Close encounters: Analyzing how social similarity and propinquity contribute to strong network connections.

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ABSTRACT

Models of network formation emphasize the importance of social similarity and propinquity in producing strong interpersonal connections. The positive effect each factor can have on tie strength has been documented across a number of studies. And yet we know surprisingly very little about how the two factors combine to produce strong ties. Being in close proximity could either amplify or dampen the positive effect that social similarity can have on tie strength. Data on tie strength among teachers working in five public schools was analyzed to shed light on this theoretical question. The empirical results indicated that teachers who were similar in age were more likely to be connected by a strong tie, especially teachers for whom age similarity was more likely to be salient. Moreover, teachers who took breaks at the same time or who had classrooms on the same floor communicated more frequently and felt more emotionally attached. Among the public school teachers, propinquity amplified the positive effect that age similarity had on tie strength. The strongest network connections occurred among age-similar teachers who had classrooms on the same floor. The empirical results illustrate the value of considering how social similarity and propinquity contribute to strong ties independently and when combined with each other.

Introduction

Models of network formation emphasize the importance of social similarity and propinquity in producing strong interpersonal connections (McPherson et al., 2001, provide an extensive review). A network connection is strong when the two parties involved in the relationship have known each other for a long time, communicate frequently, or feel emotionally attached (Marsden and Campbell 1984). The importance of social similarity and propinquity in producing strong ties has been established for a number of characteristics, including age (Marsden 1988, Burt 1991), education (Yamaguchi 1990), gender (Brass 1985, Ibarra 1992,1997), race (Marsden 1987, Ibarra 1995, Moody 2001), religion (Laumann 1973), and organization and professional tenure (Zenger and Lawrence 1989), as well as for a number of propinquity indicators, including classrooms (Shrum et al. 1988), dormitories (Festinger et al. 1950), neighborhoods (Mouw and Entwisle 2006), voluntary organizations (McPherson and Smith-Lovin 1986, 1987), and seating arrangements (Caldiera and Patterson 1987).

Although we know a great deal about how social similarity and propinquity contribute to strong ties independently, we know less about how social similarity and propinquity combine to produce strong interpersonal connections. In particular, being in close proximity could either amplify or dampen any positive effect that social similarity has on tie strength. On the one hand, proximity in time or space provides two people with an opportunity to develop a more meaningful relationship, but the two individuals must be interested in developing a relationship (McPherson and Smith-Lovin 1987). For example, 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. One explanation for why sharing a demographic characteristic has a positive effect on tie strength maintains that individuals have a preference for socially similar interactions (Laumann 1966). People who prefer socially similar relationships should be more likely to take advantage of an opportunity to

develop a strong tie with a socially similar contact. Thus, being in close proximity should amplify any positive effect that social similarity can have on tie strength (Zeng and Xie 2008). For example, prior research has established that people similar in age are more likely to be connected (McPherson et al. 2001: 424-425). People of the same age could prefer to interact with each other either because they have had a similar life history (e.g., were born during the 1950s or attended college during the Vietnam War) or because they are currently at a similar point in their life course (e.g., entering graduate school, becoming a new parent, or considering retirement). Given a preference for age-similar encounters, any positive effect that being the same age can have on tie strength should be even more positive when people the same age are in close proximity.

On the other hand, more-frequent contact between in-group members could reduce the positive association between social similarity and tie strength. Recent research has shown that the positive association is a function of actual and expected similarity (Hogg and Hardie 1991, Hogg et al. 1995). Expected similarity is a function of sharing a demographic or social characteristic, whereas actual similarity is a function of sharing unobserved attitudes, behaviors, and beliefs. When an in-group member meets or exceeds prior expectations with respect to unobserved attributes, his or her relationships with in-group members are stronger (Hogg et al. 1995). However, if two people who share a demographic or social characteristic are similar only on the surface, propinquity would provide them with more opportunities to discover how very little they actually have in common, which should reduce the positive effect that social similarity can have on network connections (Ziebro and Northcraft 2009: 148-149). For example, if a young person assumes all young people are liberal Democrats, more opportunities to interact with a young conservative Republican would make it more likely their differences in political philosophies would be revealed and, consequently, the positive effect of being the same age would be diminished.

Thus, while it is reasonable to assume that proximity and social similarity combine to define tie strength, exactly how the two factors combine is unclear. My research objective is to shed light

on this theoretical question. First, I provide a more detailed discussion of how social similarity and propinquity contribute to strong ties alone and in combination. I then analyze data on tie strength among teachers working in five schools and examine how social similarity and propinquity contribute to tie strength when social similarity is defined by age and status. Empirical analysis indicated that age was a primary source of demographic diversity in each school and therefore was likely to be salient or socially significant. The analysis also indicated that status was weakly connected to age and, therefore, any effect that status similarity had on tie strength was orthogonal to any effect of age similarity. The empirical results indicated that status similarity had no effect on tie strength. Age similarity had a positive effect on tie strength, and the positive effect was even more positive when teachers the same age had more opportunities to interact with each other (i.e., two teachers had a classroom on the same floor). This paper concludes with a discussion of the theoretical implications of the observed research findings.

Social Similarity and Propinquity

Initial explanations for the positive association between social similarity and tie strength focused on interpersonal dynamics in generating strong network connections. People who shared a demographic characteristic were assumed to also share life histories, experiences, and attitudes, which made it easier for them to interact (Laumann 1966, Byrne 1971, Schneider 1987). An easier and more pleasant encounter was more likely to result in a strong network connection. Any positive effect that social similarity had on tie strength was a function of people who were similar on the "surface" (e.g., both women) also being similar with respect to "deep," or unobserved, behaviors, attitudes, and characteristics (e.g., both liberal). More-recent theoretical arguments have emphasized how the salience or social significance of a demographic characteristic shapes the association between social similarity and tie strength. Even if two people share a demographic characteristic, it will be of little consequence if the characteristic is unimportant. For example,

sharing the characteristic of being American could result in a more positive interaction if two Americans meet one another on a street in Paris. But if the same two individuals were to meet on a street in Chicago, sharing that same characteristic would have little or no effect on their interaction, because almost everyone in Chicago is an American. In Chicago, the most important characteristic could be social or economic class.

Salience is important because individuals are more likely to identify with a salient characteristic, and identification with a characteristic generates positive affect for in-group members (Hogg and Turner 1985; Hogg and Hardie 1991; Hogg 1992, 1993; Hogg and Hains 1996; Grieve and Hogg 1999).[1] Researchers have emphasized how two demographic factors shape the salience of a characteristic. One factor is the composition of the focal organizational unit or group. If an organizational unit contains a minority and a majority group, its composition is skewed (Kanter 1977: 209). The demographic characteristic that defines minority status is more likely to be salient, while the characteristic that defines majority status is less likely to be salient (Tafjel and Turner 1979, Mullen 1983, Turner 1985, Brewer 1991). For example, if women represent ten percent of an organizational unit and men represent the remaining ninety percent, the category of female will be salient for women but the category of male will not be salient for men. As the composition of the unit becomes more balanced, in-group status will become more salient for every member of the unit. For example, if men and women each represent fifty percent of a unit (i.e., the unit is balanced demographically), the category of male will be salient for men and the category of female will be salient for women. A second factor is the correlation among demographic characteristics. A characteristic is more likely to be salient when in-group status with respect to one characteristic is reinforced by in-group status with respect to multiple characteristics (Blau and Schwartz 1984, Lau and Murninghan 1998). When multiple

[1] The assumption in this line of work is that identification is a function of demographic factors (i.e., proportion of in-group members) and that it is beneficial. Research has shown, however, that individuals can be primed to identify with a characteristic. Such identification can be beneficial (Kane et al. 2005) but need not be (Ambady et al. 2001).

characteristics are correlated, the boundary between the in-group and the out-group is more clearly delineated. For example, if all the women on a team are young and all the men are older, membership in each in-group (i.e., young women and older men) will be salient. Thus, a demographic characteristic can be salient even for members of a numerical majority if those members share multiple demographic characteristics.[2]

The general idea is that two individuals will assign more weight to their social similarity as the characteristic that defines their social similarity becomes more salient, which in turn should increase the magnitude of the positive association between social similarity and tie strength. Research findings are consistent with the two explanations for salience discussed above. Reported empirical results indicate that social similarity is more likely to produce a strong tie when people who share the focal characteristic (a) are part of a numerical minority (Mehra et al. 1998, Mollica et al. 2003, Reagans 2005), (b) are assigned to a balanced organizational unit (Moody 2001, Bacharach et al. 2005, Mouw and Entwisle 2006), or (c) share multiple characteristics (Blau and Schwartz 1984). Given these results, I expect sharing a salient characteristic to have a positive effect on tie strength.

HYPOTHESIS 1: *Sharing a salient social characteristic has a positive effect on tie strength.*

More-sociological explanations for strong ties give causal priority to propinquity (Festinger et al. 1950; Feld 1982, 1984; McPherson et al. 2001; Ingram and Morris 2007).[3] Propinquity in time and space could have a positive effect on tie strength either because repeated exposure provides

[2] The importance of being similar along multiple dimensions is not limited to demographic characteristics. For example, if members of a numerical minority all perform the same task or activity in an organization, or if minority status in a firm corresponds with minority status in the general population, the characteristic that defines minority status will be more salient (Turner 1987: ch. 6).

[3] It is important to distinguish propinquity-based explanations for strong network connections from contact theory (Pettigrew 1998, Troop 2007). Contact theory is concerned with the set of conditions that must exist before negative attitudes about the out-group change, while the propinquity argument emphasizes the importance of opportunity in determining tie strength. Having a strong tie with a member of the out-group is not equivalent to having positive attitudes. For example, a man could feel emotionally close to his female colleagues but believe women are inferior to men. Contact theory and propinquity-based explanations for strong ties are distinct but are also compatible (Pettigrew 1998: 75-77).

individuals with an opportunity to discover mutual or compatible interests or because individuals become more appreciative or tolerant of their differences. Propinquity-based explanations for strong ties emphasize the opportunities that individuals have to interact with each other rather than the characteristic they share. Within this framework, if sharing a demographic characteristic is correlated with strong ties, it is because institutional and structural forces provide socially similar people with more opportunities to develop a network connection. For example, typecasting by employers segregates men and women at work (Bielby and Baron 1986). As a result, men and women have more opportunities to develop relationships with members of their respective in-groups. The very same dynamics could just as well produce stronger ties between people who do not share a characteristic. For example, most of us are educated with people our own age, which generates strong ties between individuals who are proximate in age. But because most schools are coed, the same process creates stronger cross-gender ties. Housing segregation by race in the United States generates strong ties among people who belong to the same racial group. But the same dynamic can generate stronger network connections between individuals of different education levels or who belong to different economic classes. This line of thinking leads to the second hypothesis.

HYPOTHESIS 2: *Proximity has a positive effect on tie strength.*

Propinquity provides two individuals with an opportunity to develop a more meaningful relationship, but they must have some interest in developing a strong tie. If they are not interested in interacting, being in close proximity will not have a positive effect on subsequent interactions. More-frequent encounters could make future encounters more problematic. Researchers who emphasize the importance of proximity in producing strong network connections have, at least implicitly, acknowledged the importance of motivation. Those scholars have assumed that even if individuals prefer socially similar contacts, if socially similar colleagues are unavailable, individuals will develop network connections with dissimilar colleagues (McPherson and Smith-

Lovin 1987). This rationale has been used to explain a positive association between the composition of an organizational unit and the composition of a person's contact network. The same rationale also implies that the magnitude of the propinquity effect varies with how similar proximate individuals are. Any positive effect that sharing a salient characteristic has on tie strength should be even more positive when coupled with proximity, either because people who identify with the same characteristic are more interested in interacting or because when an individual identifies with a characteristic, the threshold for developing a strong tie with in-group members is lower. This line of argument leads to the following hypothesis.

HYPOTHESIS 3A: *The positive effect that sharing a salient characteristic has on tie strength increases as proximity increases.*

Although it is possible that the positive association between social similarity and tie strength is even more positive when proximity is high, the exact opposite could also be true. Initial research assumed that people who shared a demographic characteristic also shared unobserved behaviors, attitudes, and beliefs. However, the extent to which that is true is an empirical question, and the available empirical evidence indicates the association between the two kinds of similarity is often weak (Harrison et al. 1998). Moreover, more-recent research indicates that both kinds of similarity contribute to strong ties (Hogg and Hardie 1991, Hogg et al. 1995). Despite the weak correlation between surface and deep similarity, however, people often assume that there is a positive association between surface and deep characteristics (Phillips 2003, Phillips and Lewin Loyd 2006). If people who identify with a salient characteristic assume that surface and deep similarity are congruent for members of their group, then, when two group members meet, each will expect deep (i.e., actual) similarity to be near its maximum value or at least above some threshold value. If the assumption holds, a stronger network connection will occur. If, however, the in-group members discover that deep similarity is lower than expected, sharing the characteristic will have less of a positive effect on tie strength. For example, when people who

share a characteristic discover that surface and deep similarity are incongruent, they are often irritated and annoyed (Phillips 2003). Thus, when surface and deep similarity are weakly correlated, propinquity will provide in-group members with more opportunities to discover what they do not have in common. Consequently, any positive effect that social similarity can have on tie strength should be diminished when proximity is high. This line of argument leads to the following hypothesis.

HYPOTHESIS 3B: *The positive effect that sharing a salient characteristic has on tie strength declines as proximity increases.*

Method

The Study Population

Elementary and middle school teachers who worked in five different schools in a large metropolitan area defined the study population. The teachers had experienced a number of change initiatives aimed at improving student performance, and relationships with colleagues affected how the teachers interpreted each initiative. Moreover, relationships between teachers were important because network connections allowed teachers to benefit from each other's experience and expertise (Gibbons 2004), which could have increased the quality of their teaching. The schools had a number of features that made them attractive settings for evaluating the current research questions. With respect to the first hypothesis, the schools were small. The number of teachers in each school varied from 22 to 65. This small number made it more likely that the teachers were aware of each other's demographic characteristics (Lawrence 2006). As a result, it was more likely that each teacher would know where he or she was located in the distribution of a particular characteristic. Greater awareness should have translated into how much each teacher identified with the focal demographic characteristic and how he or she interacted with colleagues who shared the characteristic. With respect to the second hypothesis, teachers were scheduled to

take breaks at different times during the week. The break schedule was set for each teacher at the beginning of the academic year and provided them with the opportunity to interact. How the teachers spent their break time varied. Some took the break in their classroom, while others spent the time socializing or working in the teachers' lounge. However teachers decided to spend their break time, taking breaks at similar times during the week provided them opportunities to interact. In addition to the break schedule, the physical layout of the school shaped the opportunity teachers had to interact. Teachers with classrooms on the same floor had more opportunities to interact.

INSERT TABLE 1 ABOUT HERE

Demographic and Social Characteristics

The teachers were surveyed four times over a one-and-a-half-year period (approximately every three months). A section of the survey asked teachers about demographic characteristics such as age, gender, race, professional tenure, and school tenure. Table 1 shows the descriptive statistics for the demographic characteristics.[4] In addition to the demographic characteristics, Table 1 includes an indicator of organizational status, which came from asking each teacher to name five colleagues that he or she would nominate for teacher of the year on the basis of their "strength, competence, and ability as a teacher. To define each teacher's standing in the teaching-status hierarchy, the number of nominations received by each teacher was divided by the maximum number of nominations received by any teacher in the school. As noted above, the schools varied in the number of classroom teachers who were employed at the school. There were 30 teachers in school A; 65 in school B, 39 in school C, 22 in school D, and 26 in school E. The results in Table 1 indicate that the vast majority of the teachers were female. The large proportion of female teachers was consistent with the demographic composition of the broader teaching population, as over 90 percent of the elementary and middle school teachers in the state were female. The results

[4] The results in Table 1 illustrate the average characteristics of the teachers and ignore time. There was little change in the teaching population across time, so the descriptive statistics at each point are essentially equivalent.

in Table 1 also indicate that most of the teachers were White. They were the majority of the teaching population in three of the five schools. In comparison to gender, however, there was more variation in race. White and Latino teachers represented between thirty and forty percent of the teachers in schools C and E. African Americans and Asians represented a small minority of the teaching population and were absent in a number of schools. With respect to age and tenure, the teachers in schools C and E tended to be younger and less experienced than the teachers in the other three schools, and this was especially true for the teachers in school E.

The final column in Table 1 shows the response rate to the survey at each school. Every classroom teacher employed by the focal school at time t was asked to fill out the survey. Response rates were averaged across time for each school. The results indicate that the response rate to the survey varied across schools ($F = 8.76$). An analysis of individual response rates indicated that none of the demographic characteristics in Table 1 affected the likelihood that a teacher responded to the survey at a specific time. The teachers who responded were demographically similar to the teachers who did not respond.[5]

A factor analysis of the characteristics (results not shown to conserve space) illustrated how the different characteristics "intersected" in the individual teachers. Two factors explained 34 percent of the covariance among the demographic characteristics. The first factor explained 28 percent of the covariance and illustrated the positive association between individual age, professional tenure, and school tenure. The second factor explained 6 percent of the covariance and distinguished African American teachers from Latinos and women. Although it was possible for a teacher to classify him- or herself as African American and Latino, most teachers did not. Moreover, male teachers tended to be African American. The organizational-status variable was positioned in the

[5] This statement is based on the estimates from a logistic regression analysis with responding to the survey as the dependent variable and with the demographic characteristics in Table 1 as predictors. To control for variation across schools, four school fixed effects were included in the model. An equation was estimated for each survey point, and teachers employed by the school at the time of the survey defined the risk set. Race and gender data were available for every teacher, including teachers who never responded. However, some of the demographic data for respondents and nonrespondents were missing. Missing demographic data were imputed using a multiple imputation technique.

center of the characteristic space, which indicated that status was virtually uncorrelated with the other characteristics. Additional empirical analysis reinforced this finding. The results indicated that organizational status was uncorrelated with race and gender in all five schools, and it was uncorrelated with individual age, professional tenure, and school tenure in schools A, C, and D. School tenure had a positive effect on organizational status in school B, and professional tenure had a positive effect on organizational status in school E.

The results described above illustrate how the demographic characteristics intersected in teachers and how different kinds of teachers were distributed across the five schools. The results can also provide guidance in testing the social-similarity argument. In particular, the factor analysis indicates that age and tenure were the primary sources of demographic diversity in each school. Thus, age and tenure were a readily available source of social differentiation and were more likely to be salient characteristics. Given within-school variation in age and tenure, it would be informative to test the identification-based explanation for tie strength with either age or tenure. In particular, previous research has focused on the salience of race and gender in defining how much individuals identify and interact with members of their respective in-groups, and the results indicate that women and people of color are more likely to be strongly connected to members of their respective in-groups. Identification-based explanations for strong ties emphasize the importance of dynamics *inside* an organizational unit that make a characteristic more salient and therefore produce stronger relationships between in-group members. In the general population, people of color are part of a minority, and women are equally represented. The two conditions, minority status and equal representation, are conditions under which a characteristic is more likely to be salient. Thus, the exclusive focus on race and gender in prior research makes it difficult to know if the observed positive effects for race and gender result from dynamics inside an organizational unit or from the standing of women and people of color in the general population.

As age and tenure are the primary source of demographic diversity within each school and they vary within each school, it is possible for teachers who are the same age or tenure to be part of a numerical minority *inside* a school, and it is also possible for them to be part of a balanced unit independent of their standing in the general population outside the school. Age and tenure represent an opportunity to provide a more robust test of the identification argument. I test the social-similarity argument with age and not tenure, and I do so for two distinct reasons. First, like race and gender, age is a visible demographic characteristic (Tsui and Gutek 1999: 48). Therefore, variation in age is more likely to be visible than variation in tenure. Second, the age data were more complete (in terms of missing data) than the tenure data. But since age and tenure were correlated, they were more likely to be salient because in-group status with respect to age would be correlated with in-group status with respect to tenure. Thus, age could be more salient, either because of a school's composition with respect to age or because of the consolidation between age and tenure among the teachers. The increase in salience, however, should increase the positive association between age similarity and tie strength. I also test the social-similarity argument with organizational status. Organizational status was uncorrelated with age and the tenure variables in most schools, so the degree to which an individual identified with his or her organizational status when his or her status was salient should be uncorrelated with the extent to which the individual identified with his or her age.

When compared to age and organizational status, there was less within-school variation in race and gender. The results in Table 1 indicate that almost all the teachers were female. Men represented a numerical minority and although it would be informative to test the first prediction with the characteristic of male defining minority status, the number of male teachers was small. The results also indicate that each school had a distinct racial composition. The schools differed in the kinds of racial groups that were present and also in each racial group's representation when members of the group were present. Given the distinct racial makeup of each school, it would be hard to distinguish any effect associated with belonging to a racial group (e.g., both African

American) from unmeasured school effects. Given these data limitations and the possibility of putting identification-based explanations for tie strength on firmer empirical grounds by focusing on age, I focus on age and organizational status in my empirical analysis. I do, however, control for similarity in race and gender.

Tie Strength

Network data were collected using the sociometric roster approach (Wasserman and Faust 1994: 43-56). Each respondent was given a roster of names and asked to describe his or her relationship with each listed colleague in terms of communication frequency and emotional closeness. Emotional closeness and communication frequency represent distinct dimensions of tie strength (Marsden and Campbell 1984). To reduce the potential for survey response bias, tie strength data were collected at two distinct points in the survey. At the beginning of the survey, each teacher indicated how frequently he or she communicated ("less than once a month," "once a month," "multiple times a month," "once a week", "multiple times a week," "once a day," or "multiple times a day") with each listed colleague. At the end of the survey, each respondent was presented with the same roster of names and asked to describe his or her relationship with each colleague in terms of emotional closeness ("especially close," "merely close," "less than close," or "distant").

Analysis of the tie strength data indicated that the response rate to the emotional closeness question was lower on the initial two rounds of the survey. The reason for the low response rate is unclear. Responding to a sociometric question is time-consuming, and subjects were asked to respond to the emotional-closeness question at the end of the survey. However, conversations with teachers indicated that they were concerned about revealing those sentiments for particular colleagues. As a result, the emotional-closeness data were not collected after the second wave. A cross-tabulation of the two tie-strength variables indicated that they were significantly correlated at time 1 and time 2. Pearson's Chi-Square in the first period was 3,523 ($p < .001$), and in the second period it was 2,482 ($p < .001$). One can reject the independence assumption in both time

periods. Since more data were available for communication frequency, the predictions were tested with communication frequency as the primary indicator of tie strength. As a robustness check, however, the predictions were tested with the emotional-closeness data from the first two time periods.

Independent Variables

Social Similarity. Sharing a demographic or social characteristic is more likely to produce a strong tie when the focal characteristic is socially significant or salient. Thus, how two people respond to their social similarity is relative. In some instances, their social similarity will matter a great deal, and in other situations, it will not matter very much at all. The focus on relative similarity is consistent with the position taken by researchers who highlight the importance of relational instead of simple demography (O'Reilly et al. 1989, Tsui et al. 1992, Chatman et al. 1998). For example, instead of analyzing the influence of a person's age on the focal outcome (e.g., integration, satisfaction, etc.), relational demography researchers emphasize the importance of a person's relative age, because the meaning that an individual (and any other group member) assigns to a person's age depends on the age of other group members. Relational demography scores can be used to construct a social-similarity variable that is sensitive to where social similarity occurs in the broader characteristic distribution. For any focal characteristic, an individual has a relational demography score that describes where he or she is located relative to the typical member of the group. In the current context, $(x_{ikt} - x_{kt})$ measures how far away teacher i is from his or her colleagues at school k with respect to characteristic x at time t. x_{ikt} was the level of the focal characteristic x for person i in school k at time t, and x_{kt} was the mean of x in school k at time t when person i was not included in the calculation (Tsui et al. 1992: 561). If the focal characteristic is age, large positive values would indicate the focal individual

was much older than his or her peers, and large negative values would indicate the individual was much younger than his or her peers.

For two people, the product of their relational demography scores, $(x_{ikt} - x_{kt})(x_{jkt} - x_{kt})$, is a social-similarity variable. The magnitude of the variable is a function of the composition of the broader organizational unit. Consider a 100-person organizational unit composed of two age cohorts. Individuals in the younger cohort are 30 years old, and individuals in the older cohort are 40 years old. If the younger cohort contains 20 people and the older cohort contains 80 people, the individuals in the younger cohort represent a numerical minority, and the individuals in the older cohort represent a numerical majority. The social-similarity variable would equal 65 for two members of the younger cohort (i.e., the minority group), and it would equal 4 for two members of the older cohort (i.e., the majority group). If the younger cohort contained only 10 people and the older cohort contained 90 people, the variable would equal 82 for two members of the younger cohort, and it would equal 1 for two members of the older cohort. If the older cohort contained 80 people who were 50 years old, the variable would equal 261 for two members of the younger cohort, and it would equal 16 for two members of the 50-year-old cohort. The example illustrates that the magnitude of the social-similarity variable increases as people of a kind become more of a numerical minority and especially as members of the minority become more and more distant from members of the majority group. If the organizational unit was balanced, and younger people were 30 years old and older people were 40 years old, the social similarity would equal 25 for two members of either cohort. If the older cohort contained 50-year-olds, the social-similarity variable would equal 102 for two members of either cohort. Overall, the social-similarity variable varies in ways that are consistent with theoretical explanations for salience. If the organizational unit contains a minority and a majority group, the variable for the minority group increases as the minority group becomes more of a minority *and* as the distance between the minority and majority group increases. The variable declines for the majority group as its

members become more of a majority but to a lesser extent as the distance between the minority and majority grows. The presence of a very small but distant minority can increase the salience of social similarity for members of a majority group (Harrison and Klein 2007). If the organizational unit is balanced, the variable increases as the distance between the two groups increases.

The social-similarity variable is useful but far from perfect. In particular, if the distribution of the focal characteristic is skewed, normal, or bimodal, the variable produces scores that are consistent with prior theorizing. However, if the distribution is uniform or multimodal, the variable would be high for socially similar individuals at the edge of the distribution but low for similar individuals toward the center of the distribution. Under these conditions, one would be better off defining relational demography as a function of distances between individuals as opposed to distance from the mean, because under a uniform or multimodal distribution, defining relational demography as a function of distance from the mean would obscure important demographic information. Moreover, the rate at which the variable increases with minority status or with the distance between groups is arbitrary. One could imagine transforming the relational demography scores, which would affect the rate at which distance and representation contribute to the variable. However, I do not have a theoretical reason for preferring one transformation over another or over the raw relational demography scores, so I have used the most basic approach.

Proximity. Each teacher was scheduled to take breaks during the course of a day. Overlap in the break schedule provided teachers with the opportunity to interact. The variable break overlap was defined as the "break time" that teacher i spent with teacher j, $\text{break overlap}_{ijt} = \sum_{k} P_{ikt} P_{jkt}$. P_{ikt} equaled 1 if person i took a break during period k at time t. P_{jkt} equaled 1 if person j took a break during period k at time t. So $P_{ikt} P_{jkt}$ equaled 1 if both teachers took a break during period k at time t. Summing across all the breaks k for each time t defined the number of hours that teacher i and teacher j could have interacted. In addition to the break schedule, the physical layout

of the schools provided teachers with an opportunity to interact. Teachers with classrooms on the same floor had more opportunities. To test the effect that physical proximity had on tie strength, a same-floor indicator variable was created and set equal to 1 if two teachers had classrooms on the same floor.

The proximity variables are expected to have a positive effect on tie strength. It is possible, however, that people who want to be strongly connected act in ways to increase their physical and temporal proximity. Although I cannot rule out this possibility completely, there are reasons to suspect that any influence that reverse causality had on the observed association between proximity and tie strength was limited. For example, administrators at the schools maintained that they designed the break schedule to facilitate the education of students, so the schedule was more likely to be influenced by logistics and subject matter. However, it would be naïve to think that seniority, politics, and preferences did not play a role as well. And yet, even when these factors did influence when a teacher (or two teachers) took breaks, their effects were constrained by the number of teachers who could take breaks at the same time. Even if some teachers were able to decide when they took a break, the limit on the number of teachers who could take a break at the same time constrained the ability of teachers to take breaks only with colleagues they preferred. The result was that on average, overlap in the break schedule was outside the immediate control of individual teachers. A similar logic applies to the same-floor variable. Even if some teachers were able to select where their classrooms were located, their choices limited the alternatives that were available to other teachers. As a result, while it is possible that tie strength affects proximity, it is more likely that any association I observed between proximity and tie strength is a function of the effect that proximity has on tie strength.

Controls

The control variables were categorical and continuous. The categorical control variables were race (Asian, African American, Latino,White), gender (Female, Male), and teaching certificate

(Yes, No). The teaching-certificate variable is an indicator of knowledge and expertise because a teacher could apply for a certificate after he or she completed his or her M.A. degree. To control for any effect that being the same race had on how two teachers interacted, four same-race indicator variables were created (*both African American*, *both Asian*, *both Latino*, and *both White*). Cross-race interactions provided the baseline for the same-race effects. To control for any influence that being the same gender had on how two teachers interacted, two same-gender indicator variables were created (*both female* and *both male*). Interactions between men and women provided the baseline for the same-gender effects. To control for any effect that having the same level of education had on how teachers interacted, two same-education indicator variables were created (*both certified* and *both not certified*). Interactions between teachers with different education levels provided the baseline for the same-education effects. The teachers were responsible for a number of subjects across a number of grades. To control for any effect that overlap in subjects or grades could have produced, models control for overlap in the grades taught (*grade overlap*) at time t and for overlap in the subjects covered at time t (*subject overlap*). The grade overlap and subject overlap variables were continuous and although it seemed likely that grade and subject overlap would have an effect on how teachers interacted, the exact origin of that effect was unclear. Teachers who worked in the same area could have had more opportunities to interact, and the opportunities they had to interact could have been orthogonal to the opportunities defined by being on the same floor or taking breaks at similar times. Or two teachers who taught the same grades or subjects could have viewed themselves as being more similar, which could have resulted in stronger ties. Or teachers who taught similar subjects and grades could have been more relevant as colleagues, and the knowledge that they had in common could have made it easier for them to interact, thereby increasing the frequency of their communication. Although it seemed clear that the subject- and grade-overlap variables would have an effect on tie strength, it was unclear why. Therefore, instead of using the variables to test any of the predictions, the overlap variables were included as control variables. Finally, all

models included a fixed effect for four of the five schools to control for any unmeasured differences across schools and a fixed effect for three of the four time periods to control for any unmeasured differences in tie strength across time.

Results

The responses to the communication-frequency question were ordinal. The distances between response characteristics could be unequal. For example, the distance between "once a day" and "multiple times a day" could be larger than the distance between "less than once a month" and "once a month. Instead of assuming equal spacing, ordinal logits estimate the distance between consecutive response characteristics. A second methodological concern was the units of analysis. Dyads were the units of analysis and, after excluding missing data, there were 9,176 observations. The observations were not independent. Each teacher-colleague combination could be observed multiple times. This kind of clustering violates the independence assumption in regression analysis and can artificially deflate standard errors, thereby inflating significance tests. To adjust the standard errors, a random intercept was estimated for each teacher-colleague combination. In addition to adjusting the size of the standard errors for clustering, the random intercept controls for unmeasured dynamics that could have affected how a focal teacher interacted with a specific colleague. For example, formal work requirements could have affected how much a teacher communicated with a focal colleague. Or the teacher and the colleague could have been strongly connected to each other because they belonged to the same professional club or organization or simply traveled in the same informal social group. The ordinal logit model with random intercepts was estimated using the gllamm command in Stata.[6]

[6] More formally, the error term (ξ_{ijt}) in the equation describing the communication frequency between teacher i and colleague j at time t was assumed to equal $\zeta_{ij} + \varepsilon_{ijt}$. ζ_{ij} is a random intercept, and each intercept was specific to a teacher-colleague interaction. The random intercepts were assumed to be normally distributed with zero mean and variance ψ, with ψ being estimated from the data. During estimation, ζ_{ij} was not forced to equal ζ_{ji}. Substantive conclusions are the same if ζ_{ij} was assumed to equal ζ_{ji}. However, there is no reason why the unobserved dynamics that affected how a teacher interacted with a colleague should have the same effect on how the colleague interacted with the focal teacher. Moreover,

The random intercepts allow me to adjust the standard errors for clustering and also to control for omitted variables, but the approach is not without its limitations. In particular, I make some quite strong assumptions about the association between the random intercepts and the independent variables in the regression equation. I assume the independent variables are uncorrelated with the random intercepts (Rabe-Hesketh and Skrondal 2005: 95). The assumption seems reasonable for some unmeasured features (e.g., formal work requirements) of a relationship but unreasonable for other features (e.g., membership in the same informal group). This approach, however, represents an improvement over techniques that control for omitted variables only at the individual and not the dyadic level of analysis (Reagans 2005). It falls short of the ideal of being able to control for omitted features of a relationship that could be correlated with the independent variables in the regression equation. Estimating a fixed effect for each dyad would allow controlling for omitted variables that are correlated with the independent variables. The small number of observations for each teacher pair precludes adopting a dyadic fixed effect approach.

Descriptive statistics for the variables are in Table 2. Correlations are in Table 3. The row and column numbers in Table 3 correspond to the row numbers in Table 2. In the current organizations, the correlations between the variables that measure propinquity and the variables that measure salient social similarity were modest, and thus the two factors varied independently. The results from the ordinal logit are in Table 4. Predictors were introduced in blocks. The control variables were introduced in Model 1. The first hypothesis is tested in Model 2. The second hypothesis is tested in Model 3. Hypotheses 1 and 2 are tested in Model 4. Hypotheses 3a and 3b are tested in Model 5.

INSERT TABLE 2 & 3 ABOUT HERE

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interpersonal relationships are not reciprocal by definition (Carley and Krackhardt, 1996). A teacher and a colleague did not have to feel the same way about each other. Moreover, in addition to describing how frequently two teachers communicated, reported communication frequency most likely reflected differences in who initiated communication or the desire a teacher had to communicate with a specific colleague more frequently.

I focus on the estimates in Model 5. The coefficients for the control variables are consistent with prior research. For example, overlap in grades and subjects taught had a positive effect on communication frequency. As noted earlier, the positive effects associated with these control variables could reflect increased opportunity, social similarity, or the relevance of communication. With respect to gender, interpersonal connections between women were more negative than connections between men and women, while connections between men were more positive than connections between men and women. Men represented a minority population in the schools, while women were part of a numerical majority. Thus, the observed gender effects are consistent with the idea that people who are part of a numerical minority are more likely to be connected by a strong tie, whereas similar people are more likely to be connected by a weak tie when they are part of a numerical majority (Reagans 2005). A similar pattern was observed for education. When both teachers did not have a teaching certificate, the teachers communicated with each other more frequently. When both teachers were certified, they communicated less frequently. Uncertified teachers were part of a numerical minority, while certified teachers were part of a numerical majority. With respect to race, the coefficients for both African American and both White were positive and significant. The coefficient for both Asian was positive but was only marginally significant, and the coefficient for both Latino was not significant. Again, given the unique racial composition of each school, it is difficult to interpret the exact meaning of the same-race coefficients.

For the predictions, the results appear to provide only partial support for the first hypothesis. Consistent with the first prediction, the coefficient for the age-similarity variable is positive and significant.[7] However, the coefficient for the status-similarity variable is not significant. Although the coefficient for the status-similarity variable does not provide support for the first prediction, it

[7] Although I have focused on age similarity, teachers for whom age similarity is more likely to be salient are the same teachers for whom similarity in school or professional tenure is more likely to be salient. Thus, the observed effect for age similarity more than likely reflects the combined influence of salience with respect to representation and the consolidation of multiple demographic characteristics.

is possible that it is inappropriate to test the first prediction with the status data. Salience-based explanations for strong ties assume that individuals are aware of their similarity. Teachers who were similar in terms of their organizational status could have been unaware of their social similarity. Not only is status less visible than age, but in each school, there was more variation with respect to age than status. Therefore, when compared to differences in age, differences in status were more fine grained and could have been more difficult to detect. Moreover, two teachers with the same public standing in the status hierarchy could have held very different private beliefs about their social standing (Anderson and Spataro 2005). Variation in private beliefs would affect the salience of status similarity and therefore the extent to which similarity in status translated into more-positive relationships. Thus, instead of providing mixed support for the first prediction, the results for organizational status help clarify the factors that underlie the social-similarity effect. In particular, individuals have to agree they are socially similar. If possessing a characteristic or if membership in a group is ambiguous and/or open to self-serving interpretations, people who appear to be similar (i.e., are similar on the surface) could disagree about their similarity, which would reduce any effect surface similarity could have on the strength of their relationship.

The results provide unambiguous support for the second prediction. The coefficient for the break-overlap variable is positive and significant, as well as the coefficient for the same-floor variable. The results indicate that teachers with classrooms on the same floor or who had more opportunities to interact communicated with each other more frequently. Since the main effect for the status-similarity variable was not significant, the interaction terms to test the third hypothesis were calculated for the age-similarity variable. The coefficient for the interaction between age similarity and the same-floor variable is positive and significant. The coefficient indicates that age-similar teachers communicated with each other more frequently when they were on the same floor and age-dissimilar teachers communicated with each other less. This was especially true for teachers for whom age was more likely to be salient. The coefficient for the interaction between

age similarity and break overlap was not significant. Therefore, the empirical results provide only moderate support for Hypothesis 3a. Model 6 replaces communication frequency with emotional closeness as the dependent variable, and the coefficients for the variables of interest are essentially the same. Both proximity variables had a positive effect on emotional closeness, and the coefficient for the age-similarity variable was also positive and significant. However, the coefficient for the interaction between age similarity and the same-floor dummy was not significant. Recall that the emotional-closeness data were available only during the first two time periods. If Model 5 is re-estimated with data from the first two time periods, the coefficient for the interaction term between the age similarity variable and the same floor variable is not significant. Detecting a significant interaction requires more data and it is possible that with more emotional-closeness data, the interaction between the age similarity variable and the same-floor variable would be positive and significant.

Summary and Discussion

My research objective was to analyze how social similarity and propinquity contribute to strong network connections alone and when combined with each other. Although a number of studies have documented the importance of either social similarity or propinquity, very few have focused on how the two mechanisms combine to produce strong ties. In addition to having a direct effect on tie strength, propinquity could moderate the positive association between social similarity and tie strength. Being in close proximity could either increase or decrease any positive social-similarity effect. In an analysis of network connections among teachers working in five public schools, I found that age similarity and propinquity had positive effects on tie strength. I also found that proximity in space amplified the positive association between age similarity and tie strength.

The findings illustrate how social similarity and propinquity contribute to strong ties and, in so doing, help clarify an important theoretical framework. It is widely believed that the positive effect that an increase in the salience of social similarity can have on tie strength will come at the expense of the positive effect that opportunity can have on relationships between dissimilar individuals (Blau and Schwartz 1984, Brewer and Kramer 1985, Moody 2001, Hewstone et al. 2002). Scholars who adopt this view focus on how the demographic diversity of an organizational unit affects the salience of social similarity *and* the opportunities that individuals have to interact with dissimilar colleagues. Researchers have theorized that an increase in the demographic diversity of an organizational unit increases the salience of social similarity, which in turn increases the positive effect that social similarity can have on tie strength, but the same increase in diversity should also provide individuals with fewer opportunities to interact with dissimilar colleagues, reducing the positive effect opportunity can have on relationships between dissimilar colleagues. Therefore, an increase in demographic diversity sets in motion a sequence of events that produce a trade-off between social similarity and opportunity.

Among the teachers I studied, I found no evidence for a proposed trade-off between salience and opportunity. The correlations between the indicators of propinquity (i.e., the same-floor and break-overlap variables) and salient social similarity (i.e., the age- and status-similarity variables) were modest. An increase in one mechanism did not come at the expense of an increase in the other. The research findings do indicate that the positive effect that opportunity had on relationships between socially dissimilar people declined as social similarity became more salient. Recall that the positive effect of age similarity on tie strength was even more positive under the conditions that should have increased the salience of being similar in age. And the positive age-similarity effect was even more positive when teachers of the same age had rooms on the same floor. Thus, any negative effect that age dissimilarity had on tie strength was even more negative when age-dissimilar teachers were more aware of their differences and also had classrooms on the same floor. Or, in other words, the positive effect that physical proximity had on relationships

between age-dissimilar teachers declined as differences in age became more salient. Thus, the empirical results are consistent with prior theorizing in the sense that the positive effect that opportunity had on the strength of relationships between dissimilar individuals declined as social differences became more salient. The decline in the opportunity effect was not a function of dissimilar individuals' having fewer opportunities to interact with each other. As differences in age became more salient, age-dissimilar individuals were less likely to take advantage of the opportunity to build a strong tie. The decline was significant and theoretically interesting; however, it should be considered in the context of the large and positive effect that propinquity had on tie strength. Overall, the results indicate that teachers did develop strong ties with age-dissimilar colleagues as their opportunity to develop a strong tie increased.

The research findings are important because they shift our attention away from either salience- or opportunity-based explanations for strong ties and refocus our attention on how the two mechanisms can combine in the production of network connections. I emphasize *can* because although I found a positive interaction between social similarity and propinquity among the teachers I studied, it is not immediately clear that propinquity will always increase the positive effect that social similarity can have on tie strength. In fact, I expected to find a negative interaction between social similarity and propinquity if people who were similar on the surface did not share important attitudes, behaviors, and beliefs. If socially similar individuals are only similar on the surface, more-frequent interactions should reveal how little they actually have in common and therefore reduce the positive effect that surface similarity can have on network connections (Ziebro and Northcraft 2009). I expected to find a positive interaction between social similarity and propinquity if surface and deep similarity were consolidated or congruent.

There was a positive interaction between age similarity and propinquity. And although it is possible that teachers who were similar in age were also similar in unobserved attitudes, behaviors, and beliefs, prior research has established that the association between surface and deep similarity is often weak (Harrison et al. 1998). Perhaps the critical issue is not what people

actually have in common but what they believe they have in common. If an individual identifies with a demographic characteristic, perhaps he or she could assume that everyone who shares the characteristic also possesses the behaviors and characteristics that define in-group status (Hannan et al. 2007: ch. 5). Identification with a salient characteristic could increase the tendency to give in-group members the benefit of the doubt during interactions. If in-group members are assumed to possess certain behaviors and characteristics, an individual is more likely to notice those behaviors and characteristics when they are exhibited. Individuals often see what they expect to see and do not see what they do not expect to see. If individuals are motivated to draw distinctions between themselves and members of their in-group, perhaps because they compete against members of their in-group for attention (Reagans 2005) or because they are concerned about how ties to in-group members will affect their standing in the larger group (Duguid et al. 2010), proximity would provide them with more opportunities to justify those differences. Identifying the set of factors that shape how propinquity moderates the association between social similarity and tie strength seems worthy of future inquiry.

This project makes a number of contributions to existing research on network formation. However, like any research project, it is not without its limitations. For example, although the analysis is based on tie-strength data collected at four different times, the relationships are not new, and the empirical analysis focused on the level of tie strength. Significant insight could be gained by analyzing how the causal factors operate in a dynamic framework. For example, the main effect for age similarity suggests that people defy propinquity and go out of their way to develop strong ties with socially similar colleagues when being the same is salient. It is possible that when social similarity is salient, socially similar people self-select into situations that provide them with more opportunities to interact (Denrell 2005). This raises the question of how much effort individuals are willing to exert to find similar others when a demographic or social characteristic is salient (Ibarra et al. 2005). Moreover, I have emphasized the importance of salience and in-group identification in producing the positive effect that social similarity can have

on tie strength. Prior research has established that individuals are more likely to identify with a salient characteristic and that identification with a characteristic has a positive effect on ties with in-group members. My social-similarity variable was constructed to be high when the conditions that increase salience are present (i.e., when similar individuals are part of a numerical minority or a balanced group). I did not measure salience or in-group identification and thus do not know whether this social-similarity variable predicts either dynamic. This is clearly a limitation of the study. A more systematic analysis would consider the extent to which the social-similarity variable predicts salience and in-group identification and the extent to which these dynamics mediate the association between the social-similarity variable and tie strength.

Despite these limitations and others, the current project advances our understanding of dynamics that can affect the origin of strong interpersonal connections. Scholars would be well advised to consider in future research how social similarity and propinquity combine in the production of strong ties and the dynamics that shape how propinquity moderates the association between social similarity and tie strength.

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Table 1 Individual Characteristics and Response Rate

	Female	African American	Asian	Latino	White	Age	Tenure in school	Tenure in profession	Status	Response rate
School A	100	10	0	0	90	43	10	13	.17	87
School B	94	5	6	2	88	45	11	15	.14	66
School C	90	9	11	43	37	38	6	10	.15	85
School D	91	0	0	5	95	44	9	19	.19	89
School E	79	15	12	31	42	32	3	5	.19	74

Note. The race proportions in School B do not sum to 100 percent because of rounding.

Table 2 Descriptive Statistics

	Mean	Standard Deviation	Minimum	Maximum
1. Communication frequency	4.20	1.88	1	7
2. Same grades	.46	.86	0	7
3. Same subjects	2.47	1.92	0	6
4. Both certified	.51	.49	0	1
5. Both not certified	.11	.31	0	1
6. Both female	.88	.31	0	1
7. Both male	.003	.05	0	1
8. Both African American	.002	.05	0	1
9. Both Asian	.003	.06	0	1
10. Both Latino	.03	.18	0	1
11. Both White	.64	.47	0	1
12. Break overlap	3.45	2.62	0	19
13. Same floor	.30	.46	0	1
14. Age teacher	42.87	13.49	23	68
15. Age colleague	42.92	13.47	23	68
16. Age similarity	-6.28	171.05	-506.24	559.11
17. Status teacher	.27	.28	0	1
18. Status colleague	.27	.28	0	1
19. Status similarity	.002	.08	-.20	.71

Table 3 Correlations							
	1	2	3	4	5	6	7
1. Communication frequency	1.0000						
2. Same grades	0.2407	1.0000					
3. Same subjects	-0.0708	-0.3877	1.0000				
4. Both certified	0.0153	0.1487	-0.1070	1.0000			
5. Both not certified	0.0390	-0.0743	0.0354	-0.3709	1.0000		
6. Both female	-0.0570	-0.1270	0.1345	-0.0031	-0.0148	1.0000	
7. Both male	0.0419	0.0587	-0.0371	0.0053	-0.0091	-0.1557	1.0000
8. Both African American	0.0219	-0.0065	0.0084	-0.0164	0.0279	-0.0284	0.0029
9. Both Asian	0.0100	-0.0253	0.0265	-0.0497	0.0583	0.0216	-0.0034
10. Both Latino	0.0105	-0.0387	0.0834	-0.1278	0.1465	0.0675	-0.0105
11. Both White	0.0967	0.0214	-0.1242	0.2567	-0.2849	0.0491	-0.0162
12. Break overlap	0.1930	0.1524	0.0023	0.0653	-0.0494	0.0446	-0.0334
13. Same floor	0.2359	0.0853	0.0453	-0.0200	0.0552	0.0630	-0.0066
14. Age teacher	0.0268	0.1187	-0.1143	0.3468	-0.2628	0.0551	-0.0104
15. Age colleague	0.0167	0.1180	-0.1139	0.3436	-0.2598	0.0551	-0.0106
16. Age similarity	0.1049	0.0291	0.0272	0.0497	0.0917	-0.0079	-0.0040
17. Status teacher	0.0385	-0.0299	0.0305	0.0600	-0.0256	-0.0078	0.0125
18. Status colleague	0.1007	-0.0310	0.0326	0.0559	-0.0204	-0.0095	0.0123
19. Status similarity	0.0507	-0.0097	0.0118	0.0246	-0.0114	-0.0048	-0.0033
	8	9	10	11	12	13	14
8. Both African American	1.0000						
9. Both Asian	-0.0031	1.0000					
10. Both Latino	-0.0098	-0.0115	1.0000				
11. Both White	-0.0693	-0.0808	-0.2525	1.0000			
12. Break overlap	-0.0316	-0.0117	-0.0363	0.1759	1.0000		
13. Same floor	-0.0344	-0.0124	0.0325	0.0176	0.1395	1.0000	
14. Age teacher	0.0096	-0.0502	-0.0865	0.1897	0.0186	-0.0115	1.0000
15. Age colleague	0.0130	-0.0505	-0.0873	0.1853	0.0152	-0.0137	0.0490
16. Age similarity	0.0088	0.0599	0.0020	-0.0123	0.0290	0.0029	-0.0226
17. Status teacher	-0.0219	-0.0081	-0.0138	0.0800	-0.0089	-0.0056	0.1565
18. Status colleague	-0.0093	-0.0083	-0.0145	0.0747	-0.0120	-0.0078	0.0008
19. Status similarity	-0.0130	-0.0121	-0.0044	0.0367	0.0209	-0.0032	0.0362
	15	16	17	18	19		
15. Age colleague	1.0000						
16. Age similarity	-0.0248	1.0000					
17. Status teacher	0.0021	-0.0030	1.0000				
18. Status colleague	0.1522	-0.0028	-0.0062	1.0000			
19. Status similarity	0.0353	0.0000	0.1988	0.1954	1.0000		

Table 4 Predictors of Communication Frequency

	I. Controls	II. Social similarity	III. Opportunity	IV. Similarity & opportunity	V. Similarity X opportunity	VI. Emotional closeness
Same grades	1.088•	1.082•	.972•	.962•	.962•	.331•
	(.060)	(.060)	(.059)	(.059)	(.059)	(.075)
Same subjects	.139•	.126•	.111•	.097•	.096•	.037
	(.027)	(.027)	(.026)	(.026)	(.026)	(.035)
Both certified	-.113	-.203•	-.083	-.192•	-.196•	.229
	(.096)	(.100)	(.094)	(.098)	(.098)	(.135)
Both not certified	.535•	.420•	.504•	.393•	.395•	.856•
	(.153)	(.154)	(.150)	(.150)	(.150)	(.219)
Both female	-.554•	-.541•	-.606•	-.599•	-.604•	.005
	(.171)	(.168)	(.166)	(.163)	(.163)	(.215)
Both male	1.982•	1.936•	1.983•	1.931•	1.915•	-.182
	(.933)	(.918)	(.906)	(.888)	(.888)	(1.105)
Both African American	1.742	1.717	2.304•	2.278•	2.287•	1.266
	(.990)	(.974)	(.956)	(.939)	(.938)	(1.260)
Both Asian	1.615•	1.273	1.613•	1.274	1.282	1.574
	(.822)	(.812)	(.798)	(.785)	(.784)	(1.120)
Both Latino	.519	.514	.308	.295	.301	1.140•
	(.300)	(.295)	(.291)	(.285)	(.285)	(.370)
Both White	1.222•	1.172•	1.201•	1.144•	1.136•	1.300•
	(.137)	(.135)	(.133)	(.131)	(.130)	(.175)
Break overlap		___	.069•	.072•	.071•	.070•
			(.015)	(.015)	(.015)	(.022)
Same floor		___	1.516•	1.539•	1.559•	1.190•
			(.106)	(.104)	(.105)	(.146)
Age teacher		.003	___	.005	.005	.022•
		(.004)		(.004)	(.004)	(.005)
Age colleague		-.001	___	.001	.001	-.008
		(.004)		(.004)	(.004)	(.005)
Age similarity		.002•	___	.002•	.001•	.004•
		(.0003)		(.0002)	(.0004)	(.0006)
Status teacher		.085	___	.159	.161	-.134
		(.140)		(.137)	(.137)	(.221)
Status colleague		.895•	___	.956•	.957•	1.885•
		(.140)		(.138)	(.138)	(.229)
Status similarity		.204	___	.253	.242	.001
		(.438)		(.433)	(.433)	(.757)
Age similarity X Break overlap					.000	-.000
					(.000)	(.000)
Age similarity X Same floor					.001•	-.000
					(.0005)	(.0007)
Log likelihood	-15135	-15089	-15020	-14966	-14964	-47000
/cut 1	-3.630	-3.425	-3.006	-2.652	-2.660	-2.529
/cut 2	-2.334	-2.133	-1.720	-1.369	-1.378	1.483
/cut 3	-.879	-.681	-.2778	.068	.058	5.825
/cut 4	.553	.747	1.148	1.489	1.480	___
/cut 5	2.902	3.091	3.500	3.834	3.825	___
/cut 6	4.597	4.781	5.203	5.529	5.522	___

• $p < .05$.

The table includes coefficients with their standard errors in parentheses. Models I-V include four fixed effects to control for unmeasured school effects and three fixed effects to control for time. Model VI includes four fixed effects to control for unmeasured school effects and one time dummy.

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Dynamic Network Community Detection with Coherent Neighborhood Propinquity

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ABSTRACT The community structure detection in static networks often ignores the dynamic nature of the network and it is difficult to identify the evolution of community structure in dynamic networks. The community structure will converge or split as the nodes and edges change. Understanding the evolution of communities over time is an important issue in the study of social networks. Based on the characteristics of dynamic networks, this paper analyzed the influence of variables in dynamic networks structure. We proposed an Incremental algorithm with Coherent Neighborhood Propinquity in dynamic networks. The algorithm considered the direct and indirect effects of changing nodes in their previous communities. We also considered the coherent neighborhood propinquity and improved the influence range of variable nodes. Comparing with the traditional algorithms, the experimental results showed that the proposed algorithm has better performance and less running time.

INDEX TERMS Community detection, Dynamic network, Graph analysis, Incremental algorithm

I. INTRODUCTION

The internet has developed rapidly in recent years, and the number of users worldwide is close to 3.9 billion. People enjoy a variety of convenient services on the mobile Internet, such as making friends, ordering food, job hunting, reading news, watching videos, posting photos, sharing travel, and more. It can be said that online life has penetrated all aspects of our real life [1]. Social networks have a profound impact on people's behavior in real life. For example, we will buy products recommended by friends [2], visit customers at a certain company, or have a vacation with our family. At the same time, real-life relationship also affects user relationships and community structures in social networks. The network community structure reflects the relationship of users in the network. The online social network is a typical dynamic network, such as the we may follow the new blogger, the network not only has the characteristic of dynamic change, but also has the high requirement to the computational complexity with large amount of data that changes at any time. There is growing interest in analyzing the formation and development of the user community in the social network, as well as understanding the relevant internal relationships of individuals (or communities) over time. Hence, the Dynamic Community Discovery represents one of the most challenging problems and has become a hot topic of research for observing the evolution of community structure.

Some researchers considered that the dynamic network community structure changes on the time axis is flat with less large-scale sudden changes [3]. The social relationships implied in the dynamic community changes will slowly change, so the dynamic community delays smoothness in a short period of time. The community is defined as the nodes connected densely with each other in the same group and sparsely connected to other groups [4]. As time changes, the connection status of nodes in the network will also change accordingly. The link between two nodes will be appearing or disappearing over time. Among them, historical network information and current network information in a short period of time can be integrated to realize the overall community division in the network [5]. We can divide the community structure on the series of network snapshots.

The traditional community discovery algorithm mainly aims at the static network, and the topology of static

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network can reflect the aggregation result of network data in a certain time [6]. However, the basic attribute of social network is that the network topology changes dynamically with the change of time, so the traditional static community discovery algorithm cannot meet the demand of social network development and evolution over time. In order to meet the needs of the community dynamic analysis, some researchers simulated social network change by a series of static graphs [7][8]. They have mapped out different time slices in dynamic networks in order to realize the Community Structure Division of dynamic network. However, the network topology of each time slice has a large number of nodes and complex edges, which leads to a high time complexity for each global community partition. In fact, although social networks contain a large number of nodes, social networks change only a small number of nodes and edges in a short period of time, and a large number of network structures do not change [9][10]. Therefore, using the incremental analysis of network in the time period, the temporal complexity can be greatly reduced by the evolution of the community in a short time.

In this paper, we proposed an incremental-based dynamic network community detection algorithm. This algorithm improved the dynamic update method of the nodes influence, the relevance strength of user nodes, the influence of indirect nodes, and the affiliation weight of the node in community. The traditional incremental algorithm only considered the community belonging issues of the current changing nodes, it ignored the phenomenon that the community belonging value of their neighbor nodes will change correspondingly due to the changing nodes. Thus, the algorithm proposed in this paper computed the community belonging value of variable nodes and their neighbor nodes. Meanwhile, it also considered the topological change in the two-hop range caused by the changing nodes. The algorithm synthesizes the direct influence and indirect influence of the nodes to the community and synthesizes the historical data and the new variable data to determine the community division scheme of dynamic network.

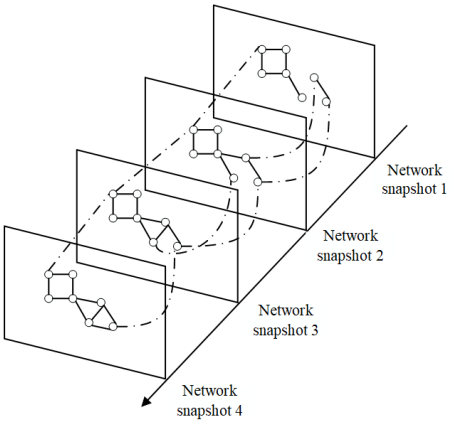

FIGURE 1. Network community smoothing change

.

II. RELATED WORK

The hidden evolution information of the dynamic community is more and more concerned. Some researcher analyzed the interaction between entities in different domains.

There are some researchers divided community structure by statistical characteristics. Nitzan revealed physical interaction networks from statistics of collective dynamics [11], Nguyen utilized statistical graphical model to resolve inverse statistical problems [12], Ma proposed the structural reconstruction though binary time series in complex network [13]. Falkowski et al. [14] proposed a new evaluation system that includes the static, density, and adhesion of the community.

In the application of dynamic network community detection, some scholars have studied the regular characteristics of dynamic network changes and analyzed the formation principles of dynamic community structure. Palla et al. [15] studied the dynamic evolution of the cooperative network of scientists and found that if there are large-scale changes in members of the community, the life cycle of these changed communities is longer. At the same time, some scholars have used the citation network as a research object and found that the large community structure in the network will shrink with time. Kumar et al. [16] analyzed two online social networks, Flickr and Yahoo, and found that the diameter of large communities in this type of network decreases with time. These algorithms considered the data of the whole network at each moment. However, the changes of users at different times are not large, which consumes a lot of computing resources.

At present, many researchers have proposed dynamic community detection based on the increment features. This type of algorithm is still subject to the smoothness feature. Based on this feature, when calculating the difference of the dynamic network community, retaining the community structure at the last moment only calculates the structure of the network change at this moment. Therefore, such an algorithm will save unnecessary time. The cost increases the efficiency of the algorithm. The current incremental dynamic community discovery is mainly divided into two categories, namely, incremental based on physics and incremental analysis based on network graph features. The incremental identification method based on physics is to treat the network as a four-dimensional space. Based on the law of universal gravitation, two forces of attraction and repulsive force between two objects [17]. Corresponding to the network, the relationship between two nodes can also be expressed by attractiveness and repulsive force. Through iterative incremental calculation, the attraction between nodes in the same community is increasing, and the repulsive force between communities Increasingly large, the nodes in the network are naturally formed into a community form.

The incremental identification method divided static network community based on network graph feature [17][18] in the initial network, and then analyze and calculate the

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newly added network information according to the changed network after time change. This small portion of the changed network structure avoids recalculation of content in the initial network. Since the algorithm is based on the static community discovery algorithm, its incremental strategy can be based on graph segmentation features, spectral features and matrix decomposition algorithms. IC algorithm [19] used the historical information of the social network and the current network topology information to analyze the current network community structure. The algorithm uses parameters to control whether the incrementally related nodes are divided into communities. However, the algorithm does not consider the phenomenon that the number of communities may change correspondingly with the dynamic changes of the community in the calculation process. Based on the MetaFac algorithm [20], some scholars optimize it by the idea of tensor decomposition [20], analyze the change relationship of network snapshots in different time slices according to network dynamics, and establish the update rule of tensor attenuation through historical network data, which is limited. The largest scale of tensor analyzes the dynamic network community structure. Some algorithms apply the static spectral clustering community partitioning algorithm to the dynamic community discovery algorithm by calculating the influence of varying nodes and edges on the network feature vector and introducing a transformed Laplacian matrix. This algorithm can reduce re-aggregation. The number of classes to improve computational performance. Xie et al. [21] based on the LabelRank algorithm of label propagation, updated the label of the changing nodes in the dynamic network. Due to the randomness of label propagation, the network community structure in the adjacent time period changes greatly. The iLCD algorithm [22] used the set of varying edges in a dynamic network to calculate the impact of the added edge on the formed community and determine whether the edge joins the community. However, the algorithm ignored the disappearance of edges and nodes in the calculation process, so it cannot be used as a method for dynamic community evolution tracking. Dinh et al. [23] analyzed the nodes' own characteristics and divided the nodes into two types of roles: leader and follower. It calculated the approximation between the nodes to define the incremental rules of the algorithm. In the DEMON algorithm [24], the network divides the network structure by merging the local communities in which each node is formed. In this algorithm, all nodes need only be traversed once, and it is not necessary to traverse all nodes in the network multiple times with time. And the changed nodes can be processed at any time, but the algorithm is sensitive to the parameters adopted in the community merging process, and it is easy to form overlapping communities with high repetition.

III. BACKGROUND AND DEFINITIONS

In dynamic networks, it is often used $G^t(V^t, E^t)$ to represent the structure of the network diagram at the t moment, which V^t represents the nodes in the network at the t moment, E^t represents the edge of the network at the t moment. We can represent the dynamic network as $G^d = \{G_0, \Delta G_1, ..., \Delta G_t, ...\}$, where $G_0 = (V_0, E_0)$ represents the initial state of the network, V_0 is the collection of nodes in the network at the initial time, E_0 represents the set of edges in the network at the initial moment. $\Delta G_t = (\Delta V_t, \Delta E_t)$ is a differential network to show the changes at the adjacent time $t-1$ and t, which ΔV_t represents the collection of changing nodes in the network during $[t-1, t]$. ΔE_t represents the collection of changing nodes in the network during $[t-1, t]$. The research of the dynamic network community detection is mainly expressed as discovered the community structure P_t at t moment based on the known community structure P_{t-1} and the network snapshot G_t at t moment, where $P_t = \{C_{t,1}, C_{t,2}, ..., C_{t,k}\}$. The $C_{t,1}$ means the first community in the network and k means the number of communities in the network at t moment.

The incremental community detection algorithm mainly considered the influence of changing nodes and edges to the whole communities in the interval time. It divided the changing node into the community generated or isolated nodes. Nguyen et Al. [23] divide the changes in the two adjacent network snapshots into four operations:

1) Add node: we note $v^+ \in (V_t / V_{t-1})$ that the node does not exist at the $t-1$ moment, but it appears at the present moment t. The collection of the changing nodes defined as V^+.
2) Delete node: we note $v^- \in (V_{t-1} / V_t)$ that the node exists at the $t-1$ moment, but it disappears at the present moment t. The collection of the changing nodes defined as V^-.
3) Add edge: we note $e^+ = (v_u, v_v) \in (E_t / E_{t-1})$ that the edge does not exist at the $t-1$ moment, but it appears at the present moment t. The collection of the changing edges defined as E^+.
4) Delete edge: we note $e^- = (v_u, v_v) \in (E_{t-1} / E_t)$ that the edge exists at the $t-1$ moment, but it disappears at the present moment t. The collection of the changing edges defined as E^-.

The above four operations generalized all the changes in the dynamic network, so that the network increment ΔG_t can be obtained by integrating these operations. It is expressed as $\Delta G_t = \{V^+ \cup V^- \cup E^+ \cup E^-\}$.

The algorithm proposed in this paper is based on the network incremental basis analysis. In this paper, it considered the associated information between nodes to calculate the relationship between the changing node and relation communities. We defined some expressing formulas:

The set of direct neighbor nodes of node v_i is defined as:

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$$N_d(v_i)=\{v_j \mid v_j \in V, e_{ij} \in E\}$$

The set of indirect neighbor nodes of node v_i is defined as:

$$N_{ind}(v_i)=\{N_d(v_j) \mid v_j \in V, e_{ij} \in E\}$$

The set of direct neighbor nodes of node v_i in the community c is defined as:

$$comN_d(v_i,c)=\{v_j \mid v_j \in c, e_{ij} \in E\}$$

The set of indirect neighbor nodes of node v_i in the community c is defined as:

$$comN_{ind}(v_i,c)=\{N_d(v_j) \mid v_j, v_k \in c, e_{ij}, e_{jk} \in E(c)\}$$

The set of edges connecting the indirect neighbor nodes of node v_i is defined as:

$$comE_{ind}(v_i)=\{e_{jk} \mid v_j, v_k \in N_{ind}(v_i)\}$$

The set of edges connecting the indirect neighbor nodes of node v_i in the community c is defined as:

$$comE_{ind}(v_i,c)=\{e_{jk} \mid v_j, v_k \in comN_{ind}(v_i,c)\}$$

IV. INCREMENTAL ALGORITHM WITH COHERENT NEIGHBORHOOD PROPINQUITY

Aiming at the characteristics of real-time change of nodes and edges in dynamic networks, we proposed an Incremental algorithm with Coherent Neighborhood Propinquity (ICNP) to detect the community structure quickly and accurately. Based on the foregoing premise, this paper considered the changing nodes and edges in the current network as compared with the previous time-slice network, considered the impact of the changes on their adjacent nodes and their communities. The community structure of the current network is based on historical information and changing information in the network.

A. NODE WEIGHT SETTING

In the incremental algorithm, the change of community structure depends on the influence of the changing node. Hence, the influence of the node and the affiliation of membership to the community are emphases in this paper. The traditional incremental algorithms only considered the degree of the node and the compactness of the adjacent nodes. This paper calculated the affiliation of the nodes to the community by combining the adjacent nodes and the relations between indirect adjacent nodes.

The direct affiliation weight of node v in community c is defined as:

$$w_d(v,c)=\frac{|com.N_d(v)|}{|N_d(v)|} \quad (1)$$

Where, $|com.N_d(v)|$ means the number of direct neighbors representing the node v in the community c. $|N_d(v)|$ indicates the number of adjacent nodes of the node.

The indirect affiliation weight of node v in community c is defined as:

$$w_{ind}(v,c)=\frac{|com.N_{ind}(v)|}{|N_{ind}(v)|} \quad (2)$$

Where, $|com.N_{ind}(v)|$ means the number of indirect neighbors of node v in the community c. $|N_{ind}(v)|$ indicates the number of indirect neighbors of the node v.

In addition, we also considered the closeness of the indirect neighbor nodes in the community c. If the indirect nodes are closely connected in the community c, the node v has a strength social cohesion with the community c, the affiliation to the community c should be higher. If the indirect nodes in the community c are isolated and not connected to each other, the social cohesion of community membership is lower than that of the former situation.

The cohesion of the indirect neighbors of node v in the community c is as follows:

$$d(v,c)=\frac{|com.E_{ind}(v)|}{|com.N_{ind}(v)|*(|com.N_{ind}(v)|-1)/2} \quad (3)$$

Where, $|com.E_{ind}(v)|$ means the number of edges connect the indirect neighbor nodes in the community c. The denominator in the formula indicates the number of edges that may exist between the nodes v in the community c between the indirect neighbor nodes.

Hence, the weight of the node v in the community c is:

$$w(v,c)=\frac{w_d(v,c)+w_{ind}(v,c)*(1+\exp(-1/d(v,c)))}{2} \quad (4)$$

If the indirect neighbor nodes of node v are not connected to each other in the community c, we will not calculate the cohesion of the indirect neighbor nodes.

In the Figure 2, the simple network should be divided into two communities: Community A and Community B. We list the node relationship analysis and the affiliation weight in Table I and Table II respectively.

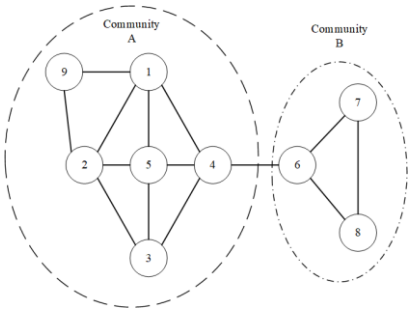

FIGURE 2. A simple network

TABLE I
NODE RELATIONSHIP ANALYSIS

Node	$N_d(v_i)$	$N_d(c_A)$	$N_{ind}(v_i)$	$N_{ind}(c_A)$	$N_{ind-e}(c_A)$
1	4	4	2	1	0
2	4	4	1	1	0
3	3	3	3	2	1
4	4	3	4	2	1
5	4	4	2	1	0
9	2	2	3	3	3

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TABLE II
THE AFFILIATION WEIGHT IN COMMUNITY A

node	1	2	3	4	5	9
$w(v,c)$	0.75	1	1.06	0.717	0.75	1.18

We can find the affiliation weight of node 9 in community A has the highest value. It is a result due to the fact that the direct nodes (node 1 and node 2), indirect nodes (node 3, 4 and 5) and the edges connect these indirect nodes (edges (3,4), (3,5) and (4,5)) all in the same community A.

We also can find the similar nodes 1, 2 and 3 have different affiliation weight in Community A. The node relationship analysis shows that node 3 has the most indirect nodes among the three nodes in community A. There is an edge between the nodes 1 and 9 as the indirect nodes of node 3. Hence, the affiliation weight of node 3 is higher than nodes 1 and 2 in community A, which is consistent with the physical explanation. Both node 1 and Node 2 have only one indirect node in community A, but node 1 has two indirect nodes located in different communities. There are some affiliation parts of node 1 belongs to community B. Hence, the $w(2,A)$ is larger than $w(1,A)$. In the community A, the node 4 is the weak spot because the direct node (node 6) belongs to the community B. Since node 4 has a direct neighbor (node 6) to an outside community, the proportion of its indirect neighbors in community B is naturally greater than others. The view of the graph shows that node 4 is a node connected between two communities, so the node 4 has a minimum affiliation weight for community A.

B. INCREMENTAL COMPUTATION

When a node in a dynamic network changes, the direct neighbor nodes will be influenced. If the node is an important node, the indirect neighbors will be affected, even the entire structure of the community will make a different. We proposed an ICNP (Incremental Computation with Coherent Neighborhood Propinquity) algorithm to update the affiliation of the communities in which the relevant neighborhood nodes are located and to determine whether there is a change in the community. It will analysis all the nodes within the bounds of two-hops range. The algorithm will recurse the analysis process until the community ownership of all nodes reaches a steady state. We defined the conditional formula as follow:

$$\frac{w^t(v,c_j)-w^{t-1}(v,c_i)}{w^{t-1}(v,c_i)}>\varepsilon \qquad (5)$$

Where $w^t(v,c_j)$ means the community affiliation weigh of node v in community c_j at the t moment. $w^{t-1}(v,c_i)$ means the community affiliation weigh of node v in community c_i at the $t-1$ moment. ε is the threshold to measure the role of nodes in the new community as the network changes at the t and $t-1$ moment. The larger the ε, the harder it is for the network to change, and the smaller the ε value, the more easily the network structure changes with the dynamic network.

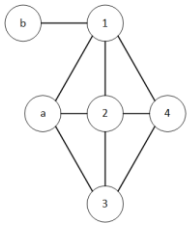

FIGURE 3. Adding edge in the same community

We analysis the four different dynamic operations as shown below:

(1) Add edges without increasing the total number of nodes

When the network adds an edge between two nodes at the t moment, we divide the situation into two types: situation $X1$: the two nodes belong to the same community at the $t-1$ moment, and situation $X2$: the two nodes belong to different communities the $t-1$ moment.

1) situation $X1$

As shown in Figure 3, the nodes a and b were in the same community. If there add an edge between node a and b, it not only will improve the community cohesion and the relationship between the two nodes, but also enhance the weight of node 4 to the community because the node a and b are both the indirect neighbor of node 4. Hence, the community structure will not change in the situation $X1$, we need record the following incremental changes:

i) Update the degree of the nodes a and b.

ii) Update the indirect neighbor number.

iii) Update the value of $com.E_{ind}(v)$

2) situation $X2$

As shown in Figure 4., the nodes a and b belong to different communities. If there add an edge between node a and b, it will reduce the affiliation weight of nodes a and b to their respective communities, and reduce the internal cohesion of the two communities. Therefore, in the case of adding edges, the affiliation weight of the two nodes with new edges to the connected community will be calculated according to the formula (5). The detailed steps are as follows:

1) Update the degree of the nodes a and b.

2) Update the indirect and direct neighbor number.

3) Update the $com.E_{ind}(v)$ values connected to the indirect nodes of the nodes a and b.

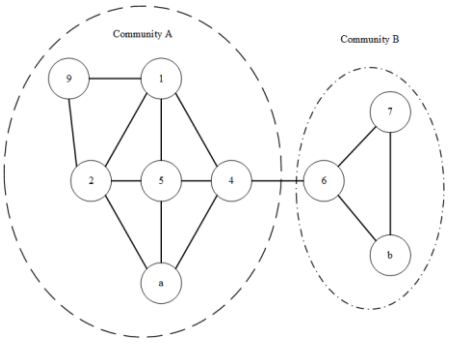

FIGURE 4. Adding edges in different communities

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4) If $\frac{w^t(a,c_b)-w^{t-1}(a,c_a)}{w^{t-1}(a,c_a)}<\varepsilon$, it means the node a is not satisfied the change community conditions, then node a is still in the pervious community. We consider the node b:

i) If $\frac{w^t(b,c_a)-w^{t-1}(b,c_b)}{w^{t-1}(b,c_b)}<\varepsilon$, node b is still in the previous community.

ii) If $\frac{w^t(b,c_a)-w^{t-1}(b,c_b)}{w^{t-1}(b,c_b)}<\varepsilon$, node b will be divided into the community A. then we consider the direct and indirect neighbor nodes of node b.

If node $v\in N_d(b)$ is already in community A, status quo.

If node $v\in N_d(b)$ is not in community A, we use the conditional formula to determine the community affiliation.

5) If $\frac{w^t(a,c_b)-w^{t-1}(a,c_a)}{w^{t-1}(a,c_a)}>\varepsilon$, we divide node a into community B.

(2) Cut edges without decreasing the total number of nodes

When the network cuts an edge between two nodes at the t moment, we divide the situation into two types: situation $X3$: the two nodes belong to different communities the $t-1$ moment, and situation $X4$: the two nodes belong to the same community at the $t-1$ moment.

1) situation $X3$

As shown in Figure 5., the nodes a and b were in the different communities. If there cut an edge between node a and b, it not only will improve the community cohesion and the relationship between the two nodes, but also enhance the affiliation weight of each community members. Hence, the community structure will not change in the situation $X3$, we need record the following incremental changes:

i) Update the degree of the nodes a and b.

ii) Update the indirect neighbor number.

iii) Update the $com.E_{ind}(v)$ value between indirect neighbors.

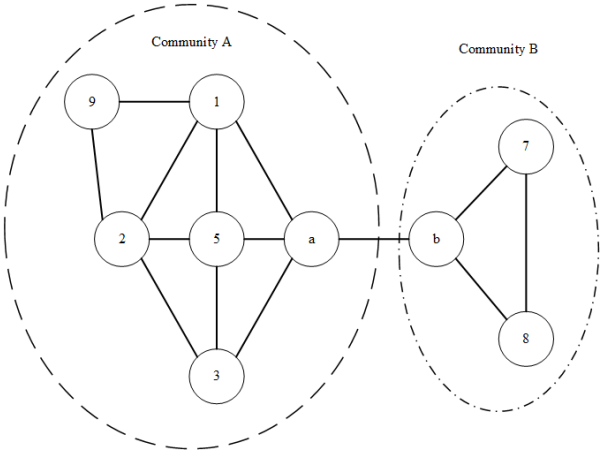

FIGURE 5. Deleting the edges crossing different communities

2) situation $X4$

As shown in Figure 5., the nodes a and b are in the same community, but for different nodes in the same community, it can be divided into two situations: Figure 6a) and Figure 6b).

(1) In Figure 6a), after the edge between the node a and the node b is deleted, the node b forms an acnode. The node b will be separated from the community A to become an independent community. The concrete steps are as follows:

1) Update the degree of the nodes a and b.

2) Update the indirect neighbor number.

3) Update the $com.E_{ind}(v)$ value between indirect neighbors.

(2) In Figure 6b), if the edges between the nodes a and nodes b are deleted, although the nodes do not form an acnode. However, the cohesion within the community will decrease. We will divide node a and nodes b into the suitable community by formula (5). If there is no node x can make $\frac{w^t(a,c_x)-w^{t-1}(a,c_a)}{w^{t-1}(a,c_a)}>\varepsilon$, the node still belongs to the original community. Otherwise, the membership between node a and the community where its direct and indirect neighbors are located will be calculated. If community x exists so that the condition $\frac{w^t(a,c_x)-w^{t-1}(a,c_a)}{w^{t-1}(a,c_a)}>\varepsilon$ is met, node a will be divided into community x and the data set of the direct and indirect neighbors will be updated. The corresponding node b also needs the above steps to be calculated in order to determine its community.

(3) Add nodes

In the case of adding and deleting nodes, the change of the acnode is the most obvious and simple situation. Because acnode does not have a structural impact on community membership whether exit or add. Hence, we simply modify the graph structure without too much calculation with acnode.

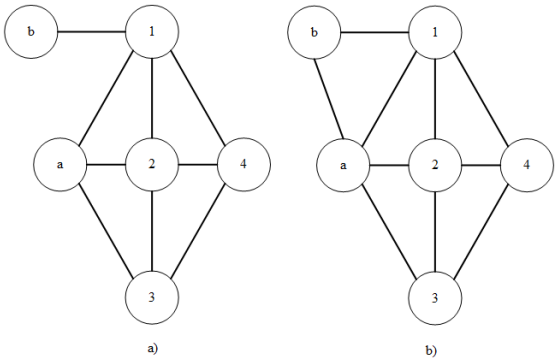

FIGURE 6. a) Cutting the edges caused acnode network b) Cutting the edges not caused acnode network

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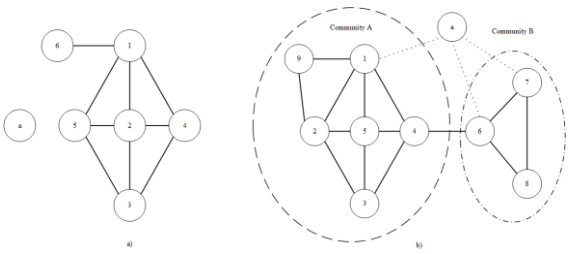

FIGURE 7. a) Adding an acnode in the network b) Adding a node in the network

If the network adds node a at the t moment, we divide the situation into two types situation $X5$: the node a is an acnode, and situation $X6$: the node a is not an acnode.

1) situation $X5$:

If the added node is an acnode, like node a in Figure7a), it has no influence for the whole network structure, we just need add a community contains node a .

i) update the total number of nodes in the network

ii) update the total number of communities in the network

2) situation $X6$:

As shown in figure Figure7b), the node a maybe connects with multiple nodes in different communities. We will divide the node a into the community with maximum afflicted weight value. The concrete steps are as follows:

i) update the number of nodes in the network,

ii) the degree of the direct neighbor node of the node a

iii) update the number of direct and indirect nodes

iv) the value of $com.E_{ind}(v)$ between the node a and the indirect nodes

(3) Delete nodes

If the network deletes node a at the t moment, we divide the situation into two types situation $X7$: the node a is an acnode, and situation $X8$: the node a is not an acnode.

1) situation $X7$:

If the deleted node is an acnode, like node a in Figure7a).

The node a is not connected to any node in the network, so deleting the node a at time t will not affect the community structure in the network. We will delete the node a in the network. The specific operation is as follows:

i) update the total number of nodes in the network

ii) update the total number of communities in the network

2) situation $X8$:

As shown in figure Figure7b), the node a maybe connects with multiple nodes in different communities and multiple edges in different communities may be deleted at the same time. Therefore, we will calculate the affiliation weight of the direct and indirect neighbors of the node a at the $t-1$ moment, and determine whether it meets the conditions for replacing the community by formula (5). The concrete steps are as follows:

i) update the number of nodes in the network,

ii) the degree of the direct neighbor node of the node a

iii) update the number of direct and indirect nodes

iv) the value of $com.E_{ind}(v)$ between the node a and the indirect nodes

C. THRESHOLD ANALYSIS

We analysis the change in dynamic network community structures with different thresholds based on Enron Email Dataset provided on the CMU Computer Institute website [25]. The dataset is one of the most widely used public data sets in current social network research. It is a real dynamic network that forms the network structure, where 150 nodes represent the company's 150 executives, and the existing side of the network indicates that there is mail traffic between the two contacts. The dataset contains the Email data from 1 April 2000 to 1 April 2002. The network contains 8 snapshots with 3 months period.

The threshold ε has important influence on the performance of the changing nodes belonging. We determined the selection of threshold ε by observing the influence of the threshold ε on the modularity Q of network community and the stability S of the network structure. We use the common measures such as modularity Q to test the effects of this algorithm.

$$Q = \sum_{i} (e_{ii} - a_i^2) \tag{6}$$

where e_{ii} is the fraction of edges in community i , and a_i is the fraction of edges that link to vertices in community i . Higher values of Q ($Q \in [-1,1]$)represent a more significant community structure.

Another commonly used measure is stability S , which has become a de facto standard for the dynamic networks.

$$S = 1 - \frac{\sum_{t=2}^{T}\sum_{i=1}^{K} \triangle C_{t,i}}{(T-1)n} \tag{7}$$

where $\sum_{t=2}^{T}\sum_{i=1}^{K} \triangle C_{t,i}$ is the average number of nodes which change the community over time.

Because the dynamic network structure has the characteristics of short and smooth, and the larger the threshold value is obtained, the less easily the network structure is changed, the smaller the network structure changes with the variables in the network. Therefore, the range of ε values selected in the analysis test in this section is [0.02,0.2] and the value interval is 0.02. We observed the quality of community dividing with the threshold selection changes. Figure 8. shows the curve of the average modularity of a network with a threshold change. Figure 8 shows that with the threshold value increases, the modularity of the network community decreases, which means that the higher the threshold, the less effective the community divided. The smaller the corresponding change threshold of network nodes, the more frequent the network changes, the more consistent with the current network structure. When the value is between 0.1 and 0.14, the module value of the network drops sharply. Because the threshold need not only module degree

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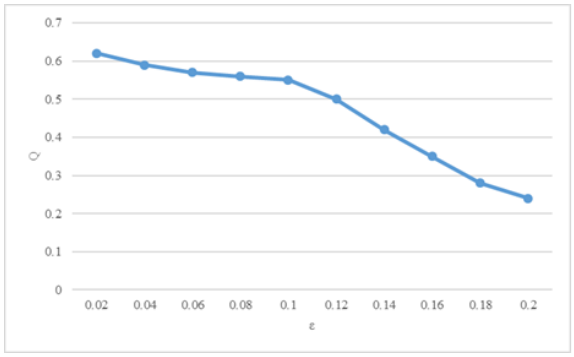

FIGURE 8. Network modularity with different thresholds

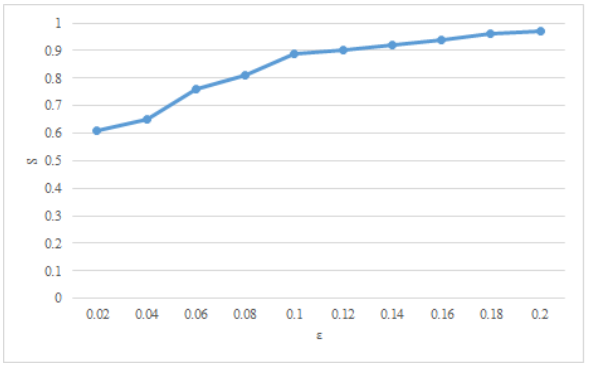

FIGURE 9. Network stability with different thresholds

analysis, but also the auxiliary analysis of network stability. Figure 9 shows how the stability of the network changes with the threshold. As the threshold increases, the more stable the community structure of the network can be found in Figure 9. This phenomenon accords with the definition of the community attribution condition of node change in the network. The stability of the network increases steeply during the threshold value of 0.8 to 0.12, and the stability after it is in a state of calm.

Hence, we integrated the network modularity and network stability, we set the threshold ε as 0.1 to divide the network satisfies the characteristics of the current time-slice community and has certain network stability.

V. EXPERIMENT

In this section, some experimental results are presented to test the performance of the ICNP algorithm. The experiments were focused on comparing the algorithms according to:(1) the quality of the unknown clustering with Q, (2) the quality of the known clustering with NMI, (3) the running time each algorithm spends for processing multiple additions/deletions.

A. REAL NETWORKS

In the Enron mail data set, we compared the performance of the FrameWork algorithm, FaceNet algorithm, IC algorithm and ICNP algorithm separately. The FrameWork Algorithm and Facet Algorithm are representative algorithms found by dynamic community, IC Algorithm is the representative algorithm in Incremental Algorithm. The FrameWork algorithm is an optimization-based approach for modeling dynamic community structure. It proved that finding the most explanatory community structure is NP-hard and APX-hard, and proposed algorithms based on dynamic programming, exhaustive search, maximum matching, and greedy heuristics. FaceNet algorithm aimed at the problem of overlapping communities in dynamic network and proposed a soft community relationship with FrameWork for analyzing communities and evolution in dynamic network model. The algorithm used K-L distance to calculate the cost function of snapshot consumption and temporal consumption as the objective function, to analyze the community structure and current network as well as the previous time. Based on the similarity degree of network snapshot, the model can find the hidden non overlapping community and overlapping community structure in different time slices and can also show the community evolution in the network. The performance of the three representative algorithms and ICNP algorithms will be compared. Figure 10 showed the network modularity of the results of these four algorithms. It can be seen from the Figure 10, the module value of the FrameWork Algorithm is always at the minimum, and the modularity of the Algorithm is very large, the minimum is 0.18 and the maximum is close to 0.5. The community structure of the ICNP Algorithm is almost always dominant in the aspect of community effect comparison with FaceNet and IC Algorithm and maintains a stable and efficient state.

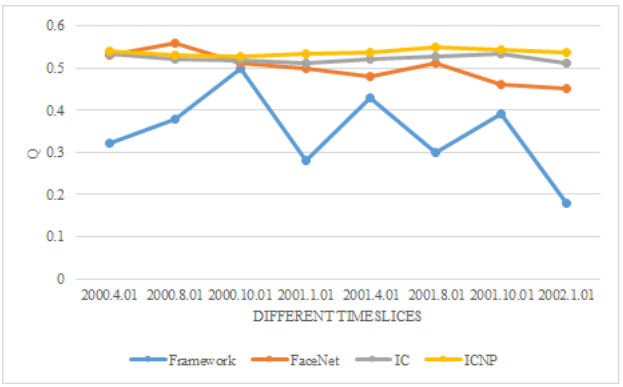

FIGURE 10. Performance of different algorithms in different time slices

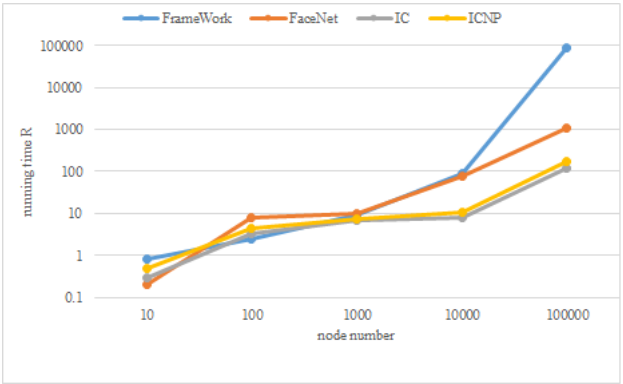

FIGURE 11. Running time in networks of different sizes

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The incremental algorithm can effectively save time in dealing with large-scale networks, the experiment selected the network size of the Enron Mail Network Snapshot, which contained 16, 112, 927, 10223, 91469, respectively, can represent five orders of magnitude 10^1,10^2,10^3,10^4,10^5. The operating time of these algorithms for different social networks of different sizes is shown in Figure 11.

Figure 11 shows that the running time of these four algorithms are similar and can be completed in almost 10s while the network nodes are not more than 10^3. The Algorithm FaceNet needs to run for a relatively long time. The Figure 11 showed that community divided by IC and ICNP algorithms using incremental ideas require much less time than the other two algorithms, especially for large network. This is due to that incremental algorithms only need to consider the changes community affiliation weight of the nodes in the community. ICNP Algorithm proposed in this paper not only considered the node in the increment, but also considered the direct and indirect neighbors of the variable nodes. Hence, the phenomenon of running slightly higher than IC Algorithm, however the computation quantity is larger than IC Algorithm.

In view of the above, compared with the FrameWork, FaceNet and IC Algorithm, ICNP algorithm can be used in the dynamic large data network with shorter running time, and divide the network community structure closer to the real situation.

We also analyzed the performance of ICNP with communication dynamic network which is a dynamic network of autonomous system communication in the Internet. The autonomous system is composed of a group of routers and networks under the control of a regulatory agency. The network shared information of each autonomous system through the Border Gateway Protocol (BGP, Border Gateway Protocol). The BGP log recorded the changes in the dynamic communication network between the autonomous system which recorded the network communication diagram of the autonomous system from 8 November 1997 to 2 January 2000. Each communication diagram represents only the state of communication at that time. We can get the changed nodes and edges by comparing the communication diagrams of adjacent times.

In this section, we experiment in 10 consecutive time communication graphs are selected as the simulation data set. The total number of nodes per graph is about 6,000 and the total number of edges is about 12,000. We found that the changing number of adjacent edges is between 200 and 400. We used FaceNet algorithm, IC Algorithm, ILP Algorithm and ICNP algorithm proposed in this paper. Incremental label propagation (ILP) is another extension of IC. This algorithm applies the label propagation algorithm in the field of real-time community detection. It monitors the changes in nodes and edges in the network to locally iterate the label propagation algorithm to save the running time. According to

TABLE III
THE MODULARITY OF EACH ALGORITHM AT EACH TIME OF THE NETWORK

Dataset	FaceNet	IC	ILP	ICNP
Network 1	0.387	0.432	0.396	0.493
Network 2	0.395	0.392	0.398	0.402
Network 3	0.41	0.42	0.401	0.521
Network 4	0.402	0.531	0.402	0.548
Network 5	0.409	0.476	0.4	0.523
Network 6	0.396	0.425	0.399	0.529
Network 7	0.42	0.496	0.41	0.546
Network 8	0.391	0.484	0.412	0.519
Network 9	0.375	0.473	0.382	0.527
Average Q	0.398	0.458	0.4	0.512

TABLE IV
RUNNING TIME OF EACH ALGORITHM AT EACH TIME OF THE NETWORK

Dataset	FaceNet	IC	ILP	ICNP
Network 1	10.37s	5.47s	5.53s	5.51s
Network 2	9.64s	4.39s	4.27s	4.69s
Network 3	11.58s	3.95s	3.82s	4.01s
Network 4	12.39s	3.64s	3.49s	3.53s
Network 5	9.82s	3.71s	3.13s	3.64s
Network 6	10.65s	4.08s	4.26s	3.98s
Network 7	9.73s	3.02s	2.98s	3.13s
Network 8	10.84s	6.21s	7.26s	6.86s
Network 9	9.26s	6.49s	6.97s	6.74s
$\overline{R}$	10.48s	4.55s	4.63s	4.68s

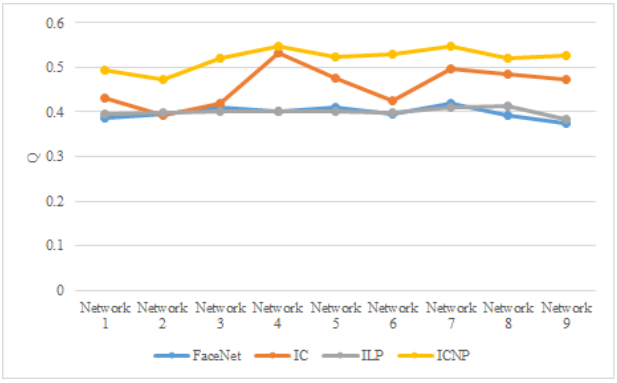

FIGURE 12. Performance of different algorithms in different networks

the previous experiment, we can find that the FrameWork algorithm is not effective in dynamic community recognition, so, this comparison experiment cancels the operation of the FrameWork Algorithm and uses the incremental label to propagate the ILP Algorithm. Table III showed the community modularity of each communication network by different algorithms.

Comparing TABLE III and TABLE IV, it can be found that ICNP algorithm has a great advantage over other algorithms in community partitioning. Its modularity is 28% higher than that of FaceNet, and its running time is much lower than that of FaceNet. It showed that the incremental algorithm has a great advantage in the complexity of time. The ILP algorithm has approximate linear time complexity. It is a kind of optimization algorithm which applies the increment thought to the label propagation algorithm. Hence the ILP algorithm has a low running time with high randomness to lead the instability of modularity. We can find the running time of ILP Algorithm is less than ICNP algorithm because of its low increment factor, but the

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community detection result module of ICNP Algorithm has obvious advantages.

It can be seen from Figure12 that the modularity of the algorithm ICP and IC are similar, which indicates that both algorithms are based on the concept of increment analysis with the basically same sensitivity to the change of community structure. However, the module degree of IC algorithm has a large fluctuation, which is since the algorithm only considers the variables of the current change and does not analyze the local environment. It also shows that the stability of the threshold value of ICNP algorithm is better than that of IC Algorithm. The randomness of the ILP Algorithm reduces the performance of community detection, which shows that the algorithm proposed in this paper has higher community partition performance than the other three classical dynamic community detection algorithms.

B. ARTIFICIAL DYNAMIC NETWORK

In this section, we analyzed the ICNP performance by comparing different algorithms with artificial dynamic networks. We constructed two different artificial dynamic networks called LFR and three dynamic networks proposed in Ref [26]. Both artificial networks are standard data sets for community detection algorithms, and the experiments with these two data sets can prove the effects of dynamic network communities in different scale of nodes.

1) The artificial data experiment network LFR consists of 128 nodes, divided into 4 communities and each community consists of 32 nodes. The number of nodes connected to a node outside the community in a parameter z regulated network is set to randomly select five nodes from each community to be added to other communities in the network of each adjacent time slice, at the same time, the structure of the edges is changed to meet the definition of community division. The fuzzy parameter z of the dynamic network is valued at 3 and 5 respectively, and the network is transformed 9 times as required to form a set of 10 time slices.

Figure 13 shows that all four algorithms can achieve higher NMI values, but the accuracy of the three incremental algorithms is close to 1, which due to the relatively clear network structure. At the same time, it can be found that the NMI value of ICNP Algorithm has always been in the leading position, which shows that the algorithm is better than other algorithms. The change of fuzzy parameter z shows that the adaptability of Facet Algorithm is low, and the accuracy NMI varies greatly in two different models. The iLCD Algorithm needs to initialize small communities made up of variable nodes. With the increase of z, the complexity of the intercommunity node relationship caused the number of small communities grows. The accuracy NMI of the iLCD algorithm is significantly lower when z takes value 5 than z takes 3.

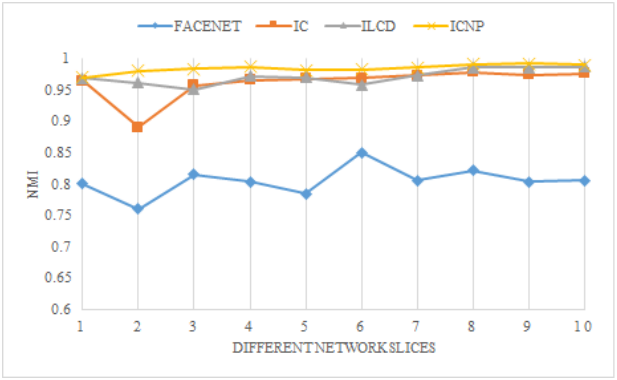

FIGURE 13. NMI value of the network in every time when z=3

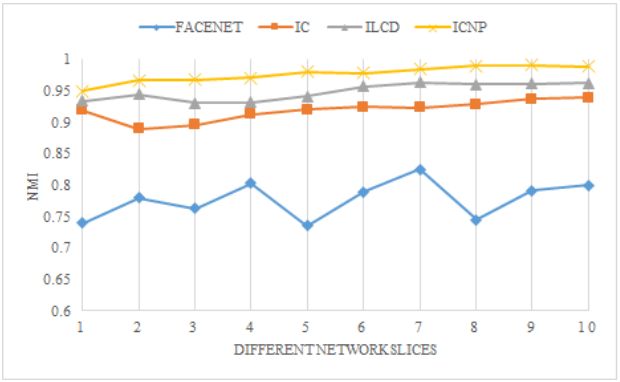

FIGURE 14. NMI value of the network in every time when z=5

TABLE V
ARTIFICIAL NETWORK PARAMETER

	N	K_{avg}	K_{max}	C_{min}	C_{max}	τ_1	τ_2	μ	O_n	O_m	S	E$_n$
Dataset 1	10000	50	120	60	100	2	1	0.2	200	3	1	6
Dataset 2	10000	60	150	60	120	2	1	0.2	2000	3	1	8
Dataset 3	10000	70	180	60	150	2	1	0.2	2000	3	1	10

The IC Algorithm dose not considered the influence of local boundary when it calculates the changing edges. Hence, the accuracy NMI of the algorithm is reduced with the fuzzy parameter z increase. For these two dynamic networks with different fuzzy parameter z, the community accuracy NMI of ICNP algorithm is always high. Hence, ICNP algorithm can recognize network structure in more complex network.

2) In addition, we compare the performance of each algorithm in large-scale dynamic networks proposed in Ref [30]. The Table V showed the dynamic artificial network with each parameter. N denotes the total number of nodes in the network, K_{avg} indicates the average of network nodes, $K_{\max}$ indicates the maximum degree of nodes in the network, $C_{\min}$ and $C_{\max}$ denote the minimum and maximum number of nodes in the community, respectively, the Power Law Distribution Coefficient of node degree and the Power Law Distribution Coefficient of community scale are

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respectively used τ_1 and τ_2 expressed. The number of overlapped nodes in the network is O_n, and the number of communities belonging to the repeating nodes is O_m. If the number of O_m is larger, it means that the more complex the internetwork node connection is, the harder it is to detect the community structure. The time slices of these dynamic networks are 11, and the number of changes in the community at each moment is E_n.

Since the artificial data set has known community structures, we used the NMI value to classify the community detection performance. However, due to the large amount of data in the artificial data sets 2 and 3, the Facet Algorithm is not valid and cannot be run to get the result. This section adds the contrast iLCD Algorithm for incremental classes. Figure15 shows the NMI values of the communities obtained by each algorithm for each data sets at each time. In the artificial data set 1, we can find that the community effect of FaceNet Algorithm is like that of the ICNP Algorithm proposed, however the Facet Algorithm needs to be entered in the community number in advance. The ICNP Algorithm does not need to know the number of communities in the network in advance. iLCD Algorithm makes the small structure community more, and the number of communities is higher than other algorithms, which influences the NMI value. The iLCD didn't work properly in the artificial dataset 3. In the real network, because the number of network communities is unknown, the proposed algorithm can not only meet the characteristics of real network community but also divide the network structure efficiently.

Through the real network experiment, it is found that the variation of running time of the same algorithm in the continuous time-slice is smaller, expect FaceNet algorithm. Hence, we use the average time as a measure to compare the running time in artificial networks. The time allocated by the initial network community is not counted to avoid the influence of different algorithms at the initial time. We mainly to analyze the running time of network change phase after the network initial structure. Figure 16 shows that the Facet Algorithm takes the highest time which is consistent with the simulation results in real networks. Since the FaceNet Algorithm did not run in Dataset 2 and Dataset 3, the Algorithm iLCD failed to realize the result in data set 3, so the corresponding comparison time is not shown in the Figure 16. The iLCD algorithm needs to match the changing nodes with the initial community. So, it increases the running time with more computation in the matching process. Through the experiment comparison in artificial networks, we can find the remarkable efficiency advantage of incremental algorithm, and the ICNP algorithm achieved better performance in dynamic network community detection.

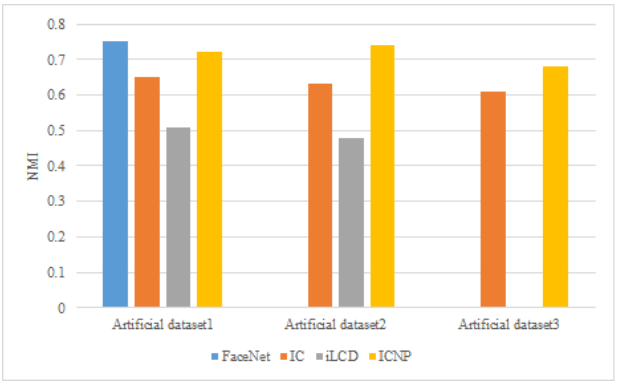

FIGURE 15. NMI value of artificial network

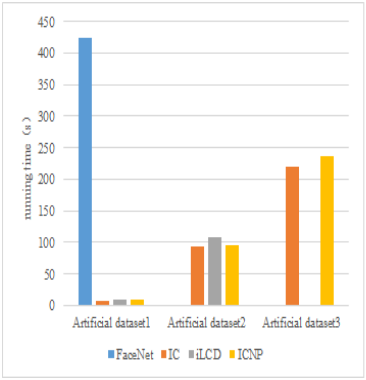

FIGURE 16. Running time of each algorithm in artificial network

VI. CONCLUSION AND FUTURE WORK

The community structure detection in dynamic network can reflect the evolution of network in real time. Due to the short smoothness of dynamic network, the network structure will not change too much in a short time. Hence, we proposed a new incremental dynamic network community detection algorithm. The algorithm utilized the historical data and the real-time variables to analyze the structure of the network at present. It can save the calculate and running time costing in the network global mining community structure each time. The incremental algorithm proposed in this paper analyzed the situation of adding edges, cutting edges, adding nodes and deleting nodes in dynamic networks. We not only considered the variables attribution, but also take into account the change of the direct neighbor and indirect neighbor of the variables. The ICNP algorithm calculated the direct and indirect nodes local affiliation weight to divide the relate nodes to suitable community in real-time.

By comparing experiments in real social networks and artificial networks, it can be found that the incremental dynamic community detection algorithm is far more efficient than the traditional non-incremental algorithm. Furthermore, the ICNP algorithm proposed in this paper improved the effect of Incremental algorithm which made the network structure much closer to the real network structure. Meanwhile, the ICNP algorithm can adapt to the network with high complexity in the artificial network experiments

and divide the network community structure smoothly and efficiently in each time slice network.

In the future, we will focus on the study of online communities' evolution and anomaly detection. Based on the study of dynamic network community detection in this paper, the abnormal points of the network can be judged through the study of changing nodes and edges. In the actual network environment, the emergence of abnormal points will have a certain impact on the network. Finding abnormal points in time and analyzing the dynamic network evolution process will help us restore the growth mode and understand network functions.

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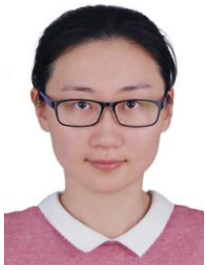

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CHARACTERISTICS AND EVOLUTION OF ELYTRAL SCULPTURE IN THE TRIBE GALERITINI (COLEOPTERA: CARABIDAE)[1]

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ABSTRACT

A reconstructed phylogeny, based primarily on structural features other than details of the elytral cuticle, provides the basis for inferring evolution of macrosculpture and microsculpture of the elytra of galeritine adults. Macrosculpture consists of a system of alternating linear depressions (interneurs) and elevations (intervals). A transformation series extends in the subtribe Galeritina from primary intervals that are broad and slightly convex (or flat) to costate to carinate, with or without development of secondary intervals. In the monobasic more plesiotypic subtribe Planetina, the elytra have developed carinate primary and secondary intervals independently of these features in the more highly evolved groups of subtribe Galeritina. Within some taxa of Galeritina, the secondary intervals (carinulae) have been reduced or lost. The microsculpture system of microlines and included sculpticells has undergone a complex series of changes in the Planetina and Galeritina. Independently, in both subtribes, the plesiotypic microlines have been lost, and sculpticells are represented by nodules, which are only parts of the original sculpticells. In the genus Eunostus *Castelnau (subtribe Galeritina), the plesiotypic microlines are evident, and sculpticells are transverse and flat, but a few exhibit small nodules. Convergence is postulated between Planetina and Galeritina with independent development of the same type of macrosculpture and microsculpture, and also within the Galeritina, with independent reduction in different lineages of the system of carinae and carinulae. The patterns of macrosculpture and microsculpture are correlated to the extent that adults with carinate intervals exhibit elongate sculpticells with transversely aligned nodules. This relationship may be the result of: 1) selective forces acting similarly on different genes to produce a functional complex; or 2) there may be a developmental constraint, such that ontogenetic development of carinae somehow channels or influences development of the derived form of microsculpture. If alternative 1 is correct, the derived, correlated forms of macrosculpture and microsculpture may be accepted as discrete character states for evaluation of phylogenetic relationships; if alternative 2 is correct, the derived pattern of macrosculpture and microsculpture must be regarded as a single character state. The biological significance of these transformation series is unknown, though the transverse form of sculpticells is generally correlated in other carabids with life in tightly packed leaf litter. The system of longitudinal carinae and sculpticells is reminiscent of a corrugated iron roof, and may be especially effective for shedding water and debris. Because this latter form of sculpture is exhibited by related species that have strikingly different*

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[1]Based on the text of an address presented to the XVII International Congress of Entomology, Hamburg, Federal Republic of Germany, August, 1984

ecological requirements, the additional inference is made that sculpture is not responding to specific environmental factors, but rather to factors that are more general.

RÉSUMÉ

Une reconstruction de la phylogênie des Galeritinês, établie principalement à partir de caractères structuraux autres que les détails de la cuticule élytrale, nous sert de base pour déduire les étapes évolutives de la macrosculpture et de la microsculpture des élytres chez les Galeritinês adultes. La macrosculpture consiste en un ensemble de sillons (interneures) alternant avec des élévations linéaires (intervalles). Dans la sous-tribu des Galeritina, il existe une série de transformations des intervalles primaires qui passent de larges et légèrement convexes (ou aplatis) à costés ou carénés, avec ou sans apparition d'intervalles secondaires. Dans la sous-tribu monogénérique des Planetina, qui constitue un groupe plus plésiotypique, les élytres ont développé des carènes primaires et des intervalles secondaires indépendamment de ceux qu'on retrouve dans les groupes plus évolués de la sous-tribu des Galeritina. Chez certains taxons des Galeritina, il y a réduction ou perte des intervalles secondaires (carènules). La microsculpture, comprenant un ensemble de microlignes et de «sculpticellules», a subi une série complexe de changements chez les Planetina et les Galeritina. Indépendamment dans les deux sous-tribus, les microlignes plésiotypiques ont disparu et les «sculpticellules» n'existent plus qu'à l'état de nodules qui correspondent à une partie des «sculpticellules» originelles. Chez le genre Eunostus *Castelnau (de la sous-tribu des Galeritina), les microlignes plésiotypiques sont évidentes et les «sculpticellules» sont transverses et aplaties, mais certaines «sculpticellules» montrent de petits nodules. Nous postulons qu'il y a eu convergence, d'une part entre les Planetina et les Galeritina lors du développement d'un type semblable de macrosculpture et de microsculpture, et d'autre part parmi les Galeritina où il y a eu réduction du système de carènes et de carènules de façon indépendante dans les différentes lignées. Les motifs de macrosculpture sont corrélés avec ceux de microsculpture dans la mesure où les adultes ayant des intervalles carénés possèdent des «sculpticellules» allongées avec des nodules alignés transversalement. Cette relation peut être le résultat soit de forces sélectives agissant similairement sur des gènes différents pour produire un ensemble fonctionnel, soit de contraintes de développement qui font que, d'une certaine façon, l'ontogénèse des carènes canalise ou influence le développement du type dérivé de microsculpture. Si la première alternative est correcte, nous pouvons accepter les types dérivés et corrélés de macrosculpture et de microsculpture comme étant des états de caractères distincts pour l'évaluation des relations phylogénétiques; par contre, si la seconde alternative est correcte, le motif dérivé de macrosculpture et de microsculpture doit être considéré comme un seul état de caractère. La signification biologique de ces séries de transformations est inconnue, bien que la présence de «sculpticellules» transverses est généralement corrélée, chez d'autres Carabiques, avec un mode de vie dans la litière compacte. Le système de carènes et de «sculpticellules» longitudinales fait penser à un toit de tôle ondulée et peut être particulièrement efficace pour se débarasser de l'eau et des débris. Étant donné que ce dernier type de sculpture se rencontre chez des espèces apparentées qui possèdent des exigences écologiques fort différentes, nous déduisons par surcroît que la sculpture n'est pas assujettie à des facteurs environmentaux spécifiques, mais plutôt à des facteurs plus globaux.*

INTRODUCTION

Most of what is known about galeritine carabids is summarized in various comparatively recent taxonomic treatments: Basilewsky (1963), Afrotropical species, Reichardt (1965 and 1967), the Asian species of *Galerita*, and the species of Galeritini in the New World, respectively; Lindroth (1969: 1091), and Ball and Nimmo (1983), species of the predominantly Nearctic subgenus *Progaleritina*.

The tribe Galeritini is pan-tropical, with northern extensions into the Nearctic (northward to southern Ontario and Québec) and eastern Palaearctic (northward to the Japanese Archipelago and southern Korea) Regions. Habitats occupied range from waterside stations and the rain forest floor in the tropics to dry open forests and savannas. Most species live at low altitudes, but in the American tropics, a number of species are known from montane forest.

Adults and larvae of all species are probably predators on other arthropods, though this has been shown for only a few species. It seems reasonable to make the extrapolation, because of general similarity in body form and details of the mouthparts among all taxa. Females of *Galerita (Progaleritina) bicolor* Drury lay their eggs in mud balls which are then attached to the undersides of leaves. This behavior is correlated with a peculiarly modified ovipositor,

which is characteristic of the more highly evolved galeritines. By extrapolation, it seems likely that all such taxa have similar habits, and that those with more plesiotypic ovipositors have more plesiotypic habits, and probably lay eggs in cavities in the soil, as do most female carabids. Adults of many of the macropterous species are found at lights, at night, showing that they are nocturnal and that they fly. Little else is known about ecological aspects of galeritines.

Although knowledge of galeritines is markedly restricted, I was able to make a reconstructed phylogeny, using previously studied features of adults, and adding analyses of structure of the mandibles and ovipositor (Ball, in press). Macrosculpture of the elytra was used to reconstruct the phylogeny of *Galerita* (*sensu lato*), but microsculpture was not studied in detail. Subsequently, I realized that elytral sculpture exhibited some interesting complexity, so I asked if patterns of sculptural variation might be correlated with the reconstructed phylogeny that I had made. Results are presented below.

MATERIAL AND METHODS

Material

The adults studied were those on hand that had been collected by me, were in the Strickland Museum of my Department, or were borrowed from other institutions for the phylogenetic study of the Galeritini. In aggregate, they represented a reasonably diverse cross-section of the tribe, but not all species. Sculpture of the elytra was examined superficially using representatives of the following taxa: *Planetes bimaculatus* MacLeay, *P. ruficollis* Nietner, *P. pendleburyi* Andrewes, and *Planetes* species?; *Eunostus herrarensis* Alluaud, *E. vuilloti* Alluaud, *Eunostus* new species; *Ancystroglossus ovalipennis* Reichardt, *A. dimidiaticornis* Chaudoir, and *Ancystroglossus* new species; *Trichognathus marginipennis* Latreille; and all seven species of *Galerita*, subgenus *Progaleritina*. From subgenus *Galerita*, I examined specimens of *G. perrieri* Fairmaire, *G. sulcipennis* Reichardt, various members of eight New World sub-groups: *americana, carbonaria, costulata, gracilis, jelskii, occidentalis, striata*, and *unicolor*; and four species of the *G. africana* group.

Detailed examination of microsculpture was made for specimens of *Planetes bimaculatus*, *Eunostus herrarensis*, *Ancystroglossus ovalipennis*, *Trichognathus marginipennis*, *Galerita mexicana* Chaudoir, *G. sulcipennis*, *G. perrieri*, *G. ruficollis* Dejean, *G. boucardi* Chaudoir, *G. balli* Reichardt, *G. attelaboides* Fabricius, and *G. procera* Gerstaecker.

Methods

Preparation and study of specimens.--Elytra of specimens chosen for superficial study were cleaned initially with ammonia applied with a moistened bit of tissue paper held in forceps. These specimens were examined with a Wild M5 Stereo-binocular microscope, at 50X magnification. On the basis of such examination, major types of sculpture were identified and specimens representing each type were selected for detailed examination.

For such study, except for the specimen of *G. perrieri*, the left elytron was removed, cleaned in water using a sonicator, attached to a standard mount, and coated with gold using a sputter coater. Specimens were examined and photographed, using a Cambridge S-250 "Stereoscan" Scanning Electron Microscope. The specimen of the rare Madagascan *G. perrieri*, was examined with its elytra attached to the body, uncoated, at relatively low magnifications of the SEM.

Analytical procedures.— These concerned identification of ancestral features of sculpture for each of the branching points of a tree that represented the reconstructed phylogeny of the

suprageneric groups of Galeritini. The general method used was hypothesis of transformation series (Figs. 2 and 5) polarized with the premises that flat (or slightly convex) elytral intervals are plesiotypic features of macrosculpture, and an isodiametric pattern with flat, non-imbricate sculpticells is the plesiotypic condition of the microsculpture. The latter premise is based on conclusions reached by Hinton (1970: 41-42), and Lindroth (1974).

The sequence of stages proposed in evolution of macrosculpture and microsculpture follows from the reconstructed phylogeny of Galeritini (Fig. 1, from Ball [in press]). For each pair of sister groups, the sculpture pattern most like the proposed ancestral pattern was judged the more plesiotypic, and accepted as the ancestral pattern for that pair of sister taxa. Transformation series for macrosculpture and microsculpture were established separately. The separate analyses are presented together on diagrams representing the reconstructed phylogeny of Galeritini (Figs. 7 and 8).

SCULPTURE OF THE ELYTRA

For purposes of this presentation, the term "macrosculpture" refers to the alternating system of longitudinal convexities (intervals) and concavities (interneurs) on the surface of a typical elytron. Intervals mark the areas which are the courses of veins of the fore wing (Jeannel, 1941: 30-31). "Microsculpture" refers to the network of fine lines and microscopic sculpticells (Allen and Ball, 1980: 486) that cover the surface. This network, in its most plesiotypic form, reflects the form of the cellular network of the underlying epidermis (Hinton, 1970: 41-42). Types of macrosculpture are designated by Roman numerals and capital letters; microsculpture types are designated by Arabic numerals and capital letters.

Macrosculpture

Within the tribe Galeritini, intervals range in form from broad and flat (Fig. 2, Type I) to broad and convex (costate, Fig. 2, Type III), to narrow and convex (carinate, Fig. 2, types II-IV). An elytron exhibits a simple arrangement, with all intervals being equal in width and convexity, or a complex arrangement, with a pair of secondary intervals (carinulae) intercalated between adjacent broader, primary intervals (carinae, Fig. 2, Subtype IVA, and Fig. 3). The number of carinae is either nine (Fig. 2, Subtype IIa, and Type IV), or five (Subtype IIB).

Microsculpture

At magnifications of about 50X, the cuticle of most arthropods exhibits a mesh of fine lines, like the lines of a fish net (Lindroth, 1974: 252, and Allen and Ball, 1980: 485-486). Meshes are characterized as isodiametric, transverse, or longitudinal, depending upon their relative lengths and widths. "Sculpticells" (Allen and Ball, 1980: 486) between microlines range in form from flat to slightly or markedly convex, to carinate (Ball, 1975: Fig. 114).

Galeritines exhibit a variety of forms of microsculpture. At the base of an elytron, sculpticells are flat, slightly imbricate (Harris, 1979: 19 and 30, Fig. 40). and nearly isodiametric (Fig. 6), or transverse (Fig. 4). Most of the elytral surface is:

a. covered with a network of transverse meshes (some sculpticells with posterior nodules, Fig. 5, Type 1); or
b. with nodule-like swellings, either not arranged in a pattern (Subtypes 2A and B), or aligned transversely (Types 3 and 4).

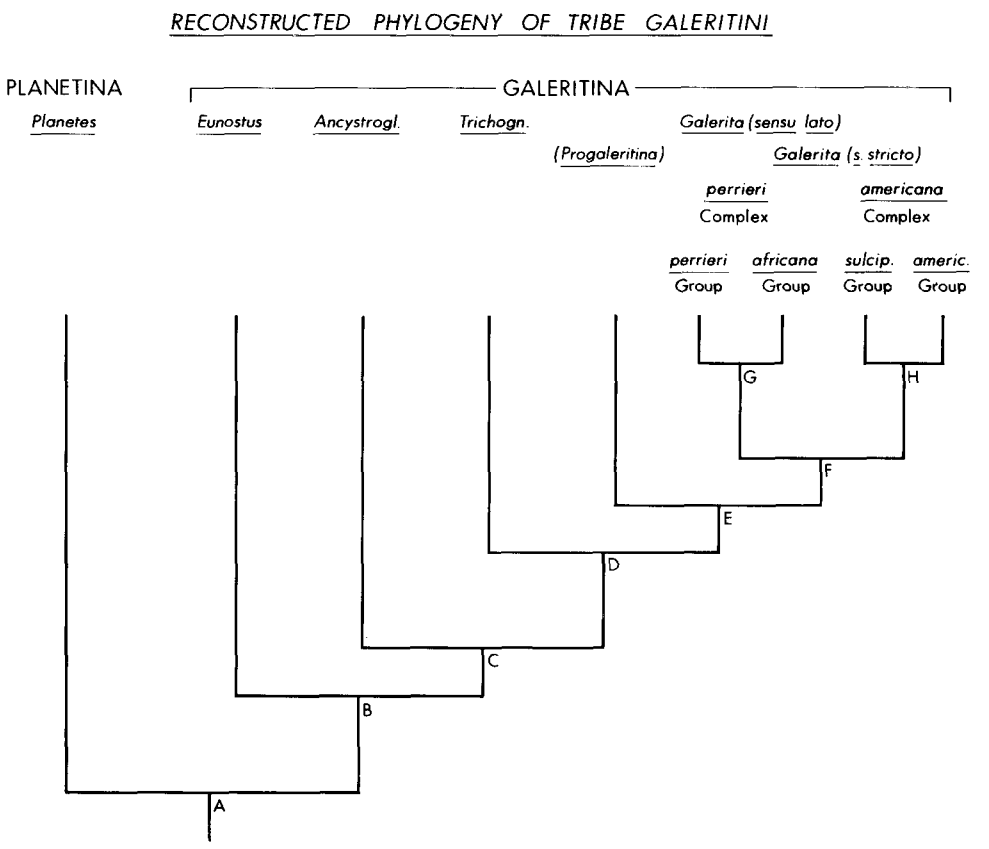


Fig. 1. Reconstructed phylogeny of Tribe Galeritini. Taxa are: Subtribe Planetina - *Planetes* MacLeay; Subtribe Galeritina - *Eunostus* Castelnau; *Ancystroglossus* Chaudoir; *Trichognathus* Latreille; *Galerita (sensu lato)* - subgenus *Progaleritina* Jeannel, and subgenus *Galerita* Fabricius, including the *G. perrieri* complex (with *G. perrieri* and *G. africana* groups), and the *G. americana* complex (with *G. sulcipennis* and *G. americana* groups).

The general term for sculpture of Types 2, 3, and 4 is nodulate (Harris, 1979: 15). As detailed below, each nodule is hypothesized as representing only part of an original sculpticell.

PHYLOGENETIC RELATIONSHIPS OF THE GALERITINI

A reconstructed phylogeny of the Galeritini (Fig. 1), based on features of adults (Ball, in press), provides a framework for an evolutionary analysis of sculpture patterns. Each node is designated by a capital letter (A-H), in alphabetical sequence, depending upon recency of common ancestry, except for the terminal two nodes. Aspects of elytral sculpture were used as a major feature to reconstruct the phylogeny of the supraspecific taxa of the genus *Galerita*, but

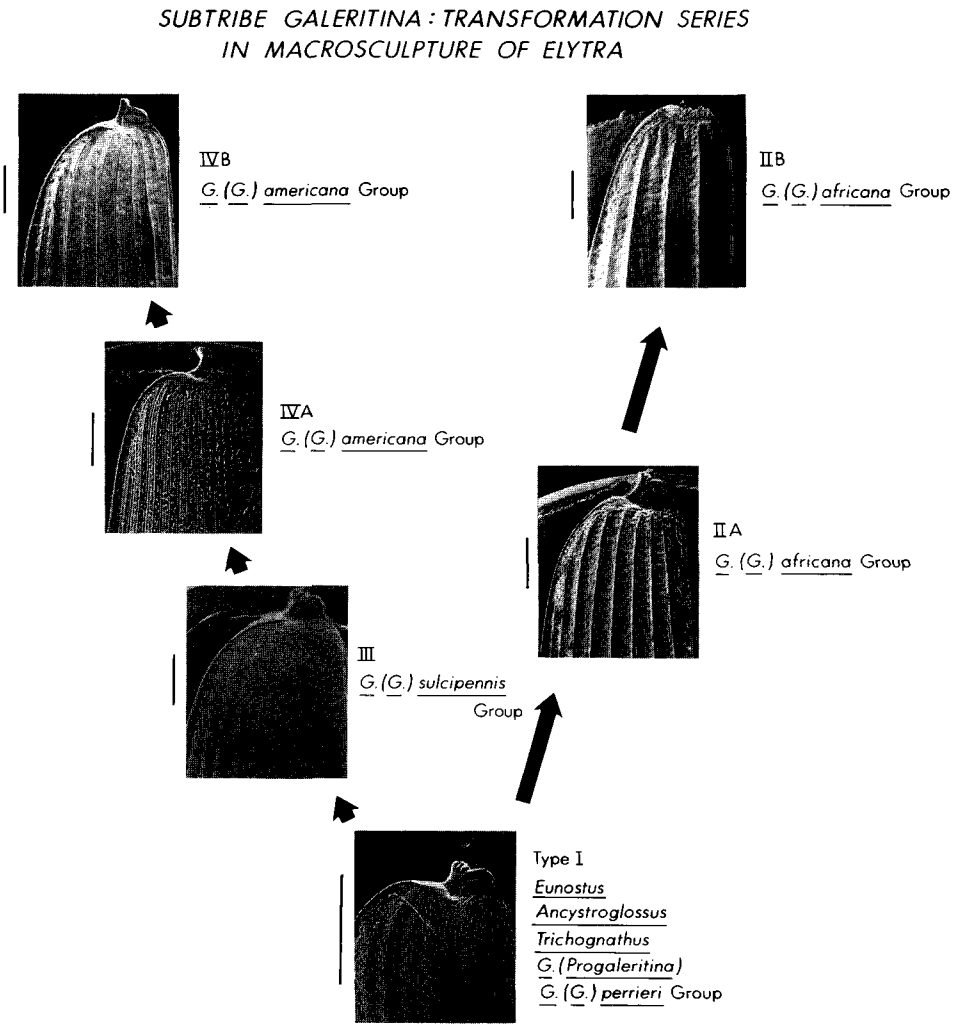


Fig. 2. Subtribe Galeritina: transformation series in macrosculpture of elytra. Types IIA-IVB represent approximately the basal one third, and Type I, the basal one quarter, of the left elytron. Species represented by illustrations are the following: Type I - *Eunostus herrarensis* Alluaud, *Ancystroglossus ovalipennis* Reichardt, *Trichognathus marginipennis* Latreille, *G. (Progaleritina) mexicana* Chaudoir, and *G. (Galerita) perrieri* Fairmaire; Subtype IIA - *G. (Galerita) attelaboides* Fabricius; Subtype IIB - *G. (Galerita) procera* Gerstaecker; Type III - *G. (Galerita) sulcipennis* Reichardt; Subtype IVA - *G. (Galerita) ruficollis* Dejean; and Subtype IVB - *G. (Galerita) balli* Reichardt. Scale bars represent 1.0 mm.

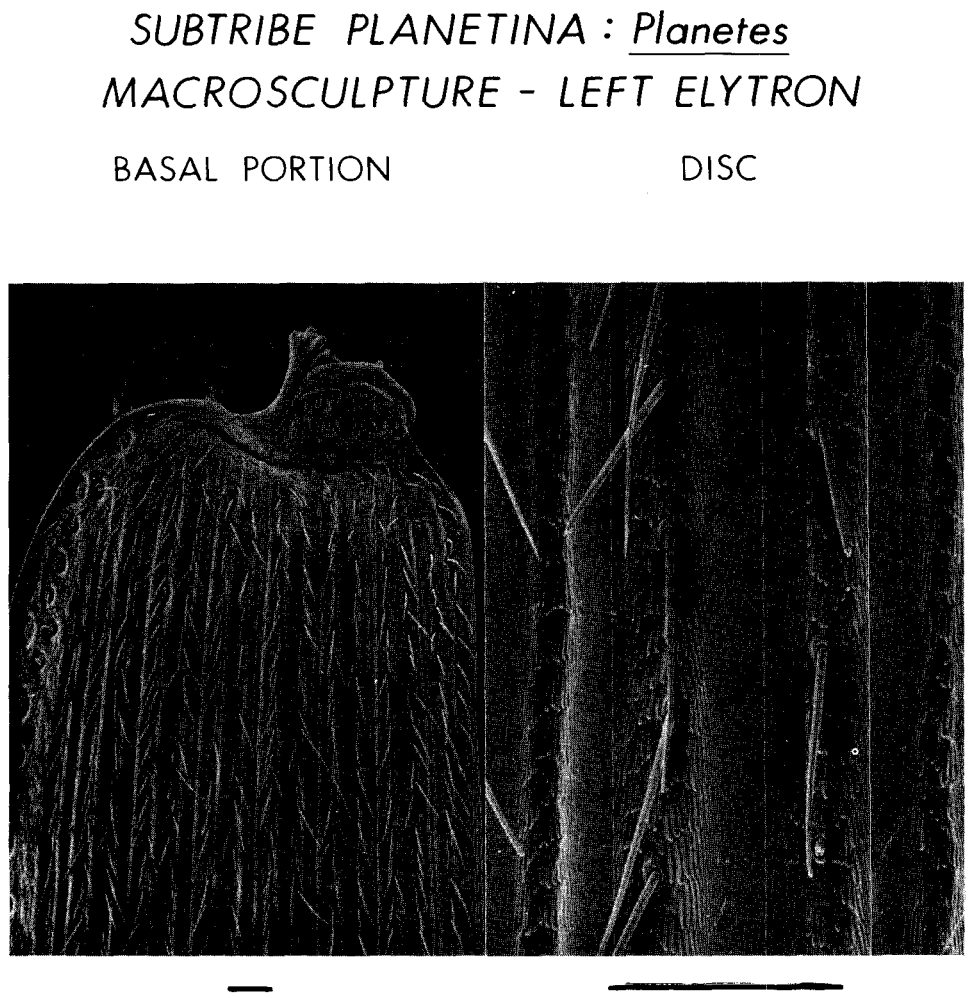


Fig. 3. Subtribe Planetina: macrosculpture of the left elytron of *Planetes bimaculatus* MacLeay. Scale bars represent 250 μm.

not to reconstruct the phylogeny of the other genera.

Overall, the system reflects important changes in structure of the mouthparts and ovipositor. There is also a striking increase in body size associated with node D, probably reflecting a change in habits from that of hunting concealed in the leaf litter to running on the surface of the forest floor, or in more open areas.

PATTERNS OF ELYTRAL SCULPTURE OF THE GALERITINI

Although the subtribe Planetina exhibits more plesiotypic features than does the Galeritina, outgroup comparison shows that planetine adults have highly derived sculpture. Thus, the subtribe Galeritina, with its greater range of sculpture types, is the focal group for elucidation

of evolution of these systems, and the following analyses begin with consideration of this subtribe.

Macrosculpture

Subtribe Galeritina.— Figure 2 illustrates the hypothesized trends in elytral macrosculpture. The figures also illustrate the reduced basal ridge that is characteristic of the adults of Galeritina. Four general types of macrosculpture are recognized, based on structural and phylogenetic considerations.

Type I includes elytra with broad intervals that are either flat or slightly convex. I did not formally distinguish between the slight difference involved. Type I is characteristic of three genera, and of one subgenus and one species group of *Galerita* (*sensu lato*).

Type II macrosculpture is characteristic of the *G. africana* group (*Galeritiola* Jeannel, of previous authors). It differs from Type I by having wider and deeper interneurs, and consequently narrower intervals, the latter being carinate. Two subtypes of macrosculpture are recognized: IIA, with nine carinae; IIB, with five carinae.

Type III macrosculpture is characteristic of the monobasic Middle American montane *G. sulcipennis* group. The elytral intervals are more elevated than in Type I, and are classified as costate. The figure, unfortunately, does not do justice to the difference between the two types of sculpture.

Type IV macrosculpture is characterized by carinae and readily seen carinulae (Subtype IVA), or if carinulae are not readily apparent, careful examination reveals vestiges of them (Subtype IVB). Subtype IVB looks very much like IIA, but the carinae of IVB are not as high, and the interneurs of IIA lack any indication of carinulae.

Subtribe Planetina.— Figure 3 illustrates macrosculpture for a specimen of *Planetes*. The pattern is Subtype IVA. Carinulae appear to be nearly as wide as the carinae, but in fact there is a substantial difference as the figure of a portion of the elytral disc, taken at higher magnification, indicates. At working magnifications (ca. 5X - 50X), however, the carinae and carinulae appear about equal, so that the elytra seem to have a densely packed system of carinae, and thus seem quite different from the Subtype IVA elytra of *Galerita*.

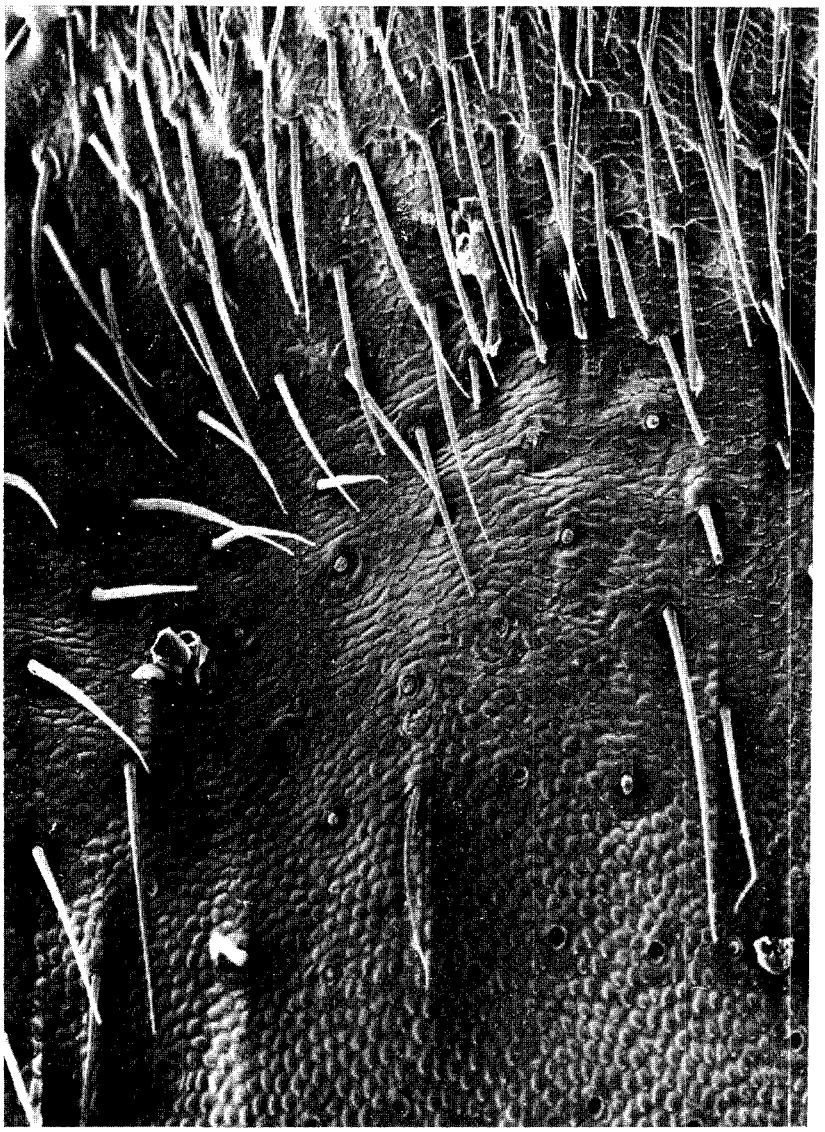
Microsculpture

Subtribe Galeritina.— Figure 4 illustrates two general types of microsculpture characteristic of galeritines: imbricate, which is confined to the basal area, principally basad of the basal ridge; and nodulate, which is more or less extensive on the disc. The sculpticells of the imbricate type are flat and broad, while the nodulate sculpticells are narrower and convex. Four types of microsculpture are recognized on the elytral disc in the Galeritina, and their proposed evolutionary trends are illustrated in Figure 5. Type I, which is characteristic of *Eunostus* the sister group of the other three galeritine genera, exhibits markedly transverse, flat sculpticells across most of the surface. Laterally, however, some sculpticells have small medio-apical nodules.

Types 2-4 are characterized by widespread nodulate microsculpture, without microlines. Type 2 exhibits a non-patterned arrangement of nodules, with Subtype 2A having fewer nodules than Subtype 2B. The former is characteristic of *Ancystroglossus*, the latter of *Trichognathus* and subgenus *Progaleritina*.

In Type 3 microsculpture, which is confined to the *G. perrieri* species complex, the nodules are in transverse rows: in 3A, exhibited by adults of the *G. perrieri* group, the nodules are short

MICROSCULPTURE AT BASE OF LEFT ELYTRON



Trichognathus marginipennis

Fig. 4. Macrosculpture at base of left elytron of *Trichognathus marginipennis* Latreille. Scale bar represents 150 μm.

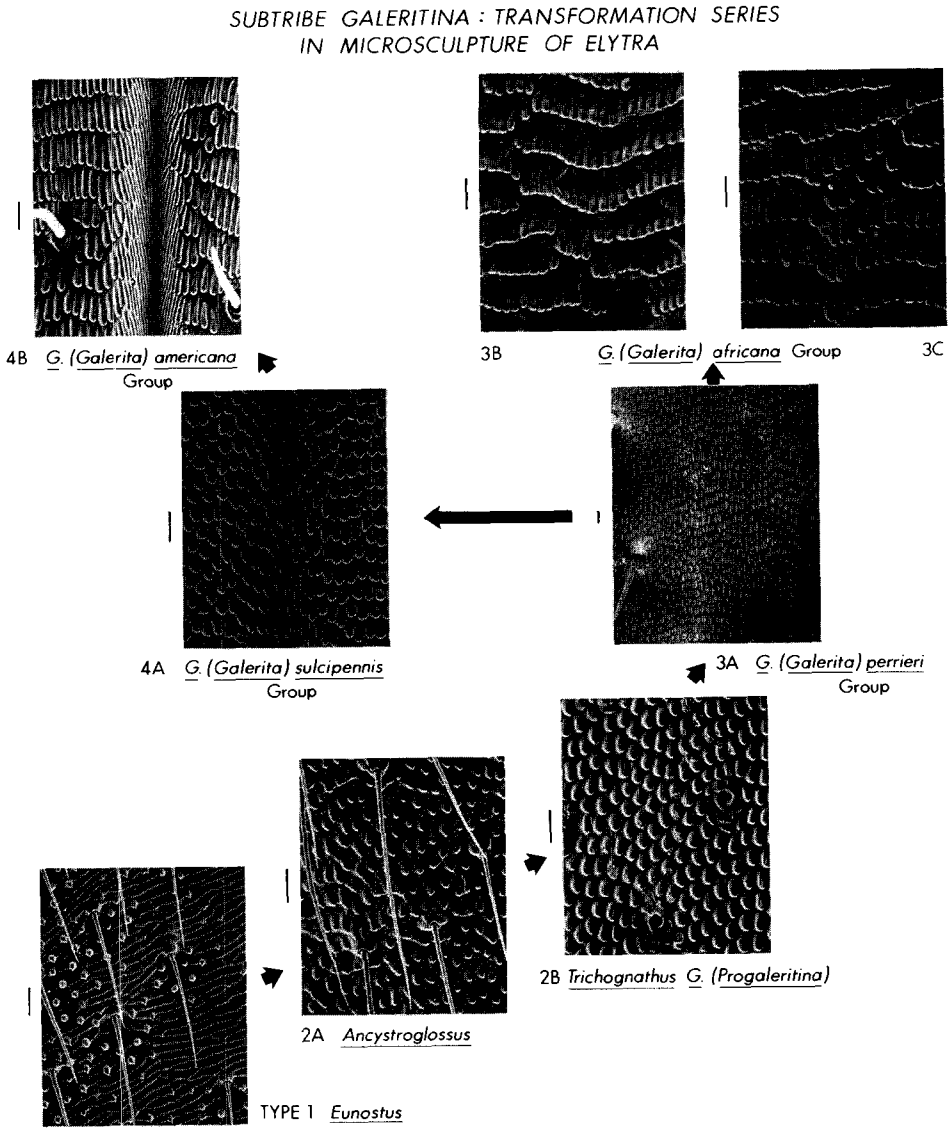


Fig. 5. Subtribe Galeritina: transformation series in microsculpture of elytra. Type I illustrates a portion of interneur 7 in the basal third of the left elytron. Subtypes 2A-4B illustrate portions of interneur 3 and/or 4, in the basal third of the left elytron. Species represented are: Type I - *Eunostus herrarensis* Alluaud; 2A, *Ancystroglossus ovalipennis* Reichardt; 2B, *Trichognathus marginipennis* Latreille, and *G. (Progaleritina) mexicana* Chaudoir; 3A, *G. (Galerita) perrieri* Fairmaire; 3B, *G. (Galerita) attelaboides* Fabricius; 3C, *G. (Galerita) procera* Gerstaecker; 4A, *G. (Galerita) sulcipennis* Reichardt; 4B, *G. (Galerita) ruficollis* Dejean. Scale bars represent 50 μm.

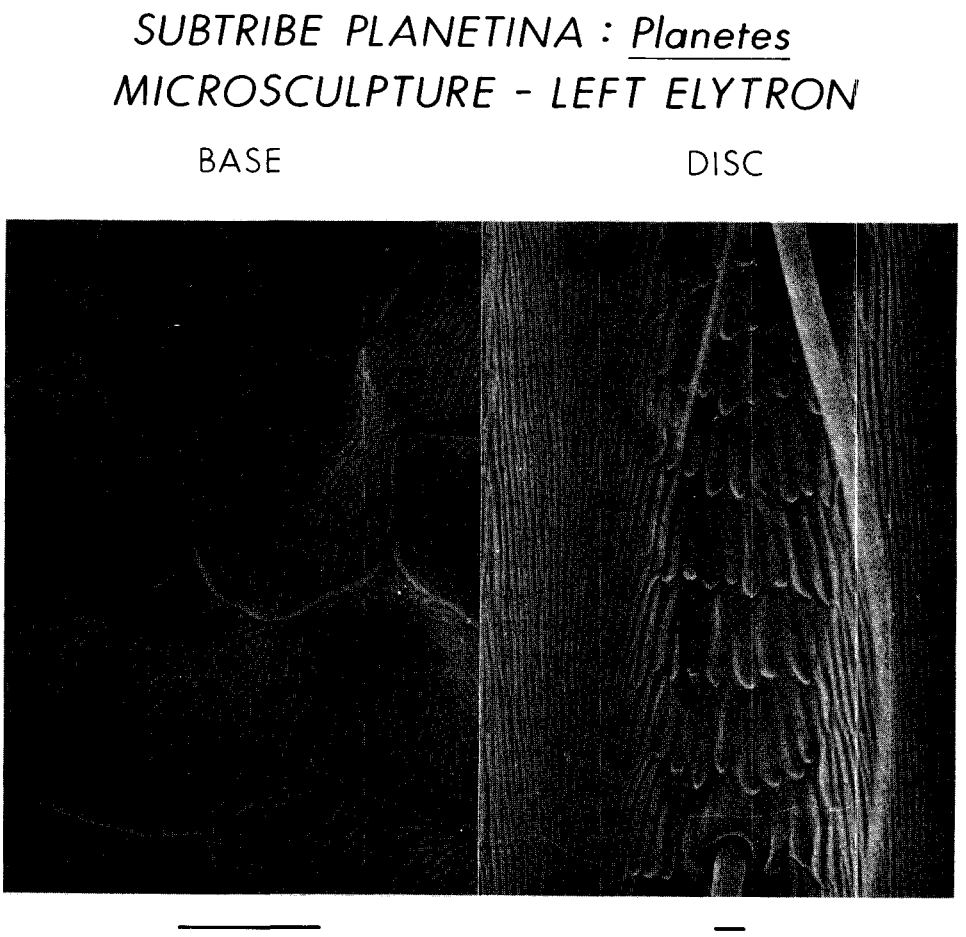


Fig. 6. Subtribe Planetina: microsculpture of the left elytron of *Planetes bimaculatus* MacLeay. The illustrations represent parts of the left elytron: the basal tenth, toward the sutural margin; and a portion of interneur 3 and adjacent carinulae. Scale bars represent 10 μm.

and uniform across the elytral surface; for 3B and 3C, characteristic of the *G. africana* group, the nodules are longer than those of 3A, but *inter se* are relatively shorter (3B) or longer (3C), flattened basally, and in fairly well marked transverse rows, between carinae. On the tops of the carinae, the sculpticells are elongate and flat, and closely adpressed.

Type 4 microsculpture is exhibited by adults of the *G. americana* complex. Of the two Subtypes, 4A (*G. sulcipennis* group) is most like that of the *G. perrieri* group. The difference is seen in the elongate and flattened nodules on the top of the elytral costae. In Subtype 4B (exhibited by adults of the *G. americana* group), the nodules are longer and the transverse rows between adjacent carinae and carinulae are better defined. In those adults exhibiting Subtype IVB macrosculpture (*i.e.*, with carinae reduced), locations of atrophied carinulae are indicated

by the markedly elongate sculpticells that are a characteristic feature of the tops of carinae and carinulae.

Subtribe Planetina.— Figure 6 illustrates microsculpture characteristic of *Planetes* adults. The elytral base has imbricate, flat, and essentially isodiametric sculpticells. The disc exhibits long, keeled nodules arranged in transverse rows between adjacent carinae and carinulae. The sculpticells of the latter are very narrow and linear.

EVOLUTION OF ELYTRAL SCULPTURE OF THE GALERITINI

The Pattern

Figures 7 and 8 illustrate and summarize the hypothesis of evolution of sculpture. Figure 8 is a continuation of Fig. 7. For the labelled nodes except G, the hypothesized ancestral combination of sculptural features is illustrated, based on features of extant galeritines, macrosculpture above, microsculpture below. The ancestral states for node G are the same as for F. For each of the extant groups whose sculptural features differ from those of the ancestral stock, illustrations are also provided.

Features of the common ancestor.--These are inferred from the most plesiotypic sculptural features of extant adult galeritines. They are Type I macrosculpture, and imbricate-isodiametric microsculpture, the latter as seen on the elytral base of *Planetes* adults.

Macrosculpture.— The reconstructed phylogeny suggests that from Ancestor A to F or G in subtribe Galeritina, there were no significant changes in macrosculpture. From Ancestor G, with Type I macrosculpture, Type II developed, and further differentiated into two subtypes, in the *G. africana* group, with Subtype IIB losing four carinae. From Ancestor F, Type III sculpture emerged in Ancestor H, and from the latter, Type IV, which in turn differentiated into two subtypes, in the *G. americana* group.

To determine polarity of Type IV sculpture, I relied on correlation of characters, for this part of the transformation series is not ordained by the reconstructed phylogeny presented in Figure 1. Subtype IVB is associated with the derived features of brachyptery and life in montane environments, in the northern part of the Neotropical Region. Subtype IVA, on the other hand, is associated with the ancestral features of macroptery and life in lowland environments, over extensive areas of the tropics. Reichardt (1967: 158) postulated, and I agree, that the traces of carinulae are evidence of loss, associated with reduction of wings and loss of flight, rather than that the traces represent the precursors of fully developed carinulae.

Although there is no sign in Type III of developing carinulae, or widened interneurs to foreshadow development of Type IV sculpture, a costate condition (Type III) could be a reasonable step between nearly flat (Type I) and carinate (Type IV) conditions.

In the lineage that gave rise to the Planetina, macrosculpture Type IVA also arose. Although intermediate extant forms are unknown, it seems unlikely that the change from the postulated ancestral condition occurred without intermediate changes like those proposed for the Galeritina.

Microsculpture.— Although changes in macrosculpture came relatively late in the Galeritina lineage, the pattern for microsculpture suggests an early striking change, followed by less marked differentiation. I suggest that imbricate isodiametric sculpture of Ancestor A changed in Ancestor B to transverse sculpture, with some sculpticells exhibiting nodules. This was followed on the surface apicad of the basal ridge, by spread of the nodules over the disc, and disappearance of the plesiotypic lines that marked the sculpticells. The number of nodules increased, and took on an arrangement in rather irregular transverse rows (Ancestor F,

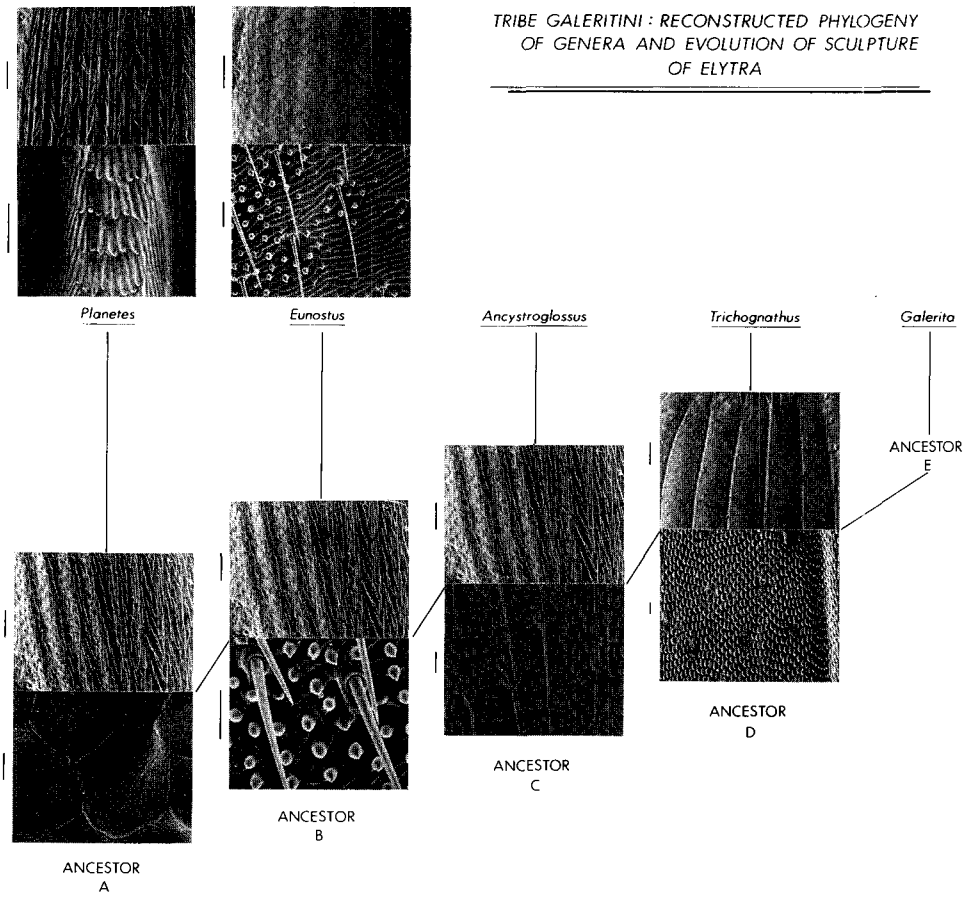


Fig. 7. Tribe Galeritini: reconstructed phylogeny of genera and evolution of sculpture of elytra. Sculpture of elytra of *Planetes, Eunostus*, and Ancestors A-D are each represented by a pair of figures, of which the lower is microsculpture, and the upper macrosculpture. The figure for Ancestor C also represents *Ancystroglossus*, and those for Ancestor D also represent *Trichognathus* and *Galerita*. The illustrations are of the left elytron, basal portion, as explained in captions for Fig. 2 (macrosculpture) and Fig. 5 (microsculpture). Specimens represented are: Ancestor A - microsculpture, *Planetes bimaculatus* MacLeay, and macrosculpture, *Ancystroglossus ovalipennis* Reichardt; *Planetes bimaculatus*; Ancestor B - microsculpture, *Eunostus herrarensis* Alluaud, and microsculpture, *A. ovalipennis*; *Eunostus herrarensis*; Ancestor C, *A. ovalipennis*; Ancestor D, *Trichognathus marginipennis* Latreille. Scale bars represent at low magnification, 500 μm; at high magnification, 50 μm.

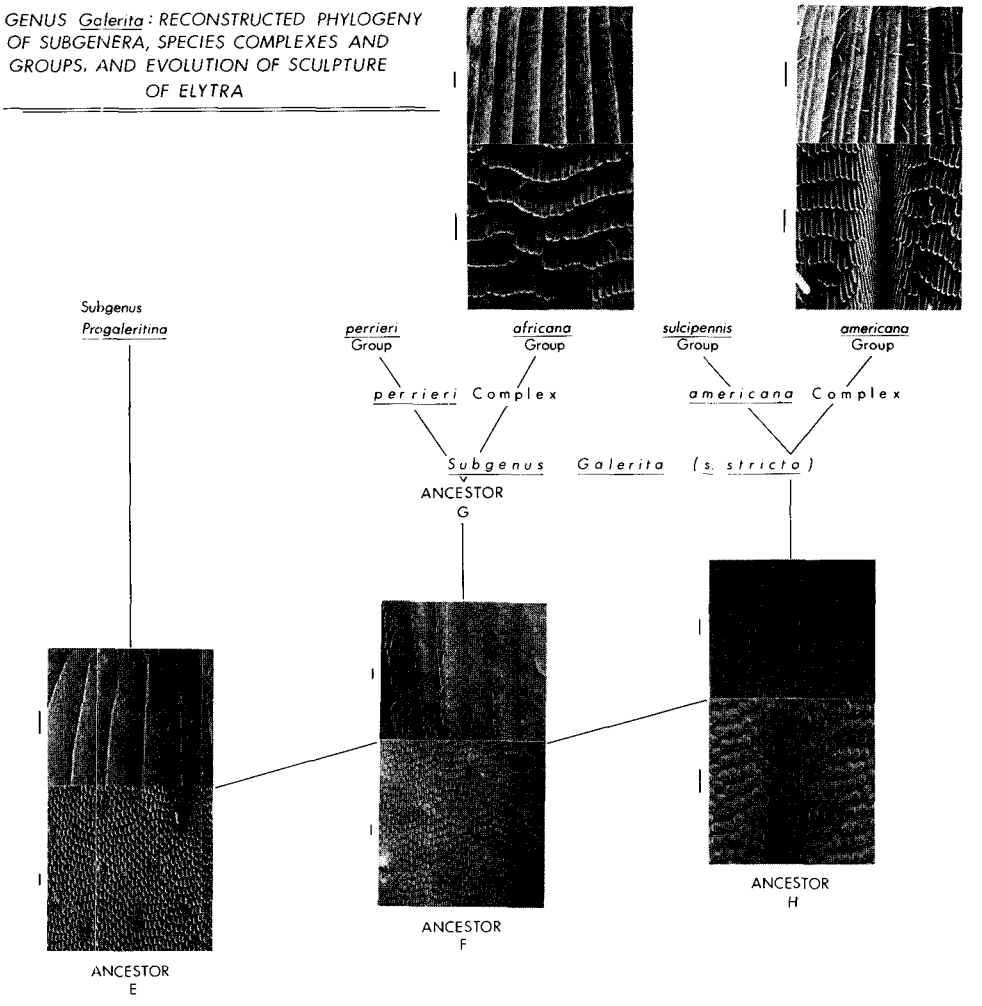


Fig. 8. Genus *Galerita*: reconstructed phylogeny of subgenera, species complexes and groups, and evolution of sculpture of the elytra. Sculpture of the elytra of Ancestor E, Ancestor F, the *G. africana* group, Ancestor H, and the *G. americana* group are each represented by a pair of figures, of which the lower is microsculpture and the upper macrosculpture. The figures for Ancestor E also represent subgenus *Progaleritina*; for Ancestor F, also Ancestor G and the *G. perrieri* group; for Ancestor H, also the *G. sulcipennis* group. The figures are of the left elytron, basal portion, as explained in the caption for Fig. 2 (macrosculpture) and Fig. 5 (microsculpture). Specimens represented are of these species: Ancestor E - *G. (Progaleritina) mexicana* Chaudoir; Ancestor F - *G. (Galerita) perrieri* Fairmaire; *G. africana* group - *G. (Galerita) attelaboides* Fabricius; Ancestor H - *G. (Galerita) sulcipennis* Reichardt; and *G. americana* group - *G. (Galerita) ruficollis* Dejean. Scale bars represent at low magnification, 500 μm; at high magnification, 50 μm, and at very high magnification, 5 μm.

Subtype 3A). As a more complex macrosculpture evolved, the transverse rows of nodules were confined to the interneurs (Subtypes 3B, 3C, 4A, and 4B).

Subtype 3A microsculpture seems easily derived from Subtype 2B by development of a more orderly arrangement of nodules. Subtypes 3B and 3C are derived from 3A by a still more ordered arrangement of nodules, and possibly by fusion of pairs of nodules, in adjacent rows, to yield nodules that are fewer and longer. The transverse rows of nodules, confined to the interneurs (Subtypes 3B, 3C, 4A, and 4B), probably decreased in number by fusion of members of adjacent rows, and, consequently, the individual nodules became longer (Subtypes 3C and 4B). On the elytral base, transverse imbricate sculpture was retained. Transformation of 3A to 4A and the latter to 4B is virtually self-evident, parallelling the transformation of 3A to 3B, and to 3C.

It is important to note that the transverse sculpticells on the elytral disc of *Eunostus* adults are not imbricate. This change is interpreted as a loss, and a reversion to a state more plesiotypic than is exhibited by the sculpture of Ancestor A.

The planetine lineage adults evolved, on the elytral surface apicad of the basal ridge, nodulate microsculpture with long nodules, similar to that of Subtype 4B. As for the macrosculpture, intermediate steps are not known for evolution of the microsculpture, between the hypothetical ancestral condition and that of the extant species of *Planetes*. On the basal area of the elytra, the imbricate isodiametric sculpture was retained.

Microsculpture of the elytral base that is characteristic of *Planetes* seems the most plesiotypic pattern among extant Galeritini. The discal sculpture, on the other hand, is highly derived, with no known extant antecedants.

Convergence among taxa.— The same derived patterns of macrosculpture and microsculpture are represented in planetines and galeritines, and within distantly related members of the Galeritina. Adults of *Planetes* and of the *G. americana* group exhibit the complex type of elytral macrosculpture, with development of a system of alternating carinae and pairs of carinulae. Similarly, within the genus *Galerita*, a system of carinate intervals has evolved independently in different groups of the subgenus *Galerita*. Also, *Planetes*, and the *Galerita americana* and *africana* groups, have evolved independently a pattern of long, transversely aligned nodular microsculpture, and elongate sculpticells on the tops of the carinae.

Loss of carinae or carinulae has occurred independently in the *G. africana* group (carinae lost), and in the *G. americana* group (carinulae lost). Although these losses involve different structures, the end result in each lineage is similar.

Parallel development of macrosculpture and microsculpture.— As noted above, carinate macrosculpture has had correlated with it development of long narrow nodules, transversely arranged between intervals.

Significance of the Pattern

In order to highlight general implications of this study, brief comments are offered about historical, developmental, and functional significance of the evolutionary pattern of sculpture of the Galeritini. From an historical perspective, I suggest that the highly complex surface of the arthropod cuticle exhibits patterns of variation that are amenable to phylogenetic analysis. This study suggests that features of the cuticle are sufficiently stable that old patterns persist. For example, if the estimate of age of *Galerita* is correct (Ball, in press, based on vicariant distribution patterns of extant taxa), the subgenera of this genus pre-date the beginning of the

Tertiary Period, and the other genera likely originated still earlier. Therefore, the microsculpture patterns ought to be of a similar range of ages. Thus, seemingly minor and inconsequential details of surface structure have potentially as much value as have other, more obvious structural features for phylogenetic analysis and taxonomic use.

The examples of convergence are interesting, for they show that even rather complex and detailed similarities may arise independently. Thus, it is important to evaluate critically such similarities if one uses cuticular features in phylogenetic analysis.

Similarities between the patterns of evolution of macrosculpture and microsculpture exhibited among the species whose adults have carinate intervals may result from a functional relationship (see below) of genetically independent elements, or they may be the result of one system constraining the other. If these derived forms of sculpture were genetically independent of one another, then they would constitute separate character states for use in analysis of phylogenetic relationship. Perhaps, however, development of carinae somehow channels or influences development of the transverse pattern of and elongation of the nodules. If this is so, and if one wanted to use the characters as sources of evidence about evolutionary relationship, it would be necessary to determine the extent of the develomental relationship. If microsculpture type were totally dependent upon type of macrosculpture, then one would have but a single character, rather than two, with which to evaluate propinquity of relationship.

Previous authors (Hinton and Gibbs, 1969: 962; Lindroth, 1974: 261-263; Erwin, 1979: 547; Allen and Ball: 544; Goulet, 1983: 375; and Ball and Shpeley, 1983: 800) have considered the ecological role played by surface features of carabids, proposing that irregularities and dullness contribute to cryptic patterns, while brilliance caused by marked reflectivity or iridescence yields flash patterns which are confusing to potential predators. Alternatively (Erwin, 1979: 547), it has been proposed that since different patterns of sculpture are associated with different types of habitats, the patterns might function to protect an insect's body against unfavorable environmental influences. For example, a grated pattern (*i.e.*, diffraction grating) might be especially effective in shedding mud and water, and thus of value to insects living in wet, sticky environments. Using the analogy of a corrugated iron roof, the correlation of elytral carinae with longitudinally directed nodules looks like a run-off system for shedding unwanted material that comes in contact with the cuticle. Perhaps this system has therefore a similar function to that of a grated system of microsculpture, the different solutions being the result of selection for different types of environmental impediments.

More specifically, adults of *Eunostus* exhibit the transverse pattern of microsculpture. In other carabid taxa, this pattern is correlated with life in tightly-packed leaf litter, but I do not know if this is the type of habitat frequented by *Eunostus*. The nodular forms of microsculpture are characteristic of all other galeritine groups, whose range of habitats collectively extends from closed canopy rain forest to open woodland and riparian situations. So, the functional significance of the different types of microsculpture is not likely to be found by seeking correlates with different habitats. Correlation might be found at the level of microhabitats, when these have been determined for galeritines.

In spite of my inability to demonstrate its adaptive significance, since this evolutionary pattern has developed and has been maintained for an extended period of time, and since the features are exposed to environmental pressures including potential predators that rely on eyesight while hunting, it seems reasonable to infer that natural selection has influenced and is maintaining this structural system. Futhermore, in view of the rather small steps in at least portions of the transformation series, it seems reasonable to infer sustained directional

selection, perhaps associated with either changes in habitat, or with improved design for occupying the old habitats. (Ball, in press).

ANOTHER INTERPRETATION OF EVOLUTION OF ELYTRAL SCULPTURE IN THE GALERITINI

Reichardt (1967: 158) considered evolution of macrosculpture of the elytra of subgenus *Galerita*. Assuming that Subtype IVA sculpture was plesiotypic for this group, which he ranked as a genus, and to which he related *Planetes*, he proposed that Types I, II, and III and Subtype IVB were derived from the former Subtype: for II and IVB, by simple loss of carinulae; and for Types I and II, both by loss of the carinulae and reversion from carinate to costate or nearly flat intervals. In turn, this notion was based on two considerations: evident reduction of the carinulae in adults of highland species in Middle America, and association of this loss with brachyptery, an apotypic condition. However, he did not take account of the fact that associated with macrosculpture Types I and III is a plesiotypic form of microsculpture, nor that in the *G. africana* group (with Type II macrosculpture) there is no evidence that carinulae had ever been present.

Having taken account of these facts, and as well having shown elsewhere (Ball, in press) that the subgenus *Galerita* and *Planetes* are not closely related to one another, and consequently there is no need on the basis of out-group comparison to postulate that Subtype IVA macrosculpture is plesiotypic, I believe that Reichardt's hypothesis of the evolution of elytral macrosculpture in the Galeritini can be rejected.

CONCLUDING STATEMENT

In this paper, I have recognized and described the types of sculpture exhibited by representative galeritines, using both structural and phylogenetic considerations to do so. I have demonstrated a marked correlation between microsculpture pattern and the reconstructed phylogeny that I had made previously. Underlying the reconstructed phylogeny based on structural features, there ought to be a correlated series of ecological transformations. When the latter are found and analyzed, I believe we will have the basis for understanding in both functional and historical terms the patterns of evolution of elytral sculpture postulated here.

ACKNOWLEDGEMENTS

I offer thanks for the loan of especially important material for this study: to P. Basilewsky (Musee Royal de l'Afrique Centrale, Tervuren, Belgique), for making available a specimen of *Galerita perrieri* Fairmaire; and to D. H. Kavanaugh (California Academy of Science, San Francisco, California), for the loan of specimens of *Planetes* and *Eunostus*.

Technical assistance was provided by various members of the staff of my Department. D. Shpeley and G. D. Braybrook collaborated in undertaking the work with the SEM. J. S. Scott did the layout and prepared the plates, which are vital components of this presentation. I. E. Bergum assisted with preparation of the final copy of the manuscript.

My associates R. S. Anderson and J. R. Spence reviewed a preliminary draft of the manuscript, and offered useful suggestions for improvement of presentation. Though I accepted most of their proposals and made extensive revisions, I declined to accept all of them. I am, nonetheless, grateful for their thoughtful, thorough reviews of both form and substance.

I must also acknowledge members of the audience at Hamburg, at the XVII International Congress, whose comments following my oral presentation, caused me to modify some of the statements that I made there.

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propinquity

Contents

English

WOTD – 11 August 2009

Etymology

propinqu(ent) + *-ity*, from Old French *propinquité* or Latin *propinquitās*, from *propinquus* (“neighbouring”) (from *prop(e)* (“near”) + *(h)inc* (“hence”) + *-uus*).

Pronunciation

- (*UK*) IPA(key): /pɹəˈpɪŋ.kwɪ.ti/
- Audio (UK) (file)

Noun

propinquity (*countable and uncountable*, *plural* **propinquities**)

1. Nearness or proximity.

    Synonym: appropinquity (*obsolete*)

- **1904**, Edith Wharton, *The Other Two*:

    Some experimental spirits could not resist the diversion of throwing Varick and his former wife together, and there were those who thought he found a zest in the **propinquity**.

- **1963**, Melvin M. Webber, “Order in Diversity: Community without Propinquity”, in Lowdon Wingo Jr., editor, *Cities and Space: The Future Use of Urban Land*, page 43 (https://archive.org/details/citiesspacefut00wing/page/43/mode/1up):

    Yet, never before in human history has it been so easy to communicate across long distances. Never before have men been able to maintain intimate and continuing contact with others across thousands of miles; never has intimacy been so independent of spatial **propinquity**.

- **1973**, Kyril Bonfiglioli, *Don't Point That Thing at Me*, Penguin, published 2001, page 70:

    Surely, too, it would be a waste of an agent, for after several hours of **propinquity** I could scarcely fail to recognise him in the future.

- **1985**, Anthony Burgess, *The Kingdom of the Wicked*:

    There was also the question of Julius’s glandular responses to the almost daily **propinquity** of his Empress, so naked under her lawn.

- **1993**, Samuel P. Huntington, *The Clash of Civilizations?*[1] (https://www.foreignaffairs.com/articles/united-states/1993-06-01/clash-civilizations):

    Geographical **propinquity** gives rise to conflicting territorial claims from Bosnia to Mindanao.

- **2021** January 28, Sam Knight, “Adam Curtis Explains It All”, in *The New Yorker*[2] (https://www.newyorker.com/news/letter-from-the-uk/adam-curtis-explains-it-all):

    A seventy-second section of the film, spelling out the concept of time and **propinquity**, involves archival footage of (and this is an incomplete list) American cars going through an underpass; flaring streetlights; two men in loud suits, their faces out of the frame, smoking cigars and drinking whisky while sitting on garden furniture on the balcony of a high rise; […]

2. Affiliation or similarity.

- *c.* **1603–1606**, William Shakespeare, “The Tragedie of King Lear”, in *Mr. William Shakespeares Comedies, Histories, & Tragedies: Published According to the True Originall Copies* (First Folio), London: […] Isaac Iaggard, and Ed[ward] Blount, published 1623, OCLC 606515358 (http://worldcat.org/oclc/606515358), [Act I, scene i], lines 112–115, page 284 (https://archive.org/details/mrvvilliamshakes00shak/page/284/mode/1up):

  Heere I diſclaime all my Paternall care, / **Propinquity** and property of blood, / And as a ſtranger to my heart and me, / Hold thee from this for euer.

- **1970**, Michel Foucault, *The Order of Things*, Routledge, translation of *Les mots et les choses*, published 2002, page xviii:

  What is impossible is not the **propinquity** of the things listed, but the very site on which their **propinquity** would be possible.

- **1979**, Ybarra v. Illinois, 444 U.S. 85, 86 (1979):

  [A] person's mere **propinquity** to others independently suspected of criminal activity does not, without more, give rise to probable cause to search that person.

- **1997**, Don DeLillo, *Underworld*:

  Decent people out there. Russ wants to believe they are still assembled in some recognizable manner, the kindred unit at the radio, old lines and ties and **propinquities**.

- **2012**, Andrew Marr (heard at the Leveson inquiry.)

  Propinquity and corruption don't always go side by side.

Translations

proximity	
▪ Persian: نزدیکی (fa) (nazdiki) ▪ Russian: бли́зость (ru) (blízostʹ)	▪ Spanish: propincuidad *f*, proximidad (es) *f*
affiliation or similarity	
▪ Persian: شباهت (fa) (še(a)bāhat/) ▪ Russian: родство́ (ru) (rodstvó)	▪ Spanish: propincuidad *f*, projimidad

Close encounters: Analyzing how social similarity and propinquity contribute to strong network connections.

Author(s)
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Abstract
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Close encounters: Analyzing how social similarity and propinquity contribute to strong network connections.

Close Encounters: Analyzing How Social Similarity and Propinquity Contribute to Strong Network Connections

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ABSTRACT

Models of network formation emphasize the importance of social similarity and propinquity in producing strong interpersonal connections. The positive effect each factor can have on tie strength has been documented across a number of studies. And yet we know surprisingly very little about how the two factors combine to produce strong ties. Being in close proximity could either amplify or dampen the positive effect that social similarity can have on tie strength. Data on tie strength among teachers working in five public schools was analyzed to shed light on this theoretical question. The empirical results indicated that teachers who were similar in age were more likely to be connected by a strong tie, especially teachers for whom age similarity was more likely to be salient. Moreover, teachers who took breaks at the same time or who had classrooms on the same floor communicated more frequently and felt more emotionally attached. Among the public school teachers, propinquity amplified the positive effect that age similarity had on tie strength. The strongest network connections occurred among age-similar teachers who had classrooms on the same floor. The empirical results illustrate the value of considering how social similarity and propinquity contribute to strong ties independently and when combined with each other.

Introduction

Models of network formation emphasize the importance of social similarity and propinquity in producing strong interpersonal connections (McPherson et al., 2001, provide an extensive review). A network connection is strong when the two parties involved in the relationship have known each other for a long time, communicate frequently, or feel emotionally attached (Marsden and Campbell 1984). The importance of social similarity and propinquity in producing strong ties has been established for a number of characteristics, including age (Marsden 1988, Burt 1991), education (Yamaguchi 1990), gender (Brass 1985, Ibarra 1992,1997), race (Marsden 1987, Ibarra 1995, Moody 2001), religion (Laumann 1973), and organization and professional tenure (Zenger and Lawrence 1989), as well as for a number of propinquity indicators, including classrooms (Shrum et al. 1988), dormitories (Festinger et al. 1950), neighborhoods (Mouw and Entwisle 2006), voluntary organizations (McPherson and Smith-Lovin 1986, 1987), and seating arrangements (Caldiera and Patterson 1987).

Although we know a great deal about how social similarity and propinquity contribute to strong ties independently, we know less about how social similarity and propinquity combine to produce strong interpersonal connections. In particular, being in close proximity could either amplify or dampen any positive effect that social similarity has on tie strength. On the one hand, proximity in time or space provides two people with an opportunity to develop a more meaningful relationship, but the two individuals must be interested in developing a relationship (McPherson and Smith-Lovin 1987). For example, 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. One explanation for why sharing a demographic characteristic has a positive effect on tie strength maintains that individuals have a preference for socially similar interactions (Laumann 1966). People who prefer socially similar relationships should be more likely to take advantage of an opportunity to

develop a strong tie with a socially similar contact. Thus, being in close proximity should amplify any positive effect that social similarity can have on tie strength (Zeng and Xie 2008). For example, prior research has established that people similar in age are more likely to be connected (McPherson et al. 2001: 424-425). People of the same age could prefer to interact with each other either because they have had a similar life history (e.g., were born during the 1950s or attended college during the Vietnam War) or because they are currently at a similar point in their life course (e.g., entering graduate school, becoming a new parent, or considering retirement). Given a preference for age-similar encounters, any positive effect that being the same age can have on tie strength should be even more positive when people the same age are in close proximity.

On the other hand, more-frequent contact between in-group members could reduce the positive association between social similarity and tie strength. Recent research has shown that the positive association is a function of actual and expected similarity (Hogg and Hardie 1991, Hogg et al. 1995). Expected similarity is a function of sharing a demographic or social characteristic, whereas actual similarity is a function of sharing unobserved attitudes, behaviors, and beliefs. When an in-group member meets or exceeds prior expectations with respect to unobserved attributes, his or her relationships with in-group members are stronger (Hogg et al. 1995). However, if two people who share a demographic or social characteristic are similar only on the surface, propinquity would provide them with more opportunities to discover how very little they actually have in common, which should reduce the positive effect that social similarity can have on network connections (Ziebro and Northcraft 2009: 148-149). For example, if a young person assumes all young people are liberal Democrats, more opportunities to interact with a young conservative Republican would make it more likely their differences in political philosophies would be revealed and, consequently, the positive effect of being the same age would be diminished.

Thus, while it is reasonable to assume that proximity and social similarity combine to define tie strength, exactly how the two factors combine is unclear. My research objective is to shed light

on this theoretical question. First, I provide a more detailed discussion of how social similarity and propinquity contribute to strong ties alone and in combination. I then analyze data on tie strength among teachers working in five schools and examine how social similarity and propinquity contribute to tie strength when social similarity is defined by age and status. Empirical analysis indicated that age was a primary source of demographic diversity in each school and therefore was likely to be salient or socially significant. The analysis also indicated that status was weakly connected to age and, therefore, any effect that status similarity had on tie strength was orthogonal to any effect of age similarity. The empirical results indicated that status similarity had no effect on tie strength. Age similarity had a positive effect on tie strength, and the positive effect was even more positive when teachers the same age had more opportunities to interact with each other (i.e., two teachers had a classroom on the same floor). This paper concludes with a discussion of the theoretical implications of the observed research findings.

Social Similarity and Propinquity

Initial explanations for the positive association between social similarity and tie strength focused on interpersonal dynamics in generating strong network connections. People who shared a demographic characteristic were assumed to also share life histories, experiences, and attitudes, which made it easier for them to interact (Laumann 1966, Byrne 1971, Schneider 1987). An easier and more pleasant encounter was more likely to result in a strong network connection. Any positive effect that social similarity had on tie strength was a function of people who were similar on the "surface" (e.g., both women) also being similar with respect to "deep," or unobserved, behaviors, attitudes, and characteristics (e.g., both liberal). More-recent theoretical arguments have emphasized how the salience or social significance of a demographic characteristic shapes the association between social similarity and tie strength. Even if two people share a demographic characteristic, it will be of little consequence if the characteristic is unimportant. For example,

sharing the characteristic of being American could result in a more positive interaction if two Americans meet one another on a street in Paris. But if the same two individuals were to meet on a street in Chicago, sharing that same characteristic would have little or no effect on their interaction, because almost everyone in Chicago is an American. In Chicago, the most important characteristic could be social or economic class.

Salience is important because individuals are more likely to identify with a salient characteristic, and identification with a characteristic generates positive affect for in-group members (Hogg and Turner 1985; Hogg and Hardie 1991; Hogg 1992, 1993; Hogg and Hains 1996; Grieve and Hogg 1999).[1] Researchers have emphasized how two demographic factors shape the salience of a characteristic. One factor is the composition of the focal organizational unit or group. If an organizational unit contains a minority and a majority group, its composition is skewed (Kanter 1977: 209). The demographic characteristic that defines minority status is more likely to be salient, while the characteristic that defines majority status is less likely to be salient (Tafjel and Turner 1979, Mullen 1983, Turner 1985, Brewer 1991). For example, if women represent ten percent of an organizational unit and men represent the remaining ninety percent, the category of female will be salient for women but the category of male will not be salient for men. As the composition of the unit becomes more balanced, in-group status will become more salient for every member of the unit. For example, if men and women each represent fifty percent of a unit (i.e., the unit is balanced demographically), the category of male will be salient for men and the category of female will be salient for women. A second factor is the correlation among demographic characteristics. A characteristic is more likely to be salient when in-group status with respect to one characteristic is reinforced by in-group status with respect to multiple characteristics (Blau and Schwartz 1984, Lau and Murninghan 1998). When multiple

[1] The assumption in this line of work is that identification is a function of demographic factors (i.e., proportion of in-group members) and that it is beneficial. Research has shown, however, that individuals can be primed to identify with a characteristic. Such identification can be beneficial (Kane et al. 2005) but need not be (Ambady et al. 2001).

characteristics are correlated, the boundary between the in-group and the out-group is more clearly delineated. For example, if all the women on a team are young and all the men are older, membership in each in-group (i.e., young women and older men) will be salient. Thus, a demographic characteristic can be salient even for members of a numerical majority if those members share multiple demographic characteristics.[2]

The general idea is that two individuals will assign more weight to their social similarity as the characteristic that defines their social similarity becomes more salient, which in turn should increase the magnitude of the positive association between social similarity and tie strength. Research findings are consistent with the two explanations for salience discussed above. Reported empirical results indicate that social similarity is more likely to produce a strong tie when people who share the focal characteristic (a) are part of a numerical minority (Mehra et al. 1998, Mollica et al. 2003, Reagans 2005), (b) are assigned to a balanced organizational unit (Moody 2001, Bacharach et al. 2005, Mouw and Entwisle 2006), or (c) share multiple characteristics (Blau and Schwartz 1984). Given these results, I expect sharing a salient characteristic to have a positive effect on tie strength.

HYPOTHESIS 1: *Sharing a salient social characteristic has a positive effect on tie strength.*

More-sociological explanations for strong ties give causal priority to propinquity (Festinger et al. 1950; Feld 1982, 1984; McPherson et al. 2001; Ingram and Morris 2007).[3] Propinquity in time and space could have a positive effect on tie strength either because repeated exposure provides

[2] The importance of being similar along multiple dimensions is not limited to demographic characteristics. For example, if members of a numerical minority all perform the same task or activity in an organization, or if minority status in a firm corresponds with minority status in the general population, the characteristic that defines minority status will be more salient (Turner 1987: ch. 6).

[3] It is important to distinguish propinquity-based explanations for strong network connections from contact theory (Pettigrew 1998, Troop 2007). Contact theory is concerned with the set of conditions that must exist before negative attitudes about the out-group change, while the propinquity argument emphasizes the importance of opportunity in determining tie strength. Having a strong tie with a member of the out-group is not equivalent to having positive attitudes. For example, a man could feel emotionally close to his female colleagues but believe women are inferior to men. Contact theory and propinquity-based explanations for strong ties are distinct but are also compatible (Pettigrew 1998: 75-77).

individuals with an opportunity to discover mutual or compatible interests or because individuals become more appreciative or tolerant of their differences. Propinquity-based explanations for strong ties emphasize the opportunities that individuals have to interact with each other rather than the characteristic they share. Within this framework, if sharing a demographic characteristic is correlated with strong ties, it is because institutional and structural forces provide socially similar people with more opportunities to develop a network connection. For example, typecasting by employers segregates men and women at work (Bielby and Baron 1986). As a result, men and women have more opportunities to develop relationships with members of their respective in-groups. The very same dynamics could just as well produce stronger ties between people who do not share a characteristic. For example, most of us are educated with people our own age, which generates strong ties between individuals who are proximate in age. But because most schools are coed, the same process creates stronger cross-gender ties. Housing segregation by race in the United States generates strong ties among people who belong to the same racial group. But the same dynamic can generate stronger network connections between individuals of different education levels or who belong to different economic classes. This line of thinking leads to the second hypothesis.

HYPOTHESIS 2: *Proximity has a positive effect on tie strength.*

Propinquity provides two individuals with an opportunity to develop a more meaningful relationship, but they must have some interest in developing a strong tie. If they are not interested in interacting, being in close proximity will not have a positive effect on subsequent interactions. More-frequent encounters could make future encounters more problematic. Researchers who emphasize the importance of proximity in producing strong network connections have, at least implicitly, acknowledged the importance of motivation. Those scholars have assumed that even if individuals prefer socially similar contacts, if socially similar colleagues are unavailable, individuals will develop network connections with dissimilar colleagues (McPherson and Smith-

Lovin 1987). This rationale has been used to explain a positive association between the composition of an organizational unit and the composition of a person's contact network. The same rationale also implies that the magnitude of the propinquity effect varies with how similar proximate individuals are. Any positive effect that sharing a salient characteristic has on tie strength should be even more positive when coupled with proximity, either because people who identify with the same characteristic are more interested in interacting or because when an individual identifies with a characteristic, the threshold for developing a strong tie with in-group members is lower. This line of argument leads to the following hypothesis.

HYPOTHESIS 3A: *The positive effect that sharing a salient characteristic has on tie strength increases as proximity increases.*

Although it is possible that the positive association between social similarity and tie strength is even more positive when proximity is high, the exact opposite could also be true. Initial research assumed that people who shared a demographic characteristic also shared unobserved behaviors, attitudes, and beliefs. However, the extent to which that is true is an empirical question, and the available empirical evidence indicates the association between the two kinds of similarity is often weak (Harrison et al. 1998). Moreover, more-recent research indicates that both kinds of similarity contribute to strong ties (Hogg and Hardie 1991, Hogg et al. 1995). Despite the weak correlation between surface and deep similarity, however, people often assume that there is a positive association between surface and deep characteristics (Phillips 2003, Phillips and Lewin Loyd 2006). If people who identify with a salient characteristic assume that surface and deep similarity are congruent for members of their group, then, when two group members meet, each will expect deep (i.e., actual) similarity to be near its maximum value or at least above some threshold value. If the assumption holds, a stronger network connection will occur. If, however, the in-group members discover that deep similarity is lower than expected, sharing the characteristic will have less of a positive effect on tie strength. For example, when people who

share a characteristic discover that surface and deep similarity are incongruent, they are often irritated and annoyed (Phillips 2003). Thus, when surface and deep similarity are weakly correlated, propinquity will provide in-group members with more opportunities to discover what they do not have in common. Consequently, any positive effect that social similarity can have on tie strength should be diminished when proximity is high. This line of argument leads to the following hypothesis.

HYPOTHESIS 3B: *The positive effect that sharing a salient characteristic has on tie strength declines as proximity increases.*

Method

The Study Population

Elementary and middle school teachers who worked in five different schools in a large metropolitan area defined the study population. The teachers had experienced a number of change initiatives aimed at improving student performance, and relationships with colleagues affected how the teachers interpreted each initiative. Moreover, relationships between teachers were important because network connections allowed teachers to benefit from each other's experience and expertise (Gibbons 2004), which could have increased the quality of their teaching. The schools had a number of features that made them attractive settings for evaluating the current research questions. With respect to the first hypothesis, the schools were small. The number of teachers in each school varied from 22 to 65. This small number made it more likely that the teachers were aware of each other's demographic characteristics (Lawrence 2006). As a result, it was more likely that each teacher would know where he or she was located in the distribution of a particular characteristic. Greater awareness should have translated into how much each teacher identified with the focal demographic characteristic and how he or she interacted with colleagues who shared the characteristic. With respect to the second hypothesis, teachers were scheduled to

take breaks at different times during the week. The break schedule was set for each teacher at the beginning of the academic year and provided them with the opportunity to interact. How the teachers spent their break time varied. Some took the break in their classroom, while others spent the time socializing or working in the teachers' lounge. However teachers decided to spend their break time, taking breaks at similar times during the week provided them opportunities to interact. In addition to the break schedule, the physical layout of the school shaped the opportunity teachers had to interact. Teachers with classrooms on the same floor had more opportunities to interact.

INSERT TABLE 1 ABOUT HERE

Demographic and Social Characteristics

The teachers were surveyed four times over a one-and-a-half-year period (approximately every three months). A section of the survey asked teachers about demographic characteristics such as age, gender, race, professional tenure, and school tenure. Table 1 shows the descriptive statistics for the demographic characteristics.[4] In addition to the demographic characteristics, Table 1 includes an indicator of organizational status, which came from asking each teacher to name five colleagues that he or she would nominate for teacher of the year on the basis of their "strength, competence, and ability as a teacher. To define each teacher's standing in the teaching-status hierarchy, the number of nominations received by each teacher was divided by the maximum number of nominations received by any teacher in the school. As noted above, the schools varied in the number of classroom teachers who were employed at the school. There were 30 teachers in school A; 65 in school B, 39 in school C, 22 in school D, and 26 in school E. The results in Table 1 indicate that the vast majority of the teachers were female. The large proportion of female teachers was consistent with the demographic composition of the broader teaching population, as over 90 percent of the elementary and middle school teachers in the state were female. The results

[4] The results in Table 1 illustrate the average characteristics of the teachers and ignore time. There was little change in the teaching population across time, so the descriptive statistics at each point are essentially equivalent.

in Table 1 also indicate that most of the teachers were White. They were the majority of the teaching population in three of the five schools. In comparison to gender, however, there was more variation in race. White and Latino teachers represented between thirty and forty percent of the teachers in schools C and E. African Americans and Asians represented a small minority of the teaching population and were absent in a number of schools. With respect to age and tenure, the teachers in schools C and E tended to be younger and less experienced than the teachers in the other three schools, and this was especially true for the teachers in school E.

The final column in Table 1 shows the response rate to the survey at each school. Every classroom teacher employed by the focal school at time t was asked to fill out the survey. Response rates were averaged across time for each school. The results indicate that the response rate to the survey varied across schools ($F = 8.76$). An analysis of individual response rates indicated that none of the demographic characteristics in Table 1 affected the likelihood that a teacher responded to the survey at a specific time. The teachers who responded were demographically similar to the teachers who did not respond.[5]

A factor analysis of the characteristics (results not shown to conserve space) illustrated how the different characteristics "intersected" in the individual teachers. Two factors explained 34 percent of the covariance among the demographic characteristics. The first factor explained 28 percent of the covariance and illustrated the positive association between individual age, professional tenure, and school tenure. The second factor explained 6 percent of the covariance and distinguished African American teachers from Latinos and women. Although it was possible for a teacher to classify him- or herself as African American and Latino, most teachers did not. Moreover, male teachers tended to be African American. The organizational-status variable was positioned in the

[5] This statement is based on the estimates from a logistic regression analysis with responding to the survey as the dependent variable and with the demographic characteristics in Table 1 as predictors. To control for variation across schools, four school fixed effects were included in the model. An equation was estimated for each survey point, and teachers employed by the school at the time of the survey defined the risk set. Race and gender data were available for every teacher, including teachers who never responded. However, some of the demographic data for respondents and nonrespondents were missing. Missing demographic data were imputed using a multiple imputation technique.

center of the characteristic space, which indicated that status was virtually uncorrelated with the other characteristics. Additional empirical analysis reinforced this finding. The results indicated that organizational status was uncorrelated with race and gender in all five schools, and it was uncorrelated with individual age, professional tenure, and school tenure in schools A, C, and D. School tenure had a positive effect on organizational status in school B, and professional tenure had a positive effect on organizational status in school E.

The results described above illustrate how the demographic characteristics intersected in teachers and how different kinds of teachers were distributed across the five schools. The results can also provide guidance in testing the social-similarity argument. In particular, the factor analysis indicates that age and tenure were the primary sources of demographic diversity in each school. Thus, age and tenure were a readily available source of social differentiation and were more likely to be salient characteristics. Given within-school variation in age and tenure, it would be informative to test the identification-based explanation for tie strength with either age or tenure. In particular, previous research has focused on the salience of race and gender in defining how much individuals identify and interact with members of their respective in-groups, and the results indicate that women and people of color are more likely to be strongly connected to members of their respective in-groups. Identification-based explanations for strong ties emphasize the importance of dynamics *inside* an organizational unit that make a characteristic more salient and therefore produce stronger relationships between in-group members. In the general population, people of color are part of a minority, and women are equally represented. The two conditions, minority status and equal representation, are conditions under which a characteristic is more likely to be salient. Thus, the exclusive focus on race and gender in prior research makes it difficult to know if the observed positive effects for race and gender result from dynamics inside an organizational unit or from the standing of women and people of color in the general population.

As age and tenure are the primary source of demographic diversity within each school and they vary within each school, it is possible for teachers who are the same age or tenure to be part of a numerical minority *inside* a school, and it is also possible for them to be part of a balanced unit independent of their standing in the general population outside the school. Age and tenure represent an opportunity to provide a more robust test of the identification argument. I test the social-similarity argument with age and not tenure, and I do so for two distinct reasons. First, like race and gender, age is a visible demographic characteristic (Tsui and Gutek 1999: 48). Therefore, variation in age is more likely to be visible than variation in tenure. Second, the age data were more complete (in terms of missing data) than the tenure data. But since age and tenure were correlated, they were more likely to be salient because in-group status with respect to age would be correlated with in-group status with respect to tenure. Thus, age could be more salient, either because of a school's composition with respect to age or because of the consolidation between age and tenure among the teachers. The increase in salience, however, should increase the positive association between age similarity and tie strength. I also test the social-similarity argument with organizational status. Organizational status was uncorrelated with age and the tenure variables in most schools, so the degree to which an individual identified with his or her organizational status when his or her status was salient should be uncorrelated with the extent to which the individual identified with his or her age.

When compared to age and organizational status, there was less within-school variation in race and gender. The results in Table 1 indicate that almost all the teachers were female. Men represented a numerical minority and although it would be informative to test the first prediction with the characteristic of male defining minority status, the number of male teachers was small. The results also indicate that each school had a distinct racial composition. The schools differed in the kinds of racial groups that were present and also in each racial group's representation when members of the group were present. Given the distinct racial makeup of each school, it would be hard to distinguish any effect associated with belonging to a racial group (e.g., both African

American) from unmeasured school effects. Given these data limitations and the possibility of putting identification-based explanations for tie strength on firmer empirical grounds by focusing on age, I focus on age and organizational status in my empirical analysis. I do, however, control for similarity in race and gender.

Tie Strength

Network data were collected using the sociometric roster approach (Wasserman and Faust 1994: 43-56). Each respondent was given a roster of names and asked to describe his or her relationship with each listed colleague in terms of communication frequency and emotional closeness. Emotional closeness and communication frequency represent distinct dimensions of tie strength (Marsden and Campbell 1984). To reduce the potential for survey response bias, tie strength data were collected at two distinct points in the survey. At the beginning of the survey, each teacher indicated how frequently he or she communicated ("less than once a month," "once a month," "multiple times a month," "once a week", "multiple times a week," "once a day," or "multiple times a day") with each listed colleague. At the end of the survey, each respondent was presented with the same roster of names and asked to describe his or her relationship with each colleague in terms of emotional closeness ("especially close," "merely close," "less than close," or "distant").

Analysis of the tie strength data indicated that the response rate to the emotional closeness question was lower on the initial two rounds of the survey. The reason for the low response rate is unclear. Responding to a sociometric question is time-consuming, and subjects were asked to respond to the emotional-closeness question at the end of the survey. However, conversations with teachers indicated that they were concerned about revealing those sentiments for particular colleagues. As a result, the emotional-closeness data were not collected after the second wave. A cross-tabulation of the two tie-strength variables indicated that they were significantly correlated at time 1 and time 2. Pearson's Chi-Square in the first period was 3,523 ($p < .001$), and in the second period it was 2,482 ($p < .001$). One can reject the independence assumption in both time

periods. Since more data were available for communication frequency, the predictions were tested with communication frequency as the primary indicator of tie strength. As a robustness check, however, the predictions were tested with the emotional-closeness data from the first two time periods.

Independent Variables

Social Similarity. Sharing a demographic or social characteristic is more likely to produce a strong tie when the focal characteristic is socially significant or salient. Thus, how two people respond to their social similarity is relative. In some instances, their social similarity will matter a great deal, and in other situations, it will not matter very much at all. The focus on relative similarity is consistent with the position taken by researchers who highlight the importance of relational instead of simple demography (O'Reilly et al. 1989, Tsui et al. 1992, Chatman et al. 1998). For example, instead of analyzing the influence of a person's age on the focal outcome (e.g., integration, satisfaction, etc.), relational demography researchers emphasize the importance of a person's relative age, because the meaning that an individual (and any other group member) assigns to a person's age depends on the age of other group members. Relational demography scores can be used to construct a social-similarity variable that is sensitive to where social similarity occurs in the broader characteristic distribution. For any focal characteristic, an individual has a relational demography score that describes where he or she is located relative to the typical member of the group. In the current context, $(x_{ikt} - x_{kt})$ measures how far away teacher i is from his or her colleagues at school k with respect to characteristic x at time t. x_{ikt} was the level of the focal characteristic x for person i in school k at time t, and x_{kt} was the mean of x in school k at time t when person i was not included in the calculation (Tsui et al. 1992: 561). If the focal characteristic is age, large positive values would indicate the focal individual

was much older than his or her peers, and large negative values would indicate the individual was much younger than his or her peers.

For two people, the product of their relational demography scores, $(x_{ikt} - x_{kt})(x_{jkt} - x_{kt})$, is a social-similarity variable. The magnitude of the variable is a function of the composition of the broader organizational unit. Consider a 100-person organizational unit composed of two age cohorts. Individuals in the younger cohort are 30 years old, and individuals in the older cohort are 40 years old. If the younger cohort contains 20 people and the older cohort contains 80 people, the individuals in the younger cohort represent a numerical minority, and the individuals in the older cohort represent a numerical majority. The social-similarity variable would equal 65 for two members of the younger cohort (i.e., the minority group), and it would equal 4 for two members of the older cohort (i.e., the majority group). If the younger cohort contained only 10 people and the older cohort contained 90 people, the variable would equal 82 for two members of the younger cohort, and it would equal 1 for two members of the older cohort. If the older cohort contained 80 people who were 50 years old, the variable would equal 261 for two members of the younger cohort, and it would equal 16 for two members of the 50-year-old cohort. The example illustrates that the magnitude of the social-similarity variable increases as people of a kind become more of a numerical minority and especially as members of the minority become more and more distant from members of the majority group. If the organizational unit was balanced, and younger people were 30 years old and older people were 40 years old, the social similarity would equal 25 for two members of either cohort. If the older cohort contained 50-year-olds, the social-similarity variable would equal 102 for two members of either cohort. Overall, the social-similarity variable varies in ways that are consistent with theoretical explanations for salience. If the organizational unit contains a minority and a majority group, the variable for the minority group increases as the minority group becomes more of a minority *and* as the distance between the minority and majority group increases. The variable declines for the majority group as its

members become more of a majority but to a lesser extent as the distance between the minority and majority grows. The presence of a very small but distant minority can increase the salience of social similarity for members of a majority group (Harrison and Klein 2007). If the organizational unit is balanced, the variable increases as the distance between the two groups increases.

The social-similarity variable is useful but far from perfect. In particular, if the distribution of the focal characteristic is skewed, normal, or bimodal, the variable produces scores that are consistent with prior theorizing. However, if the distribution is uniform or multimodal, the variable would be high for socially similar individuals at the edge of the distribution but low for similar individuals toward the center of the distribution. Under these conditions, one would be better off defining relational demography as a function of distances between individuals as opposed to distance from the mean, because under a uniform or multimodal distribution, defining relational demography as a function of distance from the mean would obscure important demographic information. Moreover, the rate at which the variable increases with minority status or with the distance between groups is arbitrary. One could imagine transforming the relational demography scores, which would affect the rate at which distance and representation contribute to the variable. However, I do not have a theoretical reason for preferring one transformation over another or over the raw relational demography scores, so I have used the most basic approach.

Proximity. Each teacher was scheduled to take breaks during the course of a day. Overlap in the break schedule provided teachers with the opportunity to interact. The variable break overlap was defined as the "break time" that teacher i spent with teacher j, $\text{break overlap}_{ijt} = \sum_{k} P_{ikt} P_{jkt}$. P_{ikt} equaled 1 if person i took a break during period k at time t. P_{jkt} equaled 1 if person j took a break during period k at time t. So $P_{ikt} P_{jkt}$ equaled 1 if both teachers took a break during period k at time t. Summing across all the breaks k for each time t defined the number of hours that teacher i and teacher j could have interacted. In addition to the break schedule, the physical layout

of the schools provided teachers with an opportunity to interact. Teachers with classrooms on the same floor had more opportunities. To test the effect that physical proximity had on tie strength, a same-floor indicator variable was created and set equal to 1 if two teachers had classrooms on the same floor.

The proximity variables are expected to have a positive effect on tie strength. It is possible, however, that people who want to be strongly connected act in ways to increase their physical and temporal proximity. Although I cannot rule out this possibility completely, there are reasons to suspect that any influence that reverse causality had on the observed association between proximity and tie strength was limited. For example, administrators at the schools maintained that they designed the break schedule to facilitate the education of students, so the schedule was more likely to be influenced by logistics and subject matter. However, it would be naïve to think that seniority, politics, and preferences did not play a role as well. And yet, even when these factors did influence when a teacher (or two teachers) took breaks, their effects were constrained by the number of teachers who could take breaks at the same time. Even if some teachers were able to decide when they took a break, the limit on the number of teachers who could take a break at the same time constrained the ability of teachers to take breaks only with colleagues they preferred. The result was that on average, overlap in the break schedule was outside the immediate control of individual teachers. A similar logic applies to the same-floor variable. Even if some teachers were able to select where their classrooms were located, their choices limited the alternatives that were available to other teachers. As a result, while it is possible that tie strength affects proximity, it is more likely that any association I observed between proximity and tie strength is a function of the effect that proximity has on tie strength.

Controls

The control variables were categorical and continuous. The categorical control variables were race (Asian, African American, Latino,White), gender (Female, Male), and teaching certificate

(Yes, No). The teaching-certificate variable is an indicator of knowledge and expertise because a teacher could apply for a certificate after he or she completed his or her M.A. degree. To control for any effect that being the same race had on how two teachers interacted, four same-race indicator variables were created (*both African American*, *both Asian*, *both Latino*, and *both White*). Cross-race interactions provided the baseline for the same-race effects. To control for any influence that being the same gender had on how two teachers interacted, two same-gender indicator variables were created (*both female* and *both male*). Interactions between men and women provided the baseline for the same-gender effects. To control for any effect that having the same level of education had on how teachers interacted, two same-education indicator variables were created (*both certified* and *both not certified*). Interactions between teachers with different education levels provided the baseline for the same-education effects. The teachers were responsible for a number of subjects across a number of grades. To control for any effect that overlap in subjects or grades could have produced, models control for overlap in the grades taught (*grade overlap*) at time t and for overlap in the subjects covered at time t (*subject overlap*). The grade overlap and subject overlap variables were continuous and although it seemed likely that grade and subject overlap would have an effect on how teachers interacted, the exact origin of that effect was unclear. Teachers who worked in the same area could have had more opportunities to interact, and the opportunities they had to interact could have been orthogonal to the opportunities defined by being on the same floor or taking breaks at similar times. Or two teachers who taught the same grades or subjects could have viewed themselves as being more similar, which could have resulted in stronger ties. Or teachers who taught similar subjects and grades could have been more relevant as colleagues, and the knowledge that they had in common could have made it easier for them to interact, thereby increasing the frequency of their communication. Although it seemed clear that the subject- and grade-overlap variables would have an effect on tie strength, it was unclear why. Therefore, instead of using the variables to test any of the predictions, the overlap variables were included as control variables. Finally, all

models included a fixed effect for four of the five schools to control for any unmeasured differences across schools and a fixed effect for three of the four time periods to control for any unmeasured differences in tie strength across time.

Results

The responses to the communication-frequency question were ordinal. The distances between response characteristics could be unequal. For example, the distance between "once a day" and "multiple times a day" could be larger than the distance between "less than once a month" and "once a month. Instead of assuming equal spacing, ordinal logits estimate the distance between consecutive response characteristics. A second methodological concern was the units of analysis. Dyads were the units of analysis and, after excluding missing data, there were 9,176 observations. The observations were not independent. Each teacher-colleague combination could be observed multiple times. This kind of clustering violates the independence assumption in regression analysis and can artificially deflate standard errors, thereby inflating significance tests. To adjust the standard errors, a random intercept was estimated for each teacher-colleague combination. In addition to adjusting the size of the standard errors for clustering, the random intercept controls for unmeasured dynamics that could have affected how a focal teacher interacted with a specific colleague. For example, formal work requirements could have affected how much a teacher communicated with a focal colleague. Or the teacher and the colleague could have been strongly connected to each other because they belonged to the same professional club or organization or simply traveled in the same informal social group. The ordinal logit model with random intercepts was estimated using the gllamm command in Stata.[6]

[6] More formally, the error term (ξ_{ijt}) in the equation describing the communication frequency between teacher i and colleague j at time t was assumed to equal $\zeta_{ij} + \varepsilon_{ijt}$. ζ_{ij} is a random intercept, and each intercept was specific to a teacher-colleague interaction. The random intercepts were assumed to be normally distributed with zero mean and variance ψ, with ψ being estimated from the data. During estimation, ζ_{ij} was not forced to equal ζ_{ji}. Substantive conclusions are the same if ζ_{ij} was assumed to equal ζ_{ji}. However, there is no reason why the unobserved dynamics that affected how a teacher interacted with a colleague should have the same effect on how the colleague interacted with the focal teacher. Moreover,

The random intercepts allow me to adjust the standard errors for clustering and also to control for omitted variables, but the approach is not without its limitations. In particular, I make some quite strong assumptions about the association between the random intercepts and the independent variables in the regression equation. I assume the independent variables are uncorrelated with the random intercepts (Rabe-Hesketh and Skrondal 2005: 95). The assumption seems reasonable for some unmeasured features (e.g., formal work requirements) of a relationship but unreasonable for other features (e.g., membership in the same informal group). This approach, however, represents an improvement over techniques that control for omitted variables only at the individual and not the dyadic level of analysis (Reagans 2005). It falls short of the ideal of being able to control for omitted features of a relationship that could be correlated with the independent variables in the regression equation. Estimating a fixed effect for each dyad would allow controlling for omitted variables that are correlated with the independent variables. The small number of observations for each teacher pair precludes adopting a dyadic fixed effect approach.

Descriptive statistics for the variables are in Table 2. Correlations are in Table 3. The row and column numbers in Table 3 correspond to the row numbers in Table 2. In the current organizations, the correlations between the variables that measure propinquity and the variables that measure salient social similarity were modest, and thus the two factors varied independently. The results from the ordinal logit are in Table 4. Predictors were introduced in blocks. The control variables were introduced in Model 1. The first hypothesis is tested in Model 2. The second hypothesis is tested in Model 3. Hypotheses 1 and 2 are tested in Model 4. Hypotheses 3a and 3b are tested in Model 5.

INSERT TABLE 2 & 3 ABOUT HERE

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interpersonal relationships are not reciprocal by definition (Carley and Krackhardt, 1996). A teacher and a colleague did not have to feel the same way about each other. Moreover, in addition to describing how frequently two teachers communicated, reported communication frequency most likely reflected differences in who initiated communication or the desire a teacher had to communicate with a specific colleague more frequently.

I focus on the estimates in Model 5. The coefficients for the control variables are consistent with prior research. For example, overlap in grades and subjects taught had a positive effect on communication frequency. As noted earlier, the positive effects associated with these control variables could reflect increased opportunity, social similarity, or the relevance of communication. With respect to gender, interpersonal connections between women were more negative than connections between men and women, while connections between men were more positive than connections between men and women. Men represented a minority population in the schools, while women were part of a numerical majority. Thus, the observed gender effects are consistent with the idea that people who are part of a numerical minority are more likely to be connected by a strong tie, whereas similar people are more likely to be connected by a weak tie when they are part of a numerical majority (Reagans 2005). A similar pattern was observed for education. When both teachers did not have a teaching certificate, the teachers communicated with each other more frequently. When both teachers were certified, they communicated less frequently. Uncertified teachers were part of a numerical minority, while certified teachers were part of a numerical majority. With respect to race, the coefficients for both African American and both White were positive and significant. The coefficient for both Asian was positive but was only marginally significant, and the coefficient for both Latino was not significant. Again, given the unique racial composition of each school, it is difficult to interpret the exact meaning of the same-race coefficients.

For the predictions, the results appear to provide only partial support for the first hypothesis. Consistent with the first prediction, the coefficient for the age-similarity variable is positive and significant.[7] However, the coefficient for the status-similarity variable is not significant. Although the coefficient for the status-similarity variable does not provide support for the first prediction, it

[7] Although I have focused on age similarity, teachers for whom age similarity is more likely to be salient are the same teachers for whom similarity in school or professional tenure is more likely to be salient. Thus, the observed effect for age similarity more than likely reflects the combined influence of salience with respect to representation and the consolidation of multiple demographic characteristics.

is possible that it is inappropriate to test the first prediction with the status data. Salience-based explanations for strong ties assume that individuals are aware of their similarity. Teachers who were similar in terms of their organizational status could have been unaware of their social similarity. Not only is status less visible than age, but in each school, there was more variation with respect to age than status. Therefore, when compared to differences in age, differences in status were more fine grained and could have been more difficult to detect. Moreover, two teachers with the same public standing in the status hierarchy could have held very different private beliefs about their social standing (Anderson and Spataro 2005). Variation in private beliefs would affect the salience of status similarity and therefore the extent to which similarity in status translated into more-positive relationships. Thus, instead of providing mixed support for the first prediction, the results for organizational status help clarify the factors that underlie the social-similarity effect. In particular, individuals have to agree they are socially similar. If possessing a characteristic or if membership in a group is ambiguous and/or open to self-serving interpretations, people who appear to be similar (i.e., are similar on the surface) could disagree about their similarity, which would reduce any effect surface similarity could have on the strength of their relationship.

The results provide unambiguous support for the second prediction. The coefficient for the break-overlap variable is positive and significant, as well as the coefficient for the same-floor variable. The results indicate that teachers with classrooms on the same floor or who had more opportunities to interact communicated with each other more frequently. Since the main effect for the status-similarity variable was not significant, the interaction terms to test the third hypothesis were calculated for the age-similarity variable. The coefficient for the interaction between age similarity and the same-floor variable is positive and significant. The coefficient indicates that age-similar teachers communicated with each other more frequently when they were on the same floor and age-dissimilar teachers communicated with each other less. This was especially true for teachers for whom age was more likely to be salient. The coefficient for the interaction between

age similarity and break overlap was not significant. Therefore, the empirical results provide only moderate support for Hypothesis 3a. Model 6 replaces communication frequency with emotional closeness as the dependent variable, and the coefficients for the variables of interest are essentially the same. Both proximity variables had a positive effect on emotional closeness, and the coefficient for the age-similarity variable was also positive and significant. However, the coefficient for the interaction between age similarity and the same-floor dummy was not significant. Recall that the emotional-closeness data were available only during the first two time periods. If Model 5 is re-estimated with data from the first two time periods, the coefficient for the interaction term between the age similarity variable and the same floor variable is not significant. Detecting a significant interaction requires more data and it is possible that with more emotional-closeness data, the interaction between the age similarity variable and the same-floor variable would be positive and significant.

Summary and Discussion

My research objective was to analyze how social similarity and propinquity contribute to strong network connections alone and when combined with each other. Although a number of studies have documented the importance of either social similarity or propinquity, very few have focused on how the two mechanisms combine to produce strong ties. In addition to having a direct effect on tie strength, propinquity could moderate the positive association between social similarity and tie strength. Being in close proximity could either increase or decrease any positive social-similarity effect. In an analysis of network connections among teachers working in five public schools, I found that age similarity and propinquity had positive effects on tie strength. I also found that proximity in space amplified the positive association between age similarity and tie strength.

The findings illustrate how social similarity and propinquity contribute to strong ties and, in so doing, help clarify an important theoretical framework. It is widely believed that the positive effect that an increase in the salience of social similarity can have on tie strength will come at the expense of the positive effect that opportunity can have on relationships between dissimilar individuals (Blau and Schwartz 1984, Brewer and Kramer 1985, Moody 2001, Hewstone et al. 2002). Scholars who adopt this view focus on how the demographic diversity of an organizational unit affects the salience of social similarity *and* the opportunities that individuals have to interact with dissimilar colleagues. Researchers have theorized that an increase in the demographic diversity of an organizational unit increases the salience of social similarity, which in turn increases the positive effect that social similarity can have on tie strength, but the same increase in diversity should also provide individuals with fewer opportunities to interact with dissimilar colleagues, reducing the positive effect opportunity can have on relationships between dissimilar colleagues. Therefore, an increase in demographic diversity sets in motion a sequence of events that produce a trade-off between social similarity and opportunity.

Among the teachers I studied, I found no evidence for a proposed trade-off between salience and opportunity. The correlations between the indicators of propinquity (i.e., the same-floor and break-overlap variables) and salient social similarity (i.e., the age- and status-similarity variables) were modest. An increase in one mechanism did not come at the expense of an increase in the other. The research findings do indicate that the positive effect that opportunity had on relationships between socially dissimilar people declined as social similarity became more salient. Recall that the positive effect of age similarity on tie strength was even more positive under the conditions that should have increased the salience of being similar in age. And the positive age-similarity effect was even more positive when teachers of the same age had rooms on the same floor. Thus, any negative effect that age dissimilarity had on tie strength was even more negative when age-dissimilar teachers were more aware of their differences and also had classrooms on the same floor. Or, in other words, the positive effect that physical proximity had on relationships

between age-dissimilar teachers declined as differences in age became more salient. Thus, the empirical results are consistent with prior theorizing in the sense that the positive effect that opportunity had on the strength of relationships between dissimilar individuals declined as social differences became more salient. The decline in the opportunity effect was not a function of dissimilar individuals' having fewer opportunities to interact with each other. As differences in age became more salient, age-dissimilar individuals were less likely to take advantage of the opportunity to build a strong tie. The decline was significant and theoretically interesting; however, it should be considered in the context of the large and positive effect that propinquity had on tie strength. Overall, the results indicate that teachers did develop strong ties with age-dissimilar colleagues as their opportunity to develop a strong tie increased.

The research findings are important because they shift our attention away from either salience- or opportunity-based explanations for strong ties and refocus our attention on how the two mechanisms can combine in the production of network connections. I emphasize *can* because although I found a positive interaction between social similarity and propinquity among the teachers I studied, it is not immediately clear that propinquity will always increase the positive effect that social similarity can have on tie strength. In fact, I expected to find a negative interaction between social similarity and propinquity if people who were similar on the surface did not share important attitudes, behaviors, and beliefs. If socially similar individuals are only similar on the surface, more-frequent interactions should reveal how little they actually have in common and therefore reduce the positive effect that surface similarity can have on network connections (Ziebro and Northcraft 2009). I expected to find a positive interaction between social similarity and propinquity if surface and deep similarity were consolidated or congruent.

There was a positive interaction between age similarity and propinquity. And although it is possible that teachers who were similar in age were also similar in unobserved attitudes, behaviors, and beliefs, prior research has established that the association between surface and deep similarity is often weak (Harrison et al. 1998). Perhaps the critical issue is not what people

actually have in common but what they believe they have in common. If an individual identifies with a demographic characteristic, perhaps he or she could assume that everyone who shares the characteristic also possesses the behaviors and characteristics that define in-group status (Hannan et al. 2007: ch. 5). Identification with a salient characteristic could increase the tendency to give in-group members the benefit of the doubt during interactions. If in-group members are assumed to possess certain behaviors and characteristics, an individual is more likely to notice those behaviors and characteristics when they are exhibited. Individuals often see what they expect to see and do not see what they do not expect to see. If individuals are motivated to draw distinctions between themselves and members of their in-group, perhaps because they compete against members of their in-group for attention (Reagans 2005) or because they are concerned about how ties to in-group members will affect their standing in the larger group (Duguid et al. 2010), proximity would provide them with more opportunities to justify those differences. Identifying the set of factors that shape how propinquity moderates the association between social similarity and tie strength seems worthy of future inquiry.

This project makes a number of contributions to existing research on network formation. However, like any research project, it is not without its limitations. For example, although the analysis is based on tie-strength data collected at four different times, the relationships are not new, and the empirical analysis focused on the level of tie strength. Significant insight could be gained by analyzing how the causal factors operate in a dynamic framework. For example, the main effect for age similarity suggests that people defy propinquity and go out of their way to develop strong ties with socially similar colleagues when being the same is salient. It is possible that when social similarity is salient, socially similar people self-select into situations that provide them with more opportunities to interact (Denrell 2005). This raises the question of how much effort individuals are willing to exert to find similar others when a demographic or social characteristic is salient (Ibarra et al. 2005). Moreover, I have emphasized the importance of salience and in-group identification in producing the positive effect that social similarity can have

on tie strength. Prior research has established that individuals are more likely to identify with a salient characteristic and that identification with a characteristic has a positive effect on ties with in-group members. My social-similarity variable was constructed to be high when the conditions that increase salience are present (i.e., when similar individuals are part of a numerical minority or a balanced group). I did not measure salience or in-group identification and thus do not know whether this social-similarity variable predicts either dynamic. This is clearly a limitation of the study. A more systematic analysis would consider the extent to which the social-similarity variable predicts salience and in-group identification and the extent to which these dynamics mediate the association between the social-similarity variable and tie strength.

Despite these limitations and others, the current project advances our understanding of dynamics that can affect the origin of strong interpersonal connections. Scholars would be well advised to consider in future research how social similarity and propinquity combine in the production of strong ties and the dynamics that shape how propinquity moderates the association between social similarity and tie strength.

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Table 1 Individual Characteristics and Response Rate

	Female	African American	Asian	Latino	White	Age	Tenure in school	Tenure in profession	Status	Response rate
School A	100	10	0	0	90	43	10	13	.17	87
School B	94	5	6	2	88	45	11	15	.14	66
School C	90	9	11	43	37	38	6	10	.15	85
School D	91	0	0	5	95	44	9	19	.19	89
School E	79	15	12	31	42	32	3	5	.19	74

Note. The race proportions in School B do not sum to 100 percent because of rounding.

Table 2 Descriptive Statistics

	Mean	Standard Deviation	Minimum	Maximum
1. Communication frequency	4.20	1.88	1	7
2. Same grades	.46	.86	0	7
3. Same subjects	2.47	1.92	0	6
4. Both certified	.51	.49	0	1
5. Both not certified	.11	.31	0	1
6. Both female	.88	.31	0	1
7. Both male	.003	.05	0	1
8. Both African American	.002	.05	0	1
9. Both Asian	.003	.06	0	1
10. Both Latino	.03	.18	0	1
11. Both White	.64	.47	0	1
12. Break overlap	3.45	2.62	0	19
13. Same floor	.30	.46	0	1
14. Age teacher	42.87	13.49	23	68
15. Age colleague	42.92	13.47	23	68
16. Age similarity	-6.28	171.05	-506.24	559.11
17. Status teacher	.27	.28	0	1
18. Status colleague	.27	.28	0	1
19. Status similarity	.002	.08	-.20	.71

Table 3 Correlations							
	1	2	3	4	5	6	7
1. Communication frequency	1.0000						
2. Same grades	0.2407	1.0000					
3. Same subjects	-0.0708	-0.3877	1.0000				
4. Both certified	0.0153	0.1487	-0.1070	1.0000			
5. Both not certified	0.0390	-0.0743	0.0354	-0.3709	1.0000		
6. Both female	-0.0570	-0.1270	0.1345	-0.0031	-0.0148	1.0000	
7. Both male	0.0419	0.0587	-0.0371	0.0053	-0.0091	-0.1557	1.0000
8. Both African American	0.0219	-0.0065	0.0084	-0.0164	0.0279	-0.0284	0.0029
9. Both Asian	0.0100	-0.0253	0.0265	-0.0497	0.0583	0.0216	-0.0034
10. Both Latino	0.0105	-0.0387	0.0834	-0.1278	0.1465	0.0675	-0.0105
11. Both White	0.0967	0.0214	-0.1242	0.2567	-0.2849	0.0491	-0.0162
12. Break overlap	0.1930	0.1524	0.0023	0.0653	-0.0494	0.0446	-0.0334
13. Same floor	0.2359	0.0853	0.0453	-0.0200	0.0552	0.0630	-0.0066
14. Age teacher	0.0268	0.1187	-0.1143	0.3468	-0.2628	0.0551	-0.0104
15. Age colleague	0.0167	0.1180	-0.1139	0.3436	-0.2598	0.0551	-0.0106
16. Age similarity	0.1049	0.0291	0.0272	0.0497	0.0917	-0.0079	-0.0040
17. Status teacher	0.0385	-0.0299	0.0305	0.0600	-0.0256	-0.0078	0.0125
18. Status colleague	0.1007	-0.0310	0.0326	0.0559	-0.0204	-0.0095	0.0123
19. Status similarity	0.0507	-0.0097	0.0118	0.0246	-0.0114	-0.0048	-0.0033
	8	9	10	11	12	13	14
8. Both African American	1.0000						
9. Both Asian	-0.0031	1.0000					
10. Both Latino	-0.0098	-0.0115	1.0000				
11. Both White	-0.0693	-0.0808	-0.2525	1.0000			
12. Break overlap	-0.0316	-0.0117	-0.0363	0.1759	1.0000		
13. Same floor	-0.0344	-0.0124	0.0325	0.0176	0.1395	1.0000	
14. Age teacher	0.0096	-0.0502	-0.0865	0.1897	0.0186	-0.0115	1.0000
15. Age colleague	0.0130	-0.0505	-0.0873	0.1853	0.0152	-0.0137	0.0490
16. Age similarity	0.0088	0.0599	0.0020	-0.0123	0.0290	0.0029	-0.0226
17. Status teacher	-0.0219	-0.0081	-0.0138	0.0800	-0.0089	-0.0056	0.1565
18. Status colleague	-0.0093	-0.0083	-0.0145	0.0747	-0.0120	-0.0078	0.0008
19. Status similarity	-0.0130	-0.0121	-0.0044	0.0367	0.0209	-0.0032	0.0362
	15	16	17	18	19		
15. Age colleague	1.0000						
16. Age similarity	-0.0248	1.0000					
17. Status teacher	0.0021	-0.0030	1.0000				
18. Status colleague	0.1522	-0.0028	-0.0062	1.0000			
19. Status similarity	0.0353	0.0000	0.1988	0.1954	1.0000		

Table 4 Predictors of Communication Frequency

	I. Controls	II. Social similarity	III. Opportunity	IV. Similarity & opportunity	V. Similarity X opportunity	VI. Emotional closeness
Same grades	1.088•	1.082•	.972•	.962•	.962•	.331•
	(.060)	(.060)	(.059)	(.059)	(.059)	(.075)
Same subjects	.139•	.126•	.111•	.097•	.096•	.037
	(.027)	(.027)	(.026)	(.026)	(.026)	(.035)
Both certified	-.113	-.203•	-.083	-.192•	-.196•	.229
	(.096)	(.100)	(.094)	(.098)	(.098)	(.135)
Both not certified	.535•	.420•	.504•	.393•	.395•	.856•
	(.153)	(.154)	(.150)	(.150)	(.150)	(.219)
Both female	-.554•	-.541•	-.606•	-.599•	-.604•	.005
	(.171)	(.168)	(.166)	(.163)	(.163)	(.215)
Both male	1.982•	1.936•	1.983•	1.931•	1.915•	-.182
	(.933)	(.918)	(.906)	(.888)	(.888)	(1.105)
Both African American	1.742	1.717	2.304•	2.278•	2.287•	1.266
	(.990)	(.974)	(.956)	(.939)	(.938)	(1.260)
Both Asian	1.615•	1.273	1.613•	1.274	1.282	1.574
	(.822)	(.812)	(.798)	(.785)	(.784)	(1.120)
Both Latino	.519	.514	.308	.295	.301	1.140•
	(.300)	(.295)	(.291)	(.285)	(.285)	(.370)
Both White	1.222•	1.172•	1.201•	1.144•	1.136•	1.300•
	(.137)	(.135)	(.133)	(.131)	(.130)	(.175)
Break overlap		___	.069•	.072•	.071•	.070•
			(.015)	(.015)	(.015)	(.022)
Same floor		___	1.516•	1.539•	1.559•	1.190•
			(.106)	(.104)	(.105)	(.146)
Age teacher		.003	___	.005	.005	.022•
		(.004)		(.004)	(.004)	(.005)
Age colleague		-.001	___	.001	.001	-.008
		(.004)		(.004)	(.004)	(.005)
Age similarity		.002•	___	.002•	.001•	.004•
		(.0003)		(.0002)	(.0004)	(.0006)
Status teacher		.085	___	.159	.161	-.134
		(.140)		(.137)	(.137)	(.221)
Status colleague		.895•	___	.956•	.957•	1.885•
		(.140)		(.138)	(.138)	(.229)
Status similarity		.204	___	.253	.242	.001
		(.438)		(.433)	(.433)	(.757)
Age similarity X Break overlap					.000	-.000
					(.000)	(.000)
Age similarity X Same floor					.001•	-.000
					(.0005)	(.0007)
Log likelihood	-15135	-15089	-15020	-14966	-14964	-47000
/cut 1	-3.630	-3.425	-3.006	-2.652	-2.660	-2.529
/cut 2	-2.334	-2.133	-1.720	-1.369	-1.378	1.483
/cut 3	-.879	-.681	-.2778	.068	.058	5.825
/cut 4	.553	.747	1.148	1.489	1.480	___
/cut 5	2.902	3.091	3.500	3.834	3.825	___
/cut 6	4.597	4.781	5.203	5.529	5.522	___

• $p < .05$.

The table includes coefficients with their standard errors in parentheses. Models I-V include four fixed effects to control for unmeasured school effects and three fixed effects to control for time. Model VI includes four fixed effects to control for unmeasured school effects and one time dummy.

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The Sociology of Social Inclusion

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Abstract

This article looks at social inclusion from a sociological perspective. It argues that sociology complements biological and other natural order explanations of social stratification. The article interrogates a variety of forms of social integration, including ostracism within 5th century B.C. Greece, 19th-century solidarism, and Goffman's mid-20th-century work on stigma. It does so to demonstrate how in each of these contexts, social inclusion and exclusion can function as apparati that problematize people on the margins, and by extension, contribute to their governance and control. The article proposes that sociology provides a valuable orientation from which to consider social inclusion because it illuminates how social integration maintains and manages the ways in which people move about and through their socially stratified worlds.

Keywords

social inclusion, social exclusion, social integration, social stratification, sociology

> We live in the state and in society; we belong to a social circle which jostles against its members and is jostled by them; we feel the social pressure from all sides and we react against it with all our might; we experience a restraint to our free activities and we struggle to remove it; we require the services of other [people] which we cannot do without; we pursue our own interests and struggle for the interests of other social groups, which are also our interests. In short, we move in a world which we do not control, but which controls us, which is not directed toward us and adapted to us, but toward which we must direct and adapt ourselves.
>
> Gumplowicz, 1963, p. 6

This article considers the concept of social inclusion from the perspective of sociology. In doing so, it aims to complement the work of historians, economists, psychologists, and natural scientists to better understand the origins of the social inclusion concept. It argues that action and efforts to include or exclude individuals and social groups are fundamental to society as forces that govern through the oppressive or liberating effects such inclusionary or exclusionary actions promote.

As a discipline from which to consider the social inclusion and exclusion concepts, sociology offers an excellent vantage. Sociology is well oriented to consider facets of social equality and inequality, social integration and stratification, social mobility as it relates to social inclusion and exclusion, and the functional contributions of the periphery relative to the social core. Sociology provides a needed vantage from which to consider social inclusion as it lends itself to extension beyond economic or natural fitness.

In the social world, whether one is welcomed, represented, or provided for by the mainstream, or whether one is ostracized, ignored, or bemired, the outcome is a collection of social practices. These social practices result from various degrees of intimacy and interactions between friends, strangers, families, colleagues, kinship groups, communities, cultures, and even whole societies—all of which lend themselves to sociological study.

This article begins with a consideration of exclusion and inclusion societies across time and place, including gated communities, closed institutions, and caste systems. The article delves into what is described as the natural order of social inclusion and exclusion. It explores some of the theories and findings that have come out of such an approach, including the evolutionary and sociobiological work in the area. To make its case for a sociology of social inclusion, the article then gazes back in time to three examples: ostracism in 5th-century Athens, solidarism in 19th century France, and contemporary considerations of stigma as influenced by the work of Goffman. Building on this, the article proposes that societies which emphasize differences in social integration are structured by architectures of inclusion that govern and manage how marginal women and men inhabit social space, while functioning to maintain many of the attributes of the status quo.

Exclusion Hierarchies

More than 50 years ago, the anthropologist and sociologist David Pocock (1957) reflected that processes of inclusion and exclusion were features of all hierarchies. Pocock felt

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that in general terms, the discussion of inclusion and exclusion fed into efforts to define what might be called a social ontology, or the way that the existence and social positioning of groups in a hierarchically structured society would be explained. Such a social ontology has been described by Sibley (1995) as a landscape of exclusion; a form of social and philosophical geography that melds ideology with place in an exercise of social, economic, and political power that invariably results in forms of oppression, and in many instances, exploitation (Towers, 2005). Fredericks (2010) suggested that belongingness as experienced in everyday relations constructs the kinds of sentiments on which societies of exclusion (and inclusion) are based. Referencing the work of De Certeau (1984), Fredericks makes the case for the importance of the everydayness of belonging and attachment, and the memory and tradition it reinforces as means of appropriation and territorialization.

One example of such a landscape of exclusion is a gated community (Hook & Vrdoljak, 2002). Grant and Rosen (2009) proposed these communities exist as exclusion societies. They cite Flusty's (2004) argument that the community gates that enclose act to protect those inside from unforeseen and largely unwanted encounters with otherness. Examples given range from urban gated communities where exclusion is legitimized as spatial inequity (Flusty, 2004) to the present security fences undulating across Israel, or separating the United States from Mexico (Kabachnik, 2010).

Herbert (2008) reflected on the ways in which urban spaces in the United States and elsewhere are turned into exclusion societies through the criminalization of public spaces outside the rarefied protected enclaves shielded within gates and walls. Focusing on the disorderly, Herbert describes this exclusion as a form of modern day prohibition that cedes out the homeless, the transient; and those who loiter, panhandle, and display public drunkenness (Douglas, 1966). Herbert found that these practices of creating exclusion societies are not new; that they have and continue to be used as justifications for forms of social cleansing (Cresswell, 2006; Dubber, 2005; Duncan, 1978; Spradley, 1970).

Essentially the physical embodiment of territorial actions, exclusion societies seek to separate and compound the favored from the disfavored, and the hygienic from the dirty (Douglas, 1966; Sibley, 1995). To do this, they collectively create spaces of inclusion and exclusion, even if not all parties cede to such collectivism.

Disability, like gated communities, is another example of the ways societies create cultural spaces structured by exclusion. Kitchin (1998) described the reproductive nature of disablist practices, as assemblies that seek to ensure disabled people are kept in certain places from where they come to understand when they may be out of place. For Kitchin, social relations between the disabled and the able-bodied function to keep disabled people in their place and to signal when they may be stepping beyond this space.

Prisons, like asylums and other places that remove individuals from broader social life are additional if somewhat more extreme forms of exclusion societies. These institutions enclose the daily lives of certain social actors from broader society, replacing wider interaction with complex subcultures (Baer, 2005).

An altogether different type of exclusion society is a caste system, which relies less on geographical separation and more on social distance. A notable example is the caste system of India (Nayar, 2007). At the root of India's exclusion society are the untouchable castes whose marginal social position is owed to their relationship to impurities associated with death and organic pollution (Deliege, 1992).

Berreman (1967, referencing Davis & Moore, 1945; Lenski, 1966; Mills, 1963; Tumin, 1953), held that caste systems—unlike gated communities, inner cities, orphanages, leper colonies, asylums, and prisons—are fundamentally structures through which power and privilege are allocated via interdependent social classifications ordered by stratified and ranked divisions of labor. Mencher (1974) referenced Leach (1960) in suggesting that India's caste classifications facilitate divisions of labor free of the competition and expectations of mobility inherent in other systems.

As exclusion societies, caste systems perpetuate themselves and the positions of privilege provided to those included within them. Yet they are different from other exclusion societies because across many noncaste landscapes of exclusion, mobility is conceivable and emulation of status is possible. However, in caste systems, place within the exclusion or inclusion hierarchy is ascribed at birth (Berreman, 1967, referencing Bailey, 1957; Sinha, 1959, 1962; Srinivas, 1956, 1966). Such exclusion by ascription has an economic dimension also through the way in which untouchables are "denied control of the means of production" (Deliege, 1992, p. 170, referencing Oommen, 1984). This results in forms of deprivation and poverty that enforce dependence, deference, and ultimately acceptance.

Exclusion societies are identifiable at different places in time, space, and geography. Such societies tend to be associated with differential access to social and economic well-being, and differential proximity to illness and disease. Inclusion societies, however, evolve from within such contexts. They are characterized by movements toward greater social justice, equality, and collectivism in response to the kinds of global oppressions exclusion societies embody and perpetuate.

A Natural Order

Mechanisms of social inclusion and exclusion and the effects of these have been thoroughly investigated within the field of psychology and related disciplines. Work in this area has sought to better understand possible evolutionary origins of social inclusion and exclusion, and potential

sociobiological purposes to these different explanations of integration (Kurzban & Leary, 2001).

Eisenberger and Lieberman (2005) and MacDonald and Leary (2005) have approached inclusion and exclusion from a psychosocial and physiological perspective in which they consider how the impacts of these social practices share overlapping characteristics with our physical pain systems. Eisenberger and Lieberman reflected that our social interconnectivity is as fundamental as our most basic human needs for fire, sustenance, and shelter and that the absence of such connectivity is experienced, literally, as pain. They propose that the pain of social exclusion, separation, or rejection share many of the experiential attributes of forms of physical pain. Referencing Baumeister (2000), Eisenberger and Liberman described how across many centuries and cultures, various forms of storytelling and artistic expression reflect how the interruption, loss, or absence of social bonds can manifest as intense experiences of human pain and suffering. They point out that the pain and suffering associated with the loss of social bonds is recognized by many legal systems also.

To help explain the social, psychological, and physical pain experienced by exclusion, Eisenberger and Lieberman (2004) developed *pain overlap theory*. This theory holds that different kinds of pain utilize elements of shared processing systems. As reflected by MacDonald and Leary (2005), among our less developed ancestors, both physical and social pain were functional in that they steered kin and other social groups from environmental and other threats, reorienting them in the direction of helpful others. As such, the social pain of exclusion was seen to have evolved as a means of responding to danger.

In detailing their *sociometer theory*, Leary, Tambor, Terdal, and Downs, (1995) explained why inclusionary and integrational practices are so fundamentally important to social interactions and how we are designed to detect them. They note that many writers have suggested that the human need to seek inclusion and to avoid exclusion is essential, and furthermore, that as a developmental trait, this orientation likely can be traced to its survival benefit (Ainsworth, 1989; Barash, 1977; Baumeister & Leary, 1995; Baumeister & Tice, 1990; Bowlby, 1969; Hogan, 1982; Hogan, Jones, & Cheek, 1985).

For Leary et al. (1995), an individual's sociometer is managed through self-esteem where social inclusion and exclusion are used as mechanisms to monitor the well-being of an individual or group's social relations. These authors use the sociometer to underscore pain overlap theory by suggesting that self-esteem is a kind of inclusion detector that meters changes in the inclusionary or exclusionary positioning of individuals. From this perspective, it would be this need for detection that ultimately drives individuals to maximize their quest for inclusion while minimizing the possibility of exclusion.

Along with the overlapping pain thesis and the sociometer/self-esteem thesis, Baumeister and Leary (1995) have posited a *belongingness thesis*. This suggests the need to belong is a fundamental human motivation. Here, along with base needs like food and shelter (Bernstein, Sacco, Young, Hugenberg, & Cook, 2010), belongingness is held to be a foundational human need that results in a general pattern whereby social inclusion is used to reward, and social exclusion to punish. The outcome is a gauge that structures both social values and comportment (Baumeister & Leary, 1995).

Whereas a sociological perspective might suggest at the societal level that there exist a series of motivations to *design* inclusive frameworks for the betterment of social life, a natural order perspective would suggest that basic human survival and reproduction benefit from the evolution of cohesive group living; that to an extent, inclusion and exclusion as components of a behavioral repertoire may have helped to ensure evolutionary and reproductive fitness (Leary et al., 1995). This thinking suggests that such fitness at the level of kin networks or community groups may mirror existing physiological traits for responding to physical pain, to also structure responses to social pain. From this perspective, the exclusion/inclusion continuum exists alongside a biologically driven, psychological reaction that leads to the adoption of a generalized dislike of social exclusion and a favoring of the maintenance of adequate inclusion (Eisenberger & Lieberman, 2005; MacDonald & Leary, 2005).

Such arguments present another perspective as to why different societies and social groupings across diverse historical periods and geographical locations develop intense drives to create and strengthen social institutions around various aspects of social integration and exclusion. Yet, as the examples of ostracism, solidarism, and stigmatism will reflect, any biological *push* with regards to social stratification is accompanied by a social world *pull*. The examples of ostracism, solidarism, and stigmatism will demonstrate how at different intervals in history, it is not necessarily biological forces but instead social architectures that become employed in the creation and continuance of inclusion societies.

Ostracism

Acts and practices of including or excluding others as aspects of systems of stratification may be as old as much of humanity itself. Certainly, most societies display some degree of taboos and customs concerning forms of both social rejection and social acceptance (Douglas, 1966, Gruter & Masters, 1986; Lévi-Strauss, 1963; Radcliffe-Brown, 1952).

In institutional terms, a very early form of social exclusion is evident in the scholarship of the role of ostracism in Athens, Greece, during the 5th century B.C., when the provision of an official mechanism to institutionalize ostracism was enacted.

Although there is some debate within the works of Aristotle and Androtion as well as subsequent scholars about whether the law of ostracism originated with Cleisthenes

prior to the first official ostracism of Hipparchos, son of Charmos, in 488 B.C. (Kagan, 1961; Raubitschek, 1951; Robinson, 1939, 1945, 1946, 1952), there is consensus that the law appeared sometime in the 20 years surrounding the battle at Marathon. The law of ostracism was instituted as a means to protect young democratic institutions from the resurgence of tyranny (Raubitschek, 1951). It did so through the enactment of an *ostrakophoria* (Goligher, 1910, p. 558, referencing Carcopino, 1909; Rehbinder, 1986, p. 323). Thus, ostracism was considered a democratic process in which those who were qualified to vote would "scratch onto a clay shard the name of a party leader to be banned (hence the name ostrakismos = shard judgment)" (Rehbinder, 1986, p. 323).

As an initial incident in a series of expulsions driven by the desire for political control (Kagan, 1961), the very first political ostracism was followed by the successive exclusion of Magakles in 487-6, Xanthippos in 485-4, and Aristeides in 483-2.

As institutionalized more than 25 centuries ago, ostracism was used almost exclusively as a political weapon against male generals (Raubitschek, 1951), as a means to mitigate the influence of political rivals (Kagan, 1961) and to police and control the well-being of the state. Rehbinder (1986) suggested the main aim of ostracism was to "exclude the losing party leader from the state" as "early democracy could not integrate the continuous action of opposition parties into the political process" (p. 321). To address this and to solve party conflicts, a law of ostracism essentially functioned to banish the leader of the opposition.

Importantly, Athenian ostracism was levied against an already elite class who for tyrannical activities or suspicions of tyranny were considered political liabilities or dangers. These acts did not bring shame on the recipient, but rather were prestigious, even honorable—a status reflected in the convention for the ostracized individual to retain his property, and, after his return, to regain his elite personal and social status (Rehbinder, 1986).

As Aristotle wrote in *Politics*:

> Democratic states institute the rule of ostracism [because] such states are held to aim at equality above anything else; and with that aim in view they used to pass a sentence of ostracism on those whom they regarded as having too much influence owing to their wealth or the number of their connexions or any other form of political strength. (Barker, 1952, p. 135, referenced in Masters, 1986, p. 390)

Ostracism as it came to be enacted in Attic democracy was not an event applied lightly or arbitrarily. It required careful deliberation, a large quorum, and the immunity of an ostracized person's family. In essence, ostracism acted like a safety valve that ensured a smoother, more peaceful, and less tumultuous running of the state (Kagan, 1961).

As instituted at the time, the law of ostracism was seen to be successful. It so weakened the ability of potentially disruptive subversive groups to wreak havoc on society and its political systems, that in the more than 90 years between 508 and 417 B.C., no more than 20 official ostracisms took place (Ostwald, 1955).

Given that modern industrial societies increasingly tend to frown on the kinds of excluding practices as reflected in the legal practice of ostracism (Rehbinder, 1986), it can be challenging to acknowledge that ostracism exists in contemporary societies also, legally through, for example, formal punishments such as imprisonment, or racial prejudice, scapegoating, and xenophobia (Gruter & Masters, 1986). For Kort (1986), ostracism can be considered as coerced or involuntary exit of an individual or individuals from the society in which they live that manifests as a range of exclusions. Thus, a society demonstrating variation in ostracism practices reflects a society with solidaristic strategies for the exclusion of its members from participation and from occupying positions of respect (Kort, 1986, referencing Masters, 1986).

Solidarism

To turn from the ostracism of 5th-century Athens to the solidarism of late-19th-century France, allows for the contrast of an early institutional approach to social exclusion with an equally enlightening historical era of inclusion.

The concept of solidarism evolved in the late-19th-century in France during a period of social, epistemological, and ontological change. It was an age when understandings of autonomy were being reconsidered by "scientism, political ideologies (especially Marxism) and the Roman Catholic Magister," entities united in their intent to denounce an increasing vanity-like individualism (Vincent, 2001, p. 414).

Although, within this period, the idea of solidarity was not an established ethical reference, French Protestants united around this new form of solidarity known as solidarism. In doing so, the Protestants defined a path forward in their transformed identity as a social minority (Vincent, 2001).

For this underclass, being an excluded minority was not seen as a stance from which to claim social or human rights. Rather, exclusion was seen as igniting the kind of freedoms of thought and associations, which lent themselves to the reconciliation of identity-lending conceptualizations like justice and liberty (Vincent, 2001).

Although French Protestants were bound by religion, their move to solidarism is not seen as being directly related to religious teachings or directives. If anything, French Protestantism of this period was wary of "religious pietism and political liberalism and generally suspicious of any institutional expression of the desire for social justice" (Vincent, 2001, p. 415). As a result, they turned instead to groups not known as religious in connotation, such as trade associations, unions, and left-of-centre political parties.

It has been suggested that the story of solidarism is essentially the story of France's move to the welfare state. In opposing collectivism because it potentially threatened individual liberty, while promoting the empowerment of the working class, the new philosophy of solidarism countered the individualism of laissez-faire liberalism and social Darwinism. In time, solidarism would come to help to dismantle existing resistance to social reform and to usher in this new era of Welfarism (Sheradin, 2000).

Léon Bourgeois's book *Solidarité* (1998), which first appeared in 1896, is held to be a form of manifesto for the solidarism movement. In the decades prior to the First World War, the newly empowered French Radical Party were looking for a philosophy that would help them to maintain central power against the right-leaning individualists and the left-leaning collectivists (Hayward, 1961, 1963). In 1895-1896, during the short-lived Radical government of Bourgeois, he published a pamphlet titled *Solidarité* based on a series of his public letters that had appeared earlier. The main intent of this document was to advocate for a new approach, between "retreating laissez-faire liberalism and ascendant socialism." The aim of the particular piece of writing was to shine a light on "the duties that citizens owed to each other" (Koskenniemi, 2009, p. 285).

Bourgeois's *Solidarité* is seen as representing what has been described as a *belle époque* within the Third Republic (Hayward, 1963). Solidarism became the main social philosophy of his new radical party (Koskenniemi, 2009), orienting it and the nation toward what in time would become a new more inclusive state. As a new political and collective philosophy, solidarism was seen as reflective of a modernization of the revolutionary maxim: *liberty, equality, and fraternity*.

Notably, solidarism's narrative features the influences of democracy and humanism, through its belief in the development and contributions of every individual, and through its assertion of the inherent dignity of all of humanity (Sheradin, 2000).

Solidarism was committed to democracy, to the empowerment of the working class, and to 19th-century understandings of human reliance and interdependence (Sheradin, 2000). In being so committed, one can find a second meaning in this movement, one interwoven with concern over balancing self-interest with the era's philosophical humanistic ideals.

It is not surprising that among the principles of French solidarism was the belief that the liberty of human kind was not freedom absolute, but rather an understanding that free individuals were also in debt to society, to every other citizen, and to future generations (Koskenniemi, 2009).

In time, with the passing of World War I, the French Radical Party fell from favor as many of the working class shifted their allegiance to the Socialists following the Bolshevik Revolution of 1917 (Hayward, 1963). Ultimately, the harshness of World War I ended much of the utopian inclusivity inherent within the solidarist approach, and by the 1920s, much of the impact and influence of solidarism had been depleted (Koskenniemi, 2009).

However, for the generation or two of those in France moved by the solidarist approach to social integration, one of the most persuasive elements of the philosophy and one that lent to its fashionableness was what Hayward (1961) described as an *open sesame* inclusive approach to mitigating the social conflicts of the era. The philosophy was meaningful to the time also because as an approach, it was not really radical at all. Rather, it melded elements of community, inclusivity, and social solidarity—all useful mechanisms to help the populace attain security against poverty, illness, unemployment, and war (Hayward, 1961).

The broad solidarism movement was oriented to the reconciliation of individual and social ethics with the belief that all citizens had the free will to interact and develop relationships with others (Vincent, 2001). Solidarism in essence acted as a shared and uniting philosophy—a precondition of the era's new approaches toward social contractuality (Foschi & Cicciola, 2006)

For Koskenniemi (2009), the influences of these preconditions would be felt at home and abroad, playing a defining role in solardistic evolutions throughout the Spanish Civil War, World War II, the beginning forays across the continent toward the establishment of the European Union (EU), and ultimately, as the sociological lens helps reveal, trickling through Goffman's 1950s work on stigma and France's 1970s social inclusion as promoted by René Lenoir.

Stigmatism

Stigma and the act of stigmatizing is a common and recognizable form of social exclusion, yet, efforts to contend with some of the prejudices and discriminations recognized as components of stigmatization reflect forms of social inclusion.

Inherent within Goffman's (1963) work: *Stigma: Notes on the Management of Spoiled Identity*, is a belief in the universality of stigma and social exclusion. Stigma as a process leads certain individuals to be "systematically excluded from particular sorts of social interactions because they possess a particular characteristic or are a member of a particular group" (Kurzban & Leary, 2001, p. 187). The concept embodies the functionality of "outsiderderness"; and the utility of why humans, as "an inherently social species with a strong need for social acceptance should be so inclined to reject members of its own kind" (Kurzban & Leary, 2001, p. 187). For Goffman and those influenced by him (Crocker, Major, & Steele, 1998; Elliott, Ziegler, Altman, & Scott, 1982; Jones et al., 1984; Kleinman et al, 1995; Schneider, 1988), stigmatization occurs when the evaluation of an individual results in that person being discredited (Kurzban & Leary, 2001).

As a sociologist, Goffman's approach was both dramaturgical and oriented toward a symbolic interactionist

perspective. His main interest was in the structure of social interactions and the rules that governed them (Goffman, 1967). For Goffman, social structures provided the context for interactions, as it was social structure that steadied and sustained social hierarchies (Scambler, 2009). Yet some have suggested that Goffman may not have sufficiently attended to political economy, or to elements considered traditionally beyond the foci of symbolic interactionists such as class, power, gender, and ethnicity (Scambler, 2006, 2009).

From a functional perspective, stigma in the natural world reflects certain biological elements. Kurzban and Leary (2001) suggested that this world is structured by a series of interconnected interactions that result in variable costs and benefits (see Whiten & Byrne, 1988, 1997). As reflected earlier, there is a universality to stigma in the sense that it has been observed in most human cultures and even in the animal kingdom (Behringer, Butler, & Shields, 2006; Buchman & Reiner, 2009; Dugatkin, FitzGerald, & Lavoie, 1994; Oaten, Stevenson, & Case, 2011). Examples of this near universality include territoriality in fish, birds, reptiles, and mammals, and cross-species status hierarchies and social ostracism.

Some like Kurzban and Leary (2001) sought to frame the exclusion of stigma from the perspective of biological determinism. That is, as psychological rather than social systems structured by natural selection to ease some of the challenges of sociality. The proposition is that these systems or exclusionary mechanisms often influence individuals to subconsciously exclude dangerous others from social structures and interactions (Archer, 1985). Thus, from this biologically deterministic perspective, stigma is not so much owing to the kind of negative evaluation as theorized by Goffman and colleagues, but rather to a form of protective disassociation.

Another deterministic approach to stigmatism has considered the exclusion of stigma from the perspective of disease, and specifically as a mechanism of disease avoidance. Here, the basic claim derives from several observations. First, that we tend to evaluate those who are infectious in the same way as we would evaluate other kinds of stigmatized individuals (Snyder, Kleck, Strenta, & Mentzer, 1979). Second, that the most severely stigmatized groups (i.e., those who are most avoided) are individuals who are evidently ill or who demonstrate characteristics of the ill or diseased (Oaten et al., 2011 referencing Bernstein, 1976; Heider, 1958; Kurzban, & Leary, 2001; Schaller, & Duncan, 2007). Leprosy and smallpox are but two examples. For these authors, envisioning stigma as disease-avoidance does not negate other processes that contribute to discriminatory or exclusionary behavior. Rather, it suggests that beneath or antecedent to other processes is an avoidance system that seeks to limit possible contact with infectiousness and disease (Oaten et al., 2011).

Parker and Aggleton (2003) reflected that often stigma goes undefined in academic scholarship or reverts to somewhat of a stereotypical, two-dimensional description of exclusion. In a series of articles, these authors have argued for the development of a more nuanced conceptual framework that would go beyond the works of Goffman and of biological determinists (Parker, 2012, referencing also Parker & Aggleton, 2003, and Maluwa, Aggleton, & Parker, 2002), to think beyond evolutionary stigma or differentially valued stigma and more directly about stigma as a "social process fundamentally linked to power and domination" (Parker, 2012, pp. 165-166).

Parker (2012, referencing Stuber, Meyer, & Link, 2008) reflected that theory and research has tended to operationalize stigma either as discrimination (as in the work of Goffman, 1963) or as prejudice (as in the work of Allport, 1954). Subsequently, over the second half of the 20th century, the two foci evolved along parallel but distinctly separate directions, with the work on prejudice tending much more to tackle race, ethnicity, and associated social relations.

Yet as Parker (2012), Parker and Aggleton (2003), Link and Phelan (2001), and others have argued, discrimination and prejudice, as components or forms of stigma, share key relations with the production and reproduction of power relations.

It is arguably owing to this revisioning beyond dramaturgical performance and biological determinism that stigma can be envisioned as a somewhat supplanted component of the contemporary discourse of social exclusion and inclusion.

The suggestion that stigma is not (or not only) performed and not (or not only) determined but rather is culturally produced as a social, relational, and powerful artifact is a compelling argument (Buchman & Reiner, 2009). Equally compelling is Scambler's (2009) reflection that stigma can be a very convoluted social process, one for which sociology is well-oriented to imagine as a combination of experience, anticipation, and perception, of the harms of blame and devaluation; the fears and pain of rejection and exclusion; and the hopes and desires for acceptance and inclusion.

Social Inclusion

How cultures and societies stratify and divide; how they account for customs around inclusion, exclusion, belonging, and togetherness; and how the processes that include and exclude are talked about, described, understood, and experienced, all provide some clues as to the role of social integration and stratification within a given society. Indeed, how stratification is conceived and discussed can obscure the very nature of the processes by which such divisions come to be. This is precisely why the discipline of sociology is so useful. Unlike natural order sciences, it does more than identify and posit explanations for social divisions. Sociology, in addition to this, can reflect also on the disciplinary discourses encircling discussions of these social partitions. For example, one of the means by which stratification is conceptualized and discussed could take as a

reflective example, the pre–World War II writings of Sorokin (1998), who in considering stratification differentiated between horizontal and vertical social mobility. Sorokin suggested that horizontal mobility related to changes in occupational position or role, but not to changes within a social hierarchy, whereas vertical mobility did describe changes within the social hierarchy. Sorokin summarized his theory by reflecting that within systems of vertical and horizontal mobility, there could be individual social infiltration as well as collective social movement. Furthermore, that although it was possible to identify forms of mobile and immobile societies within different geographical and historical contexts, it was rare for a society's strata to be closed absolutely, and rare for the vertical mobility of even the most mobile society to be completely free from obstacles.

As proposed by Sorokin, these types of social movements could often vary across time and space, yet even across time, trends—particularly as they might apply to vertical mobility—were unlikely to be writ in stone. Although autocratic societies might be less mobile than democratic societies, the rule was not fixed and could have exceptions (Sorokin, 1998).

While often used to describe low or zero labor market involvement (Foster, 2000), early definitions of social exclusion in time broadened to consider barriers to effective or full participation in society (Du Toit, 2004). These types of barriers were considered to contribute to progressive processes of marginalization that could lead to deprivation and disadvantage (Chakravarty & D'Ambrosio, 2006). As the exclusion concept took on currency, it began to reflect more than a simple material nature and to begin to encompass the experience of individuals or communities who were not benefitting or were unable to benefit relative to others in society (Davies, 2005; Levitas, 1998). In time, the concept would evolve to reflect lapses in social integration and social cohesion that plagued advanced capitalist societies (Chakravarty & D'Ambrosio, 2006). It would evolve also to refer to processes that prevent individuals or groups from full or partial participation in society, as well as the crippling and reifying inability to meaningful participation in economic, social, political, and cultural activities and life (de Haan & Maxwell, 1998; Duffy, 1995, 2001; Horsell, 2006)—a definitional approach that imbues exclusion in terms of neighborhood, individual, spatial, and group dimensions (Burchardt, Le Grand, & Piachaud, 1999, referenced in Percy-Smith, 2000).

March, Oviedo-Joekes, and Romero (2006) suggested that one of the elements that unify the divergent definitional approaches to social exclusion and inclusion is that social exclusion is a process as opposed to a static end state. Further, that inclusion, in addition to being a context-based social and historical product reflective of social and national history, tends to mirror also what Silver (1995) proposed were the very limits of the borders of belonging.

Despite attempts at globally applicable definitions of social exclusion and inclusion, it has been suggested that there will always be patterns of border shaping that are particular to specific contexts. This is in part because the weight of inclusion versus exclusion is dependent on the particulars of any given society (de Haan & Maxwell, 1998; March et al., 2006; O'Brien, Wilkes, de Haan, & Maxwell, 1997). Such society-specific particulars might take the form of traditional and historic patterns of stratification, or be based on how individual groups and/or characteristics may be valued over others. Less clear, however, is which, if any, elements of a given society or social structure may mitigate the kinds of exclusion/inclusion dynamics that may be held aloft as representative of normative practice. For example, in some social contexts, patterns of inclusion and exclusion may reflect different stages of social and economic development. Alternately, these patterns may vary by type and/or political orientation of governments, or by the religious, ethnic, or cultural makeup of a given society.

Ultimately, however, the use of inclusion and exclusion concepts has evolved to the point where within a number of contexts, they are used as a descriptor for those who represent a particular kind of threat to social harmony (Silver & Miller, 2003). In sum, the terms *social inclusion* and *social exclusion* have been used throughout the social science and humanities literature in a number of different ways—to describe acts of social stratification across human and animal societies, as a principle to reflect the ordering that occurs within societies to determine social position, and as a narrative to explain and at times justify why one or more groups merit access to the core or the periphery, to the benefit or expense of others.

Initial discourses of social inclusion are widely attributed to having first appeared in France in the 1970s when the economically disadvantaged began to be described as *the excluded* (Silver, 1995). The preliminary uses of this new parlance appeared as a means to refer to a variety of disabled and destitute groups. The government of France was among the earliest adapters of exclusion terminology, and it is there that most often the concept is suggested to have found its contemporary meaning (Silver & Miller, 2003).

As a fully documented policy response, the concept of social inclusion to counteract social exclusion emerged toward the end of the 1980s, when the European Community (EC) first used the term social exclusion (Wilson, 2006). The appearance of the term social inclusion in the rhetoric of the EC was in itself a key point of departure, in that exclusion was suddenly held to be a reflection that "poverty was no longer the right word to use to describe the plight of those marginalized from mainstream society" (Williams & White, 2003, p. 91).

Ascertaining the contemporary use of the terms social inclusion and social exclusion involves a study of diffusion of, most importantly, the applications of René Lenoir, France's Secretary of State for Social Welfare in the Chirac government of the 1970s (Davies, 2005, citing Lenoir, 1974; Pierce, 1999; Silver, 1995).

L'Inclusion Sociale

In 1965, a French social commentator, Jean Klanfer, published *L'Exclusion sociale: Étude de la marginalité dans les sociétés occidentales* [Social exclusion: The study of marginality in Western societies] (Béland, 2007). Described as an anthropology of poverty (Cl, 1968), Klanfer's work argued that society rewarded personal responsibility with inclusion and personal irresponsibility with exclusion. If the work of Bourgeois was a primary influence on the soldarism movement almost 100 years earlier, the writings of Klanfer would fuel the imagination of René Lenoir (1974), most notably in his book *Les exclus*.

In his political tome, Lenoir contended social exclusion was a result of France's postwar transition from a largely agricultural society to an urban one (Davies, 2005). While the belief was that these events could lead to poverty, Lenoir argued that they could lead to a brand of social polarization also, which challenged the *Liberté, Egalité*, and *Fraternité* ideals of the French Republican project.

Many have suggested that if there were a birth of the modern rhetoric of social inclusion, it would be here, in French thought that sought a means to reintegrate the large numbers of ex-industrial workers and a growing number of young people excluded from opportunities to join the labor force in the new economies of the 1970s and beyond.

According to Silver (1995) and Silver and Miller (2003), one of the reasons the inclusion and exclusion concepts resonated so strongly for the French was that in their society, the Anglo-Saxon idea of poverty was seen to essentially insult the equality of citizenry contained within the *Liberté* manifesto—an equality that, as reflected in France's late-20th-century welfare state, operationalized charity as basic social assistance in response to poverty, and as essentially a right of citizenry. Furthermore, what would come to be seen as an inclusive welfare state was held to be the most effective and civilized way to eliminate absolute material deprivation and the risks to well-being such deprivation could cause.

However, as the 1970s progressed, and as unemployment became endemic, the passage of time brought even greater numbers of those considered excluded, and with them ever-increasing reiterations of the new exclusion discourse (Silver, 1995). The result in France was a movement to protect *les exclus*. The movement was so strong that by 1998, the French posited legal codification to prevent and combat social *exclusions* (note the plural) as a means to foster universal access to fundamental human rights.

Within French Republican thought in particular, social exclusion was seen to reflect ruptures in solidarity and the social bond (*lien social*), something essentially tantamount to heresy within the French social contract. Heresy because the French social contract of the time was seen to hold (and some may argue continues to hold) reciprocity, both between the social obligations French citizens have for the French state and the obligations that society has in return, to provide reasonable livelihoods for its members. Here, though, the accepted exceptions, as in many welfare regimes, were restricted to those who could not work due to older age, disability, or ill health, and did not extend to those whose deliberate actions and/or deliberate tendencies toward illicit pleasure, removed them from broader labor force opportunities or expectations.

In some respects, the mutuality and reciprocity evident in elements of French Republican thought reflected a social contract that favored the already-included in its definition of society. For the positioning of reciprocity within the social contract, such a context has implications for the creation of biases against the failings of the excluded. In particular, against those who vary from society's includable norms. In the place of any such consideration leading to action, appeared a sort of stoic romanticism. Thus, for the French, the excluded came to represent a martyred or punished sector of a society against whom the included had failed to live up to their side of the social contract.

As the concept of exclusion grew to gain broader credence beyond France, the EC and the subsequent EU, it increasingly incorporated target groups who were not simply poor or without sufficient resources. It incorporated those segregated also from the social core through attributes such as ethnicity or race, age, gender, and disability, and whose characteristics could contribute to justify the need for deliberate social inclusion programs (Omidvar & Richmond, 2003). That these attributes tended to be noncriminalized and relatively politically correct, as opposed to criminalized and/or contested, is a feature that should not be lost.

Even though the concepts of citizenship and social integration in the French tradition may present some challenges for Anglo-Saxon manners of thinking, this did not, according to Gore, Figueiredo, and Rodgers (1995), prevent the wider adoption of exclusion frameworks across Western Europe. These authors suggested that in appropriating the concept as integral to modern and meaningful social development, the EC was linking the concept of social exclusion more closely with evolving thoughts around the implications of unrealized social rights.

While EC and EU directives sought to carve out greater social inclusion, other countries, particularly Commonwealth countries—notably the United Kingdom, Australia, New Zealand, Canada, and South Africa—were beginning to roll out their own interpretations of this rhetoric.

In its initial contemporary use, the exclusion terminology adopted in France and subsequently diffused elsewhere, was meant to refer to those individuals who were considered to be on the margins of French society of the 1970s. That is, individuals considered society's social problems, who tended to share a particular social reality, a less than successful material existence compounded with real barriers in accessing benefits provided by the French welfare state (Daly, 2006).

So great were the social problems, that Lenoir, would suggest that a full 10% of the French population were *exclu*, or outcast. According to Davies (2005), "the novel characteristic of les exclus was not that they were poor (although most were), but that they were disconnected from mainstream society in ways that went beyond poverty" (p. 3). This disconnect, it was argued, was facilitated by their relative social positioning and by factors related to poor health and social, economic, and geographical isolation from active engagement in politics. From this perspective, to be socially excluded was paramount to being of the underclass; to be among those people who did not fit into the norms of industrial societies, who were not protected by social insurance and who were essentially considered social misfits. (Silver, 1995; Stegemen & Costongs, 2003). Beliefs about social conformity aside, Silver's (1995) near definitive list of the socially excluded reads in some regards as a full 50% of the world's population. In doing, so it lends credence to Labonte's (2004) assertion that the socially excluded are liable to comprise everyone who is not middle-aged, middle class, and male.

It follows that just naming who is at risk of social exclusion, based on identity, vulnerability, membership, or biology will not suffice without some reflection as to who is naming the excluded, where those who label or define the excluded stand ontologically relative to their own or others' exclusion, and what if any the influences of personal, political, stereotypical, or xenophobic biases may be. It is an element of the conceptualization of social inclusion and exclusion particularly well-suited to sociology's contribution.

A Sociological Lens

In many ways, despite the contribution of the psychological and life sciences, and even the contributions of social policy, the concepts of social inclusion and exclusion are profoundingly sociological. This is because at the very root of both classic and contemporary sociological thinking are concerns with social stratification, social inequality, and social class—key concepts which the social inclusion literature repeatedly touches upon.

Witcher (2003, referencing Burchardt et al., 1999) reflected that social inclusion and exclusion were concepts that were often poorly defined or theorized. Daly (2006) has suggested that although there is nothing inherent in the inclusion and exclusion concepts that defy or negate theorization, in general, sociology's attempts at their theorization could be inconsistent or facile.

Horsell (2006) referenced Crowther (2002) in suggesting that the contemporary interest in social exclusion and inclusion were reflective of similar attempts to conceptualize the dual influences of poverty and social deprivation. As such, these concepts signaled that somehow the cumulative impacts of poverty and social deprivation (or the cumulative effects of social exclusion in the absence of social inclusion) could represent a threat to social order.

Horsell's (2006) suggestion was that, in purely operational terms, the exclusion/inclusion paradigm acted to reinforce neoliberal ideas about social actors and agency as well as to harness principles of mutual obligation and active participation; that the discourse, broadly speaking, had both symbolic and physical dimensions. In its consideration of the ways in which contemporary social policy analysis treats social position as stratification, deprivation, and inequality, attempts to tease out the causes and consequences of social exclusion relative to inclusion could risk becoming muddled by mixing together attempts to better the lives and living conditions of people living below poverty lines, with the illusion that more were being done than might be. Horsell's suggestion of illusion hinged on the reflection that those who may ultimately benefit from the application of such inclusion-speak when operationalized as policy could tend to be those who already enjoyed a number of inclusion's benefits.

Levitas (1996, 1998) has reflected that the overall flavor of the social inclusion rhetoric is strongly Durkheimian. She has stressed that Durkheim and the exclusion/inclusion discursive continuum demonstrate a tendency to repress conflict as well as a tendency toward an approach to inclusion that subversively critiques capitalism in a way that would be lacking from a purely Durkheimian analysis.

Owing in part to this, Levitas (1998) labeled the rhetoric of social inclusion "a new Durkheimian hegemony" (p. 178), given that most contemporary views of inclusion correspond to scholarly interpretations of Durkheim's sociology, including Durkheim's emphasis on an alternative attempt to navigate an understanding of society between unacceptable free market capitalism and an unacceptable state socialism.

Such hegemony, according to Bowring (2000), leads us to think of elements of exclusion like deprivation and inequality as phenomena that occur at the very margins of society, and by extension, to ignore social structures that influence the included as well as the excluded. Bowring's point was that the exclusion/inclusion rhetoric risks being somewhat of a red herring, because exclusion at the societal level could be indicative of systemic deprivation and not just a deprivation experienced or reported by those defined as socially excluded.

For Wilson (2006), it was important to recall that social integration per se was not a focus of Durkheim. For Durkheim, inequality and social stratification were natural results of society, components of a solidary system he divided into mechanical and organic: the former being a fountain of social cohesion and the latter a well of social inclusion. Together, they were envisioned as the kinds of dependencies that social actors within advanced societies share with one another. Wilson's point was that although Durkheim associated increases in solidarity with social progress, he would not

necessarily associate the same solidarity with social inclusion, since in theory, advanced societies characterized by mutual dependence would exhibit the kinds of mutual and shared bonds that would defy the need for social inclusion in the first place.

The emphasis of these authors, and arguably of a Durkheimian perspective as applied to social inclusion also, is that new or reborn ways are not necessarily different ways. That despite its focus on the socially disenfranchised and their position relative to a status quo, there remains a hollow echo to the rhetoric around social inclusion. A void that is both redolent of discussion of the hollow state (Barnett, 1999; Davies, 2000; Della Sala, 1997; Holliday, 2000; London Edinburgh Weekend Return Group, 1980; Rhodes, 1994; Roberts & Devine, 2003; Skelcher, 2000), as well as a void that references one of Levitas's (2000) and Labonte's (2004) salient points: that it is one thing to promote an inclusionary utopia. However, in the event that such a utopian vision comes to pass, how likely is it that the result will be the kind of social world foreseen? In other words, even if a utopian ideal were within the reach of real-world, applied social policy, what are the odds, as Kenyon (2003) suggested, that attaining an inclusive society would result in the banishment of all inequality.

It was Young's (1999) argument, and Wilson's (2006) reiteration that although much of the West's social inclusion rhetoric may address many things, the root cause of social exclusion is not one of them. In this, the rhetoric fails because to address these causes would require acknowledgment that even within real-world inclusion societies, people frequently continue to experience poverty in a context that envelops them with messages of the meritocracy that surrounds them—a meritocracy that suggests that anyone with desire and ambition can succeed through acceptable behavior and hard work. For these authors, this represents a relative process of deprivation—one that includes an encounter with a form of culture shock where the culture in which the excluded experience their day-to-day existence actively reinforces the notion that they are receiving a much lower standard of living than others.

Here then, one could contend, is reflected the relative deprivation that leads to social exclusion "through a subjective experience of inequality and unfairness as materially deprived people seek to obtain the unobtainable" (Young, 1999, p. 401, cited in Wilson, 2006, p. 342). In a twist on the variations in social inclusion discourses presented earlier, this view holds that social exclusion morphs into "a cultural phenomenon arising from dialectic relationships between identity and social acceptance and the contradiction of a supposed meritocracy in which the poor lack the material means to meet the aspirations they are encouraged to embrace" (Wilson, 2006, p. 343). In other words, exclusion becomes social status contested between a hierarchical valuation of different kinds of social identities (socially hazardous vs. socially accepted) within a social world attempting to remedy the inherent challenges embedded in an inequitable division of resources within an acquisitive, material world.

Residuus Exclusion

In discussing the problematization of exclusion, the sociologist Nikolas Rose wrote that the mid-19th century wore the mantle of "a succession of figures that seem to condense in their person, their name, their image all that is disorder, danger, threat to civility, the vagrant, the pauper, the degenerate" (Rose, 1999, p. 254). As the 19th century gave way to the 20th, there appeared efforts to create universally shared forms of social citizenship. Yet even within this drive toward universality, there were those who were cast as unincludable, just as there are today. Within the new liberal thinking, universal citizenship did not emulate fully the fact that the notion of *universal* was still a somewhat relative concept and that a boundary between the includable and the excludable would not only continue to exist but would be reinforced also.

From this arose "notions such as 'the residuum,' 'the unemployable' and 'the social problem group'" (Rose, 1999, p. 254), that is, states of embodied being, through social roles, social strata, and entire classes that would, in time, become integral to these new forms of liberal thinking. From such vantage, the rhetoric of exclusion/inclusion, and the array of notions and underlying beliefs about the utility of integration, would become parts of the organizing, and traceable mainstays of reform. From older, perhaps simpler conceptualizations of inequality were born new ways of understanding what Rose, citing Levitas (1996), described as a "two-thirds, one-third social order" where a seemingly continually widening gap between the included two thirds and the excluded one third would continue to unfurl (Rose, 1999, p. 258).

Rose (1999) differentiated the new excluded from previous form of unequals. Whereas minorities that arose from the welfare state had claims to unity and solidarity, the new excluded have few of these, and it is perhaps from this lack of unification that the new expertise underlying inclusion's emphasis is born. Challenged from forging identity and right of place based on shared exclusion, this new underclass is "like Marx's peasants, individualized like potatoes in a sack, incapable of forming themselves into a single class on the basis of a consciousness of their shared expropriation" (Rose, 1999, pp. 254-255).

In moving from a welfare to a postwelfare, advanced liberal order, social control is reconfigured into control that moves beyond repressing or containing individual pathology. It becomes both about knowledge and access to the production of knowledge. This is because—to paraphrase Marx—access to the production of knowledge provides for the definition of what is and is not includable (Rose, 1999, referencing Ericson & Haggerty, 1997). Thus, the new labor force of control is no longer one that is either purely reactive or purely punitive. Rather, it takes on a form of administrative function whereby it oversees the *marginalia* comprising the

bounds (and bonds) of inclusion and exclusion, of risk and safety and permissibility (Rose, 1999). It was Rose's vision that for the excluded underclass "a politics of conduct is today more salient than a politics of class" (Rose, 2000, p. 335, citing Mead, 1991, p. 4, and Procacci, 1999, p. 30).

Although Rose's discourse is compelling, one should consider also whether all of the excluded are created equal. Do they all share the same position within the underclass? For example, across the Western world, special interest groups have sprung up since the softening of the welfare state, groups which include not only those that are socially excluded—drug users, sexual deviants, the poorly socialized—but also the physically excluded such as those who are bodily or mentally challenged.

In order for the work of Rose and those who have influenced his arguments regarding the inclusion/exclusion divide to be applicable (these influences include the works of Foucault, 1979a, 1976/1979b, 1985, 1991; Mead, 1991; O'Malley, 1992, 1999, 2004; Valverde, 1998), the work will need, in part, to account for diversity and social stratification within the underclass—that is, to help shed light on how and why certain social hierarchies of the status quo become replicated within the margins, leading to some of the marginal experiencing, in a sense, double marginality. At the same time, even those who achieve core or nonperipheral social status risk facing constraining hierarchies and limits to social mobility that function to either deny or defy full integration.

Extrapolating from the work of Rose, the inclusion society would not be a utopian dream, but rather a development that to varying extents would further institutionalize themes of inclusion, permissible rights, and the breadth of acceptable conduct.

Conclusion

This article has reflected on social inclusion from the vantage of sociology. It has reflected on exclusion and inclusion societies, across time and place and has demonstrated the importance of considering the physical world's exclusion and inclusion societies not only from a natural order perspective but from a social order perspective also.

Many of the considerations explored here have embodied measurable, objective approaches to the sociological conception and consideration of exclusion and inclusion. Du Toit (2004) has suggested current definitions, and their applications within individual country contexts allow social scientists and policy makers to present social exclusion as a single outcome of potentially multiple determinants of deprivation. Yet, this article has considered arguments that position inclusion and exclusion as much more than the fodder of contemporary policy. Indeed, it has demonstrated how human integration and expulsion are both highly historical and deeply sociological; that forms of social deprivation as well as social entitlement span many hundreds of years, if not the full course of human history itself.

For all that is known about social stratification, the tendency, particularly from the perspective of sociology, has been to consider inclusion and exclusion from an observational standpoint. This has occurred through policy analysis, historical analysis, and even consideration of some of the sociobiological correlates of inclusion and exclusion. What is less well known and less well developed are approaches for understanding the subjective experiences of social inclusion and social exclusion. For example, how exclusion and inclusion are experienced socially? How experiences of inclusion and exclusion are produced and reproduced socially? How different social labels impact the experience of inclusion and exclusion, and what the role of stigma may be?

For the reader, understanding the journey from social exclusion to social inclusion sociologically is an undertaking across potentially difficult terrain. Among other things, it requires a critical eye capable of accounting for individual and group participation and lack thereof (Daly, 2006).

And what of poverty? For some writers who have sought to unpack social inclusion and exclusion, these concepts are but alternate ways of recasting the notion of poverty. Others suggest economic poverty need be seen either as only one of an interrelated group of dimensions which work in tandem together to contribute to an individual's inability to successfully access the overall labor market. Such an approach would envision poverty as one factor in a multifaceted approach to understanding the experiences of society's lower strata (Sirovátka & Mare, 2006; Woodward & Kohli, 2001).

As prescribed approaches to policy and practice, efforts to contend with contemporary social exclusion often come to be framed by a rhetoric of reformation, imbued with different traditions in terms of how poverty is framed around either relational or distributional issues (Murie & Musterd, 2004, referencing van Kempen, 2002). It is a vantage that capitalizes on Marshall's (1963) model of postwar social rights, where, rather than focus on forms of postwar poverty, the focus on social exclusion is on redistribution, access, and participation (Murie & Musterd, 2004). Then and now, sociologically speaking, when poverty rather than social structure is held up as the cause and consequence of exclusion, such deprivation is presented as a failure of capabilities as opposed to a manner of being within a social structure or society.

Chakravarty and D'Ambrosio (2006) suggested that an emphasis on the shortfalls of economic thresholds as an explanation for exclusion is not the same as emphasizing structured inabilities to participate. This is because a focus on structural inabilities allows for a more complex, multidimensional understanding of the interplay, overlap, and social distance between money, work, and belonging. As a reconceptualization of social disadvantage, such a perspective provides an important framework for thinking out alternatives to the welfare state. It links poverty, productivity by means of employment and social integration that in turn emphasizes integration and insertion into a labor market, active and personalized participation, and a multicultural national citizenry (Gore et al.,

1995). It broadens also the notion of inclusion beyond biological or economic fitness alone.

In this regard, the suggestion that social inclusion exists not necessarily as a mechanism of sociobiological well-being only but more viscerally as a reflection of outcome of economic empowerment holds much in common with Richard Parker and Peter Aggleton's post-Goffman work on stigma. Although good arguments exist—and many have been presented here—about why integration and ostracism can be interpreted through both natural order and economic lenses, inclusion and exclusion do not represent free-floating views. Like stigma, inclusion and exclusion also exist at "the historically determined nexus between cultural formulations and systems of power and domination" (Parker, 2012, p. 166).

As systems of social power, these formations constitute architectures of inclusion; that is, means and ways that inclusion and exclusion are both enacted and talked about. Such architectures exist as literal and figurative coalitions of action, reaction, governance, control, and power which together comprise how a policy aim like social inclusion is wound, entwined, draped, and displayed for public rendering and consumption.

In what can be described as a political economy of inclusion, the hierarchies embedded in these architectures of inclusion not only ascribe value to who is to be considered includable but also reflect value structures that can lead to forms of ideologically based interpretations about whether inclusion is as good or better than exclusion (Rodgers, 1995) based on variation in social power, the ability to hold rights, and the representation or embodiment of hazard.

As with more traditional, physical forms of architecture, inclusion's architectures function to both limit and facilitate the movement and interaction of people through hierarchies of integration. Enclosed within these architectures are worlds of inclusion and exclusion that push and pull amid new forms of allowance, constraint, and conflict (Gumplowicz, 1963). Parallel yet interconnected worlds in which, are reflected, the socially excluded, reduced, and idealized as somewhat two-dimensional occupiers of social space (Spina, 2005).

Gillies (2005) reflected that societies have a tendency to normalize the sins of the included while penalizing the sins of the excluded. This suggests that even if discourses about social inclusion are effectively rendered as policy and translated into practice, the act of revaluating the biases society's hold for marginal underclasses of excluded social actors may well remain. This is to say that were society able to find room within its social architectures for its marginal women and men (Park, 1928), the fact of their powerlessness coupled with their comportment could still relegate them to the periphery, occupying colonized spaces stratified on one side by accusations of nonnormative or deviant behavior and on another by power relations.

For the contemporary open thinker trying to grapple with social inclusion and exclusion as a set of potentially complex concepts between those who study and profess a natural, an economic, or a social order, ideas about power would seem to be of particular importance—be it the power of the elite or the empowerment of those with special needs. Power seems to fuel the wheels of integration. Although power can be shown to have a decisive role in both the natural and the economic orders, it is in the arena of the social where it is perhaps best understood. One only need look at the history of philosophy and social theory for evidence of how power and proximity to it can enable or bar integration. Power allows proximity to the means of inclusion—essentially, to inclusion's apparati.

Of course, simply thinking openly about social worlds as variations of inclusionary or exclusionary societies does not lead to societies that are more inclusive. It does, however, allow for a more open lens with which to consider the past as well with which to view the present.

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Bio

Dan Allman's work focuses on the social and structural production of risk and well-being, particularly for those considered marginal, vulnerable, or peripheral to a society's core. His interests include social stratification and equity, the sociology of health and medicine, and global health.


BY

Propinquity

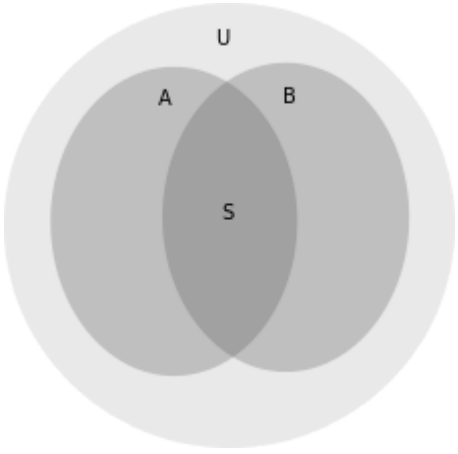
In social psychology, **propinquity** (/prəˈpɪŋkwɪtiː/; from Latin *propinquitas*, "nearness") is one of the main factors leading to interpersonal attraction.

It refers to the physical or psychological proximity between people. Propinquity can mean physical proximity, a kinship between people, or a similarity in nature between things ("like-attracts-like"). Two people living on the same floor of a building, for example, have a higher propinquity than those living on different floors, just as two people with similar political beliefs possess a higher propinquity than those whose beliefs strongly differ. *Propinquity* is also one of the factors, set out by Jeremy Bentham, used to measure the amount of (utilitarian) pleasure in a method known as felicific calculus.

Contents

Propinquity effect

The **propinquity effect** is the tendency for people to form friendships or romantic relationships with those whom they encounter often, forming a bond between subject and friend. Workplace interactions are frequent and this frequent interaction is often a key indicator as to why close relationships can readily form in this type of environment.[1] In other words, relationships tend to form between those who have a high propinquity. It was first theorized by psychologists Leon Festinger, Stanley Schachter, and Kurt Back in what came to be called the *Westgate studies* conducted at MIT (1950).[2] The typical Euler diagram used to represent the propinquity effect is shown below where U = universe, A = set A, B = set B, and S = similarity:



The sets are basically any relevant subject matter about a person, persons, or non-persons, depending on the context. Propinquity can be more than just physical distance. Residents of an apartment building living near a stairway, for example, tend to have more friends from other floors than those living further from the stairway.[2] The propinquity effect is usually explained by the mere exposure effect, which holds that the more exposure a stimulus gets, the more likeable it becomes. There is a requirement for the mere exposure effect to influence the propinquity effect, and that is that the exposure is positive. If the resident has repeatedly negative experiences with a person then the propinquity effect has a far less chance of happening (Norton, Frost, & Ariely, 2007).[3]

In a study on interpersonal attraction (Piercey and Piercey, 1972), 23 graduate psychology students, all from the same class, underwent 9 hours of sensitivity training in two groups. Students were given pre- and post-tests to rate their positive and negative attitudes toward each class member. Members of the same sensitivity training group rated each other higher in the post-test than they rated members of the other group in both the pre- and post-test, and members of their own group in the pre-test. The results indicated that the 9 hours of sensitivity training increased the exposure of students in the same group to each other, and thus they became more likeable to each other.[4]

Propinquity is one of the effects used to study group dynamics. For example, there was a British study done on immigrant Irish women to observe how they interacted with their new environments (Ryan, 2007). This study showed that there were certain people with whom these women became friends much more easily than others, such as classmates, workplace colleagues, and neighbours as a result of shared interests, common situations, and constant interaction. For women who still felt out of place when they began life in a new place, giving birth to children allowed for different ties to be formed, ones with other mothers. Having slightly older children participating in activities such as school clubs and teams also allowed social networks to widen, giving the women a stronger support base, emotional or otherwise.[5]

Types

Various types of propinquity exist, varying from *Industry/Occupational Propinquity*, in which similar people working in the same field or job tend to be attracted to one another.[6] *Residential Propinquity*, in which people living in the same area or within neighborhoods of each other tend to come together.[7] *Acquaintance Propinquity*, a form of proximity in existence when friends tend to have a special bond of interpersonal attraction. Many studies have been performed in assessing various propinquities and their effect on marriage.

Virtual propinquity

The introduction of instant messaging and video conferencing has reduced the effects of propinquity. Online interactions have facilitated instant and close interactions with people despite a lack of material presence. This allows a notional "virtual propinquity" to work on virtual relationships where people are connected virtually.[8] However, research that came after the development of the internet and email has shown that physical distance is still a powerful predictor of contact, interaction, friendship, and influence.[9]

In popular culture

William Shakespeare's *King Lear*, Act 1 Scene 1 Page 5

LEAR:
'Let it be so. Thy truth then be thy dower.
For by the sacred radiance of the sun,
The mysteries of Hecate and the night,

By all the operation of the orbs
From whom we do exist and cease to be—
Here I disclaim all my paternal care,
Propinquity, and property of blood,
And as a stranger to my heart and me
Hold thee from this for ever. The barbarous Scythian,
Or he that makes his generation messes
To gorge his appetite, shall to my bosom
Be as well neighbored, pitied, and relieved
As thou my sometime daughter.'

"Love is a Science", a 1959 short story by humorist Max Shulman, features a girl named Zelda Gilroy assuring her science lab tablemate, Dobie Gillis, that he would eventually come to love her through the influence of propinquity, as their similar last names would put them in proximity throughout school. "Love is a Science" was adapted into a 1959 episode of the Shulman-created TV sitcom *The Many Loves of Dobie Gillis*, featuring Dobie as its main character and Zelda as a semi-regular, and a 1988 made-for-TV movie based on the series, *Bring Me the Head of Dobie Gillis*, portrayed Dobie and Zelda as being married.

Propinquity (I've Just Begun To Care) is a song by Mike Nesmith of The Monkees. It was first recorded by the Nitty Gritty Dirt Band on their album Uncle Charlie & His Dog Teddy.

On page 478 of Jonathan Franzen's 2010 novel *Freedom*, Walter attributes his inability to stop having sex with Lalitha to their "daily propinquity".

On page 150 in Michael Ondaatje's novel *The English Patient*, "He said later it was propinquity. Propinquity in the desert. It does that here, he said. He loved the word – the propinquity of water, the propinquity of two or three bodies in a car driving the Sand Sea for six hours."

In Ian Fleming's 1957 James Bond novel *Diamonds Are Forever*, Felix Leiter tells Bond "Nothing propinks like propinquity."

In William Faulkner's 1936 novel *Absalom, Absalom!*, Rosa, in explaining to Quentin why she agreed to marry Sutpen, states, "I don't plead propinquity: the fact that I, a woman young and at the age for marrying and in a time when most of the young men whom I would have known ordinarily were dead on lost battlefields, that I lived for two years under the same roof with him."

In Ryan North's webcomic *Dinosaur Comics*, T-Rex discusses propinquity.[10]

In the P. G. Wodehouse novel *Right Ho, Jeeves*, Bertie asks, "What do you call it when two people of opposite sexes are bunged together in close association in a secluded spot meeting each other every day and seeing a lot of each other?" to which Jeeves replies, "Is 'propinquity' the word you wish, sir?" Bertie: "It is. I stake everything on propinquity, Jeeves."

In Ernest Thompson Seton's short story "Arnaux: the Chronicle of a Homing Pigeon," published in *Animal Heroes* (1905): "Pigeon marriages are arranged somewhat like those of mankind. Propinquity is the first thing: force the pair together for a time and let nature take its course."

See also

- Human bonding
- Proxemics – Study of human use of space and the effects that population density has on behavior

- Westermarck effect – Hypothesis that those who grow up together become desensitized to sexual attraction
- Allen curve – Graphical representation of human communication

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4. Piercy, F. P., & Piercy, S. K. (1972). Interpersonal attraction as a function of propinquity in two sensitivity groups. Psychology: A Journal of Human Behavior, 9(1), 27–30.
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8. Perry, Martha W.(2006). Instant messaging: virtual propinquity for health promotion networking, 211–2
9. Latane, B., Liu, J. H., Nowak, A., Bonevento, M., & Zheng, L. (1995). Distance matters: Physical space and social impact. Personality and Social Psychology Bulletin, 21(8), 795–805.
10. "Dinosaur Comics!" (http://www.qwantz.com/index.php?comic=2411).

External links

- Propinquity Effect (http://changingminds.org/explanations/theories/proprinquity_effect.htm)
- Human Mate Selection – An Exploration of Assortive Mating Preferences (http://forms.gradsch.psu.edu/diversity/mcnair/2003/rauch.pdf) – (has two pages of propinquity studies)

Relationalism

Relationalism is any theoretical position that gives importance to the relational nature of things. For relationalism, things exist and function only as relational entities. Relationalism may be contrasted with **relationism**, which tends to emphasize relations *per se*.

Contents

Relationalism (philosophical theory)

Relationalism in a broader sense applies to any system of thought that gives importance to the relational nature of reality. But in its narrower and philosophically restricted sense as propounded by the Indian philosopher Joseph Kaipayil[1][2][3] and others, relationalism refers to the theory of reality that interprets the existence, nature, and meaning of things in terms of their relationality or relatedness. On the relationalist view, things are neither self-standing entities nor vague events but relational particulars. Particulars are inherently relational, as they are ontologically open to other particulars in their constitution and action. Particulars, as relational particulars, are the ultimate constituents of reality. Particulars interact and make the very fabric of reality.

Relationalism (theory of space and time)

In discussions about space and time, the name relationalism (or relationism) refers to Leibniz's relationist notion of space and time as against Newton's substantivalist views.[4][5][6] According to Newton's substantivalism, space and time are entities in their own right, existing independently of things. Leibniz's relationism, on the other hand, describes space and time as systems of relations that exist between objects.

Relationalism (colour theory)

Relationalism in colour theory, as defended by Jonathan Cohen and others,[7][8] means the view that colours of an object are constituted partly in terms of relations with the perceiver. An anti-relationalist view about colour, on the other hand, would insist colours are object-dependent.[9]

Relationalism (sociological theory)

In relational sociology, relationalism is often contrasted with substantivalism. While substantivalism (also called substantialism) tends to view individuals as self-subsistent entities capable of social interaction, relationalism underscores the social human practices and the individual's transactional contexts and reciprocal relations. [10]

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9. cf.Gatzia, Dimitria Electra (2007). "Color Fictionalism: Color Discourse without Colors" (https://philarchive.org/archive/GATCF).
10. Emirbayer, Mustafa (1997). "Manifesto for a Relational Sociology" (https://pdfs.semanticscholar.org/d425/176d5ee52e3378f178eb0feef6d0f8a746c2.pdf) (PDF). *The American Journal of Sociology*. **103** (2): 281–317. doi:10.1086/231209 (https://doi.org/10.1086%2F231209). S2CID 32877513 (https://api.semanticscholar.org/CorpusID:32877513).

External links

- "Academics in Relationalism" (https://www.academia.edu/People/Relationalism). *Academia.edu*. 2015-08-03. Retrieved 2019-05-17.
- "Time/What Does Science Require of Time?" (http://www.iep.utm.edu/time/#H6). Internet Encyclopaedia of Philosophy.