minority members will not. Accordingly, the social networks that are likely to emerge in a given community jointly depend on the community's ecological characteristics and the behavioral tendencies that prevail. Some combinations will allow communities to cultivate bonding social capital, while others facilitate the cultivation of bridging social capital, and still others facilitate the combination of both forms of social capital.

Methods

This study uses an agent-based model (ABM) to investigate the relationship between a community's ecological and behavioral characteristics and its potential to cultivate

community social capital. ABMs simulate agents' (here, people) interactions with one another as they follow behavioral rules (homophily and proximity) in a setting (here, a residential community) with specific ecological characteristics (diversity and segregation). They are particularly useful for community-based research questions because they allows the researcher to examine "what if" scenarios that would be impossible or unethical to examine in the field (Neal and Lawlor in press). For example, it would be impossible to ask actual community members to form relationships with one another guided by a specific intensity of homophily, but an ABM can indicate what a community social network might look like if they did. Likewise, it would be unethical to assign individuals to live in a community with a specific level of segregation, but an ABM can indicate what might happen if they did. The goal of this ABM is not to capture the full complexity of real communities or to make predictions about any particular community. Instead, it is designed to serve as a theory-building tool: by capturing a few particularly salient aspects of community ecology and resident behavior, it can be used to develop a better understanding of community social capital formation.

The model begins by creating a simulated community populated by two types of people, and that is characterized by two ecological properties: diversity (D) and segregation (S). Diversity is operationalized as the percentage of individuals in the minority group, and ranges from $D = 0$ % for a non-diverse community, to $D = 50$ % for a maximally diverse community. Segregation is operationalized as the average percentage of one's neighbors who are the same type, and ranges from $S = 50$ % for a fully integrated community, to $S = 100$ % for a fully segregated community. Figure 3 illustrates four simulated communities that vary on these ecological characteristics. In these figures, the two "types" of people are shown as gray and black colored houses. It is important to note that the model, and the results and conclusions that follow, do not require saying exactly what these two types represent. Only two assumptions are made about the types: they are recognizable by the individuals in the community, and they are socially consequential. The first assumption excludes such things as private, non-disclosed characteristics (e.g. non-disclosed HIV status), while the second excludes things that generally do not affect one's choices about contacts or residential location (e.g. favorite ice cream flavor). However, the two types may represent a broad range of social and demographic characteristics including race, religion, ethnicity, or social class. It is for the sake of simplicity that only two types of people populate the simulated communities; the results and conclusions remain the same if the model is modified to allow three, or thirty, or three thousand different types of people.

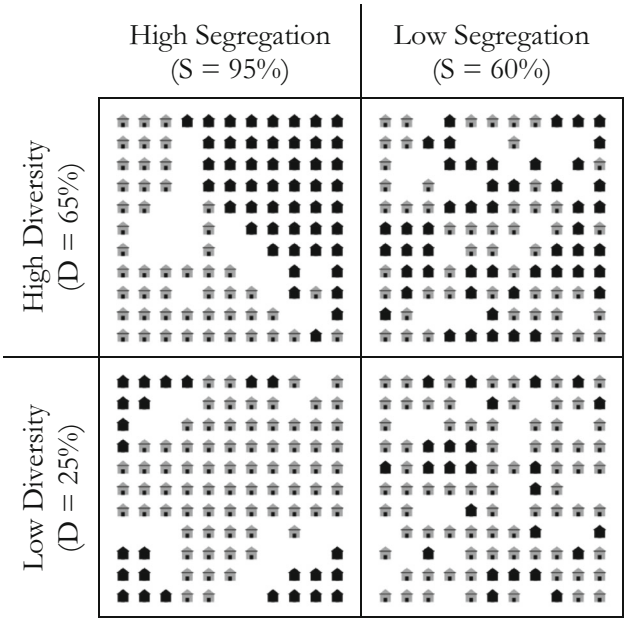


Fig. 3 Examples of simulated communities, by diversity and segregation

After the model creates a simulated community, it creates a simulated community social network. The probability that a pair of individuals form a relationship is determined by the logistic selection function defined by Neal and Neal (2014). Under this function, when the tendency toward homophily is strong, relationships are more likely between residents of the same type, while when homophily is weak, relationships are equally likely between residents of the same or different type. Similarly, when the tendency toward proximity is strong, relationships are more likely between residents living nearby, while when proximity is weak, relationships are equally likely between residents living near or far. The function is normalized such that, no matter how strong or weak these two tendencies are, the formation of the most likely relationship occurs with 50 % probability.

The final step of the model involves determining whether the community's social network has a small-world structure, and thus whether the community has the potential to simultaneously cultivate both bridging and bonding social capital. The extent to which the community network has a small-world structure is measured using the small world index (SWI):

$$SWI = \frac{L_{obs} - L_{latt}}{L_{rand} - L_{latt}} \times \frac{C_{obs} - C_{rand}}{C_{latt} - C_{rand}} \quad (1)$$

where L_{obs} and C_{obs} are the observed average path length and clustering coefficient in the simulated community, L_{latt} and C_{latt} are the values in a comparison lattice network, and L_{rand} and C_{rand} are the values in a comparison random network (c.f. Uzzi and Spiro 2005; Humphries and Gurney

2008; Telesford et al. 2011). Conceptually, the SWI evaluates (1) whether the observed network's average path length is close to that of an all-bridging random network, *and* (2) whether the observed network's clustering coefficient is close to that of an all-bonding lattice network.[2] The SWI is equal to 0 when a network does not have a small-world structure; larger values, up to a theoretical maximum of 1, indicate networks with increasingly small-worldly structures. Accordingly, large values identify communities whose social network structure offers the potential for the development of community social capital. To identify the ecological and behavioral conditions under which communities enjoy both bonding and bridging social capital, a 2 Segregation × 2 Diversity × 17 Homophily × 17 Proximity experimental design is used. Segregation was examined at high (95 %) and low (60 %) levels; Diversity was examined at high (50 %) and low (25 %) levels; behavioral tendencies toward Homophily and Proximity both ranged from non-existent (0) to strong (4) in 0.25 increments. Each experimental condition was replicated 50 times, for a total of 57,800 simulated communities (i.e. 1156 conditions × 50 replications).

Results

Figure 4 illustrates simulated community social networks observed in three of these experimental conditions. The left panel illustrates a social network that formed in a simulated community characterized by a high level of diversity and segregation, and where the formation of relationships among community members was guided by relatively strong tendencies toward homophily and proximity. In practical terms, this is a divided community in which clear lines exist between those who are (similar and nearby) and are not (different and far away) considered potential contacts. The bonding among certain groups of residents is visually evident in the social network, but there are very few bridging ties between these groups. This community's social network offers the potential to develop one component of social capital (bonding), but not the other (bridging), and thus its SWI is low (0.022). A community with this type of social network might be expected to enjoy a sense of community that is deep but narrow; members of a group stick together and develop a shared identity, but keep their distance from members of other groups. Across the 50 replications, communities with these ecological and behavioral characteristics had a mean SWI of 0.017.

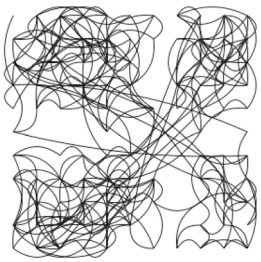
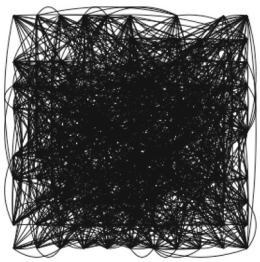
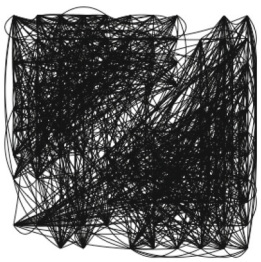
The center panel of Fig. 4 illustrates a social network that formed in a simulated community with very different ecological and behavioral characteristics. It exhibits both low diversity and segregation, and relationships form through relatively weak tendencies toward homophily and proximity. In practical terms, this is a somewhat homogenous but still integrated community where nearly everyone (same or different, near or far) is considered a potential contact. This community's social network exhibits no distinct clusters or subgroups, but rather is almost entirely composed of cross-cutting and bridging ties. It offers the potential to develop one component of social capital (bridging), but not the other (bonding), and thus its SWI is low (0.014). Members of a community with this type of social network might be expected to easily share information and other resources with one another because they each maintain such wide and bridging personal social networks, but have difficulty developing a sense of togetherness and shared identity because their social circles do not overlap. Across the 50 replications, communities with these ecological and behavioral characteristics had a mean SWI of 0.001.

Finally, the right panel illustrates a social network that formed in a community with high levels of diversity and segregation, where relationship formation is guided by a strong tendency toward homophily and a weaker tendency toward proximity. This type of community might be the most familiar throughout the United States, characterized by residential segregation where residents tend to form relationships with similar others, and where new technologies allow them to form and maintain relationships over longer distances. Unlike the first two examples, this community's social network structure offers the potential to develop both components of social capital—bonding is visible in the two relatively distinct clusters at opposite corners, while bridging is visible in the many relationships that span the two clusters—and thus has a high SWI (0.243). Although residents in this community tend to form bonds within their own group, thereby facilitating the development of a sense of community, they also form occasional relationships with members of other groups, thereby facilitating the sharing of information and diverse perspectives. Across the 50 replications, communities with these ecological and behavioral characteristics had a mean SWI of 0.233.

Whereas Fig. 4 illustrates the community social networks observed in three specific experimental conditions, Fig. 5 illustrates the mean SWI of the social networks observed in all 1156 experimental conditions through four separate heatmaps. The two heatmaps on the left display results from simulated communities in the high-segregation condition, while the two heatmaps on the right display results from simulated communities in the low-segregation condition. Likewise, the two heatmaps on the top display results from simulated communities in the high-diversity condition, while the two heatmaps on the bottom display

[2] The comparison random and lattice networks have the same size and degree distribution as the observed network.

Fig. 4 Examples of simulated community networks

Mostly Bonding	Mostly Bridging	Social Capital
High Diversity (50%)	Low Diversity (25%)	High Diversity (50%)
High Segregation (95%)	Low Segregation (60%)	High Segregation (95%)
Strong Proximity (4.0)	Weak Proximity (1.0)	Weak Proximity (0.5)
Strong Homophily (3.5)	Weak Homophily (0.75)	Strong Homophily (3)
		
SWI = 0.022	SWI = 0.014	SWI = 0.243
Mean SWI = 0.017	Mean SWI = 0.001	Mean SWI = 0.233
Diamond in Figure 5	Square in Figure 5	Circle in Figure 5

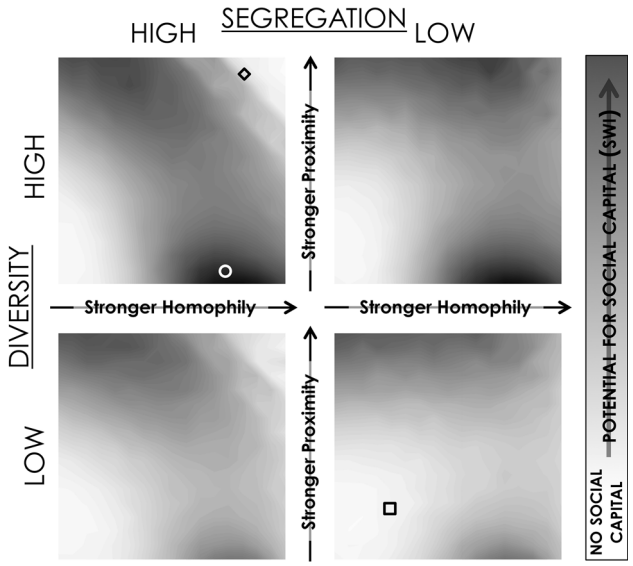


Fig. 5 Community potential for social capital

results from simulated communities in the low-diversity condition. Finally, within each of these four heatmaps, the x-axis indexes the intensity of proximity in the simulated communities, while the y-axis indexes the intensity of homophily in the simulated communities. Accordingly, each point in these heatmaps corresponds to a specific experimental condition with a specified level of segregation, diversity, homophily, and proximity. For example, the black diamond shape marks the spot in Fig. 5 that displays the result in the high-segregation, high-diversity, strong-proximity, strong-homophily condition; this condition was discussed in detail above and in the left panel of Fig. 4. The color of each point in these heatmaps indicates the mean SWI across 50 replications, with darker shades indicating experimental conditions with greater potential for the development of social capital.

To compare the potential for social capital formation under different experimental conditions, three independent-samples t-tests were conducted. First, simulated communities where homophily and proximity were both less than or equal to 1 had a significantly smaller mean SWI (0.014 vs. 0.120) than other communities ($t = 16.65$, $df = 1154$, $p < .001$). Second, high-diversity communities had a significantly larger mean SWI (0.133 vs. 0.089) than low-diversity communities ($t = 11.71$, $df = 1154$, $p < .001$). Finally, high-segregation communities had a mean SWI (0.114) that is not significantly different from the mean SWI of low-segregation communities (0.108; $t = 1.49$, $df = 1154$, n.s.)

Discussion

The patterns shown in Fig. 5 shed light on the ecological and behavioral conditions that may facilitate (or hinder) the development of community social capital, and thus can guide interventions aimed at cultivating community social capital. First, the potential for social capital formation is limited in communities with weak behavioral tendencies. In Fig. 5, this can be seen by the light regions in the lower left corner of each heatmap, and was confirmed by the first *t* test reported above. When tendencies toward homophily and proximity are weak, community social networks form randomly. Although a community social network may exist, it lacks a coherent structure because a spatial or demographic anchor around which relationships and social capital can coalesce is missing. This suggests that in communities where absolutely everyone—whether same or

different, near or far—is considered a potential contact, the structured social fabric that social capital requires simply does not exist. It thus highlights the problem with a color-blind, placeless community. Ignoring others' differences in terms of social characteristics and physical location hinders the formation of community social capital, while recognizing and respecting such differences facilitates social capital formation (c.f. Trickett et al. 1994). In practice, communities with such weak behavioral tendencies are unlikely, but this finding nonetheless calls attention to the fact that there is nothing problematic with individuals being a little selective in their relationship choices.

Second, the potential for social capital formation is greater in high-diversity than low-diversity communities. In Fig. 5, this can be seen by the generally darker color of the heatmaps corresponding to the high-diversity conditions, and was confirmed by the second t-test reported above. This finding is consistent with community psychology theory, which for decades has contended that respect for diversity and diverse perspectives is critical to strong and healthy communities (Prilleltensky 2001; Rappaport 1977; Trickett et al. 1994), but represents a departure from other recent work that has suggested diversity is inimical to the development of community (Portes and Vickstrom 2011; Putnam 2007; Neal and Neal 2014; Townley et al. 2011). However, this apparently mixed finding is easy to explain. Most past work on community and diversity has focused narrowly on bonding relationships and sense of community, while ignoring the importance of bridging relationships and resource sharing. Although diversity may reduce a community's bonding and cohesion, it simultaneously creates opportunities for bridging relationships, and thus is an important prerequisite for community social capital. The practical implication of this finding is clear: building communities with the potential to develop social capital requires promoting diversity, perhaps through such mechanisms as mixed-use and mixed-income developments that attract a range of different people to live, work, and play in the area.

Third, the potential for social capital formation is about the same in high-segregation and low-segregation communities. In Fig. 5, this can be seen by the similar colors in the heatmaps corresponding to the high- and low-segregation conditions, and was confirmed by the third t-test reported above. At first glance, this may seem counterintuitive; how can highly segregated communities have as much social capital as integrated communities? It is important to remember that segregation has many faces. The pernicious racial residential segregation that has plagued American cities for more than a century is one form (Massey and Denton 1993), but so too is the ethnic enclave that helps immigrants find a foothold (Lin 2010; Wilson and Portes 1980) and the historically black colleges and universities that Townley et al. (2011) view as playing a protective role. When it comes to forming useful social networks, segregation is not necessarily harmful. Although further research is necessary, it is possible that the cause of segregation is more important than the extent. Self-segregation, where individuals sort themselves into homogeneous spatial clusters and which is simulated in this model, is likely less detrimental than forced segregation, where individuals are required by law or circumstance to reside in homogeneous clusters. The implication of this finding, therefore, is not necessarily to abandon programs and interventions aimed at desegregation, but rather to recognize the context-dependent nature of segregation; that is, to think more carefully about the particular variety of segregation and the role it plays in a specific community.

Fourth, when a community is highly segregated, it has the greatest potential for social capital development when the tendency toward *either* homophily *or* proximity is strong. In Fig. 5, this can be seen by the dark band stretching from the upper left (strong proximity, but weak homophily) to the lower right (weak proximity, but strong homophily) in the heatmaps corresponding to the high-segregation conditions. Social capital development requires that residents have some basis for cohesion, but this basis may be rooted in either a shared characteristic (homophily) or in a shared space (proximity). Without a basis for cohesion, as noted above, the network forms randomly and the community lacks a social structure. Conversely, with too many bases of cohesion, the network forms isolated clusters like the left panel of Fig. 4 and the community enjoys bonding but not bridging. Thus, in highly segregated communities, there is a delicate balance among the behavioral tendencies that facilitate social capital formation. For interventions aimed at building social capital in such communities, this suggests adopting a targeted and measured approach: identify a single promising basis for cohesion in the community (e.g., a common local issue or a common local meeting place), and focus on building relationships around it.

Finally, when the community is relatively integrated, the role of proximity becomes particularly important. In such communities, if relationships form primarily among neighbors (i.e. high proximity), then the potential for social capital development is high regardless of any tendencies toward homophily. That is, in an integrated community where one's neighbors include many different kinds of people, it is easy to find potential contacts living nearby, no matter what one looks for in a contact. However, if residents are willing to look beyond their own neighborhoods for contacts (i.e. low proximity), then the development of social capital requires a stronger homophilic tendency. That is, if one's social life is not locally focused, developing a tightly knit circle of contacts to provide a sense of community and belonging must be found elsewhere, by seeking out similar others wherever they might live. The significant role of proximity in highly

integrated communities suggests a particular strategy for intervention: build common public spaces. Such spaces, which could include parks or community centers, provide a spatial anchor around which proximate social relationships can develop (Neal and Lawlor in press; Orum and Neal 2009).

Collectively, these findings reinforce Hughey and Speer's (2002) claim that communities need not choose between cultivating bonding social capital and cultivating bridging social capital. They can be cultivated simultaneously, but only under specific ecological and behavioral conditions. Accordingly, we can shift our attention away from any single variety of social capital, and toward helping communities find ways to capitalize on the combined benefits of both forms. Looking across the findings and the heatmaps in Fig. 5, among the greatest potential for social capital development occurs in diverse and segregated communities, where relationships form through a tendency toward homophily that is strong but not absolute. This portrait of the optimal conditions for community social capital can be found in both contemporary and historical descriptions of idealized cities. First, it bears a striking resemblance to Florida's (2003) Three T's (talent, tolerance, and technology) recipe for building cities that attract the creative class. A diverse community is populated by people with a range of different skills and perspectives, and thus represents a vast pool of talent. A community whose relationship-forming behaviors are guided by homophily is populated by people who mostly form ties with similar others, but are tolerant of and occasionally form relationships with dissimilar others. And, we might expect the role of proximity in relationship formation to be weakest in communities that have access to advanced transportation and communication technologies, which allow relationships to form and be maintained over longer distances. Indeed, others have argued that the same small-world networks I contend facilitate the formation of community social capital can also foster creativity (Uzzi and Spiro 2005), suggesting that the benefits of such social structures to communities may be wide-ranging.

Second, this portrait also recalls a description of the city now 100 years old, and offered 50 years before the Swampscott Conference:

> the city [is] a mosaic of little worlds which touch but do not interpenetrate. This makes it possible for individuals to pass quickly and easily from one moral milieu to another and encourages the fascinating but dangerous experiment of living at the same time in several different contiguous, perhaps, but widely separated worlds. (Park 1915, p. 608)

Working in Chicago, Park had in mind a patchwork city of neighborhoods, or more specifically the 75 communities areas subsequently delineated by the Social Science Research Council in 1920. For Park and for the agent-based model presented above, neighborhoods are subparts of the larger community within which residents are fairly homogeneous and form strong bonding ties with one another. However, the community as a whole is diverse, dotted with many different kinds of neighborhoods, between which residents occasionally form somewhat weaker bridging ties. As Park explained in his now-archaic 1915 prose and as the simulation model reproduces, such an arrangement allows people to simultaneously find a sense of community in their own neighborhood, but also to find fascinating new things and people in others' neighborhoods. That is, it allows people to live in big, diverse communities that feel small and familiar.

Agent-based models are powerful because they provide researchers a way to bridge the conceptual micro–macro gap, linking micro-social phenomena like individual relationship formation behaviors to micro-social phenomena like the development of community social capital. To make such models tractable and interpretable, they require a number of simplifications, assumptions, and scope conditions. These simplifications might be seen as limitations that restrict the generalizability of conclusions and identify potential directions for future research and model refinement. Although these features of the model make it "wrong" in the sense that it imperfectly mirrors reality, they also make the model "useful" in the sense that it sheds light on social phenomena that are otherwise too complex to understand (Box and Draper 1987). Nonetheless, the interpretations and conclusions discussed above must be viewed in light of the models' assumptions and simplifications. Accordingly, the models presented here can also be seen as starting points, to which additional factors that also influence community network formation could be added. For example, we know that over time, forces of transitivity shape the dynamic formation of social networks (Rivera et al. 2010); future version of these simulation models could more explicitly incorporate this phenomenon and explore how different intensities of transitivity impact social capital formation. Additionally, as with many simulation-based studies, this has been a theory-building exercise that suggests hypotheses and mechanisms, which now require empirical validation in real communities. Finally, it is important to note that the network-based conception of social capital proposed above, and the models used to explore it, focus on the conditions creating the *potential* for community social capital development. Additional theoretical and empirical work is needed to understand the next step in the process: how does potential social capital become activated social capital, put to use for creating a sense of community and sharing resources?

The concept of social capital is now widely used in the community psychology literature, as well as throughout the

social sciences, but its meaning and measurement is often ambiguous. This paper has sought to bring clarity by distinguishing two varieties of social capital—bonding and bridging—in terms of their structural causes and social consequences, and introducing the concept of small world networks as a unified way to measure the joint presence of both types. Working within this definitional and measurement framework, an agent-based model of community social network formation is used to explore the ecological and behavioral requirements for the formation of community social capital. The model suggests that the potential for community social capital is greatest when individuals seek out similar others but are still open to social differences, in communities that are diverse but segregated. The local-scale segregated neighborhoods provide an anchor for bonding ties to form, facilitating the development of a strong sense of community, while the broader community's diversity provides opportunities for bridging ties to different others, facilitating the sharing of information and resources. These findings highlight that interventions seeking to cultivate community social capital must first aim for clarity about precisely what is meant by "social capital," and then carefully consider the multiple relevant ecological and behavioral requirements and their potentially complex interactions.

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