The Arithmetic of Social Relations: The Interplay of Category and Network[1]

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This paper develops a conceptual scheme that merges the qualitatively stated propositions of Blau's recent axiomatic theory of social structure with the quantitative approach of social network analysis. The conceptual scheme is used to describe a set of inescapable features of intergroup and intragroup relations. We examine, both qualitatively and in formal equations, the tautologies that govern contact rates and network densities for any population that can be divided into two categories. We show how assumptions about the partitioning of populations into social categories can be translated into precise probabilities of contact within and between categories. We present several illustrations of the immodest implications of apparently modest assumptions. Following simulations of a high school within an adult community and an old boy network within a larger bureaucracy, we apply our conceptual scheme to actual data on social relations within a regional elite. Accompanying these examples is a discussion of a new perspective on reference groups, as well as a development of a common exception to Blau's theory. We conclude with a formal statement of the substantive propositions that follow from our conceptual scheme.

When is a category a group? What is the relation of group and network? That there is some connection among these concepts is obvious. It is the goal of this essay to examine these interrelations within a quantitative conceptual scheme for intergroup relations.

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The issue might be framed in broadly Simmelian terms. Our concern is with the effect of number, including size and proportion, on social categories, networks, and groups. Number is ubiquitous and any conclusions or insights based on it have very broad potential for application. This essay will examine how a category becomes grouplike through the effect of category size and contact segregation on social networks. We will focus on the simple case of a dichotomy that may be identified with an ingroup/outgroup or a minority/majority distinction. Since nearly any group is a minority with respect to the rest of the world, this simple case is of very general import.

The core of our presentation is the implications of constraints (which appear as equations linking different quantities) that inhere in a numerical characterization of intergroup relations. Although the constraints are purely formal or arithmetical, striking social implications follow from intuitive interpretations of the sociological effects of quantity.

The numerical relationships hold true wherever the quantities dealt with exist. Even though the social implications are contingent and depend somewhat on the particularities of settings, the universal applicability of the numerical relationships lets them serve as an organizing schema for an array of comparisons and contrasts that would not otherwise be apparent.

The basis of the discussion is a simple quantitative picture of intergroup relations. One primitive term is category: categories exist when any scheme, standard, or distinction permits unique classification of persons. In the present paper we will limit ourselves to the simple dichotomous case (although polychotomous and multiple dimension generalizations that are quite similar may be found in Rytina [1980*a*, 1980*b*]). The other primitive term is dyadic contact. Like category it can take many forms, including marriage, friendship, and telephone calls. All that is necessary for present purposes is that the number of contacts observed is independent of which member of the dyad is observed. Thus such variables as time spent in interaction or number of words shared in conversation, which have the property of numerical symmetry, are amenable to the treatment explored in this paper. Numerical symmetry does not require social symmetry, as the perfectly suitable parent-child tie illustrates, or mutual acknowledgment. It only requires the existence, in principle, of a procedure that would yield identical quantities of contact or interaction when applied to either member of a dyad.

The result of assessing categories and contacts for a population may be summarized in a tie-accounts table, a double-entry accounting device illustrated in figure 1. In a two-category population, all contacts are either within the first category, within the second, or between the two categories. In addition to these quantities, presented as per capita rates, the tie-accounts table also includes the sizes of the two categories and the per capita

		Destination of Ties		
Origin of Ties	Number of Persons in Category	To $group_1$	To $group_2$	Average Number of Ties
From $group_1$	N_1	IN_1 average number of ties from '1's to '1's	OUT_1 average number of ties from '1's to '2's	T_1
From $group_2$	N_2	OUT_2 average number of ties from '2's to '1's	IN_2 average number of ties from '2's to '2's	T_2

Population Total = N

FIG. 1

tie totals for each. Such a table might summarize the aggregated results of a study of intercategory contacts, such as interracial friendships, and could indicate the condition of intercategory relations as a whole. But such tables, and the realities they summarize, are governed by contraints that often lead to surprising conclusions. Those constraints and their consequences are the topic of this essay.

Our concerns may be related to two strands of sociological thought. First, the concern with the effect and structure of dyadic contact is shared with the eclectic body of analysis and research on social networks.[2] The great promise of the network perspective is that macro and micro can be linked by examining the structural constraints imposed by relational configurations (Coleman 1958; White, Boorman, and Breiger 1976). But this has remained more promise than accomplishment because computational and conceptual complexity has limited applications to rather small collections of individuals. Our approach achieves a leap of scale by the simple if brutish strategy of aggregation. Instead of examining the detailed configuration of ties among individuals, our concern is the flows of contact, the totals and rates of ties within and between categories of individuals. The loss of detail is severe, but the gain in simplicity and scale is considerable. It allows us to suggest that some striking effects of network are likely to be present in larger populations than are usually considered.

The second related strand of theory is found in Blau's (1977*a*, 1977*b*)

[2] In fact, the first tie-accounts tables were constructed while trying to visualize the outcomes of applying Granovetter's (1976) network-sampling ideas to a study of race relations in a metropolitan area. In this historical sense, the present effort is directly descendant from the network tradition.

primitive theory of social structure. The underlying conceptual atoms are identical since Blau also examines disjoint collections of positions and numerically symmetric dyadic interaction. Blau's grand sweep also takes in continuous distributions of positions and multidimensional distributions to yield a theory that relates structural features with overall integration. Our goals are considerably more modest.[3]

Blau looked at the integration by intergroup relations of complex structures; we are more concerned with within-category configurations and the generic concepts of group and minority. Blau assimilated the notions of in-choosing category and social group; we will attempt to spell out the conditions of size, segregation, and contact frequency that make categories grouplike through their joint effects on the networks that surround individuals. Our analysis complements Blau's in another way. Formalization of the quantitative relations renders the implications of different numerical assumptions more exactly. Such precision should serve to sharpen appreciation of the impact of Blau's notions, although it also allows us to point out a large class of examples that run counter to Blau's axiom of in-category preference. By looking at groups rather than entire structures and by displaying the underlying formalism, we hope to point out a new realm of applications for this intersection of the network metaphor and Blau's numerical conception of social structure.

One feature of our analysis is somewhat awkward to defend. The formal relations that are at the core are "mere" tautologies and the relationships are true by definition. But tautology has received something of a bum rap. Schelling (1978) has provided many examples of insights from numerical tautologies that are similarly based on double-entry accounting properties of certain social symmetries, such as quantity bought and sold. He argues that definitional truth or pure logic will supply insight whenever the terms of the argument are not matters of everyday experience. He suggests the telling example of the nonobvious but tautological answers to algebraic story problems. Many of our results are similar. Rather modest assumptions can generate immodest structural contrasts. The contrasts are logically inherent in the assumptions, but the magnitude of the results is sufficiently striking to deserve careful attention. The results follow by pure logic, but they are not immediately obvious for all that.

If such a defense is awkward, the presentation is more so. The logical truths are quite simple. But conviction about the social implications requires some coaxing. In what follows there will be an interplay of purely formal presentation and argument by example to illustrate the sociological effects. In the first section below, "Mechanics 1," the basic logic will be presented by verbal and numerical example. Mathematically inclined

[3] To recapitulate Blau's theory would take us far afield, but Turner's (1978) review provides a most accessible summary of its content.

readers may find this tedious; for them, "Mechanics 2" presents the argument as a set of formal manipulations. Those who do not enjoy wrestling with equations are invited to skip this second section. In a third section, various examples are used to illustrate the social implications of the formal results. The fourth section provides an empirical example for those disinclined to believe conclusions based on sheer speculation.[4] This is followed by a summary of the substantive propositions that follow from the discussion and by a brief concluding section.

MECHANICS 1

The goal of this section is to demonstrate the interdependencies that govern entries in tie-accounts tables. For each category, such a table records category size, total per capita contacts, and the distribution of contacts among members and nonmembers. One issue is the effect of relative size on this distribution. A second issue is the extent to which the category boundary affects the contact distribution. Following Blau, we term the latter effect the "salience" of a category. A third issue is the relative grouplikeness of each category. As a first approximation, we will examine a measure of group cohesion based on the probability that members share a tie.

For a first example, imagine a population of blacks and whites. To fill out a tie-accounts table, three kinds of information are needed: (1) the sizes of the categories (in this example, let us assume 5,000 blacks and 95,000 whites); (2) the number of contacts made by an average population member (here assumed to be 500 acquaintances per member for both categories); and (3) the distribution of ties within and between categories. We start with a random distribution, such that tie allocation is unaffected by category boundaries, and then model segregation in later examples.

Each cell in figure 2 contains the average number of ties sent either within categories (IN_i, IN_j) or between categories (OUT_i, OUT_j). The lower right cell gives the average number of ties sent from a white to other whites. Since whites are 95% of the population, 95% of 500 or 475 is the cell entry when the boundary has no effect. The remaining 5% or 25 ties sent to blacks are entered in the lower left cell. (We could, equivalently, tally the total number of contacts for each cell, e.g., in the lower left cell [$95{,}000 \times 25 = 2{,}375{,}000$ ties], but we find more intuitive appeal in the average contact patterns for members in each category. Frank [1971] and

[4] The empirical example may strike some as gratuitous since the definitional truth of the tautologies is hardly affected by whether real data or imaginary tables are manipulated. But some reviewers and other readers have indicated that actual data would increase their confidence in the results. And the empirical results do prove that some of the contingent assumptions employed in the discussion are true in at least the particular instance examined.

Origin of Ties	Number of Persons in Category	Destination of Ties: To Blacks	To Whites	Average Number of Ties
From Blacks	5,000	25	475	500
From Whites	95,000	25	475	500

Population Total 100,000

$d_{BB} = .005$ $\quad d_{WW} = .005$

FIG. 2.—Tie-accounts table displaying random mix

Granovetter [1976] give general presentations of network flows in terms of average numbers of ties.)

The random mixing of ties illustrated in figure 2 constitutes an important special case, one in which social networks are completely unaffected by category memberships. This is a sort of null or baseline social structure, in the sense that most sociologically interesting categories produce patterns of interaction that depart from random mixing. We thus take random mixing to be the zero point for our measure of category salience, I (cf. Freeman's [1978] discussion of segregation in social networks). For group cohesion, random mixing means, by definition, that two members of the same category are no more likely to share a tie than any other two members of the population. This approach differs from Blau's, in that his assumption 1.1 states that two members of the same category should exhibit higher than random rates of in-choosing; the difference is not simply a matter of distinguishing between categories as abstract ideas and socially salient categories, for we will show that there is an important class of categorizations with negative salience, in other words, with lower than random rates of in-choosing.

For the moment, however, let us examine the more common case of positive salience, in which members of a given category do have some preference for interacting with similar others. Returning to our first example, we modify the random distribution of contact to reflect a segregation in which whites take 40% of the contacts sent previously to blacks and devote them to other whites. The tie-accounts table for the population of figure 2 with the new distribution of ties is shown in figure 3. The process by which we move from figure 2 to the complete specification of figure 3 is instructive. Our new assumption about tie distribution actually affects only one of the four cells in the tie-accounts table: OUT_i in figure 3 must be 60% of OUT_i in figure 2. We can then calculate that IN_i in figure 3 is 485 because $IN_i + OUT_i = 500$. Further, we know that the average of 15 ties apiece sent from 95,000 whites must be met by an equal number of ties from the 5,000 blacks, yielding an average of 285 ties apiece for OUT_j.

What we have just seen is that the specification of one cell in the 2×2 tie-accounts table is sufficient to define the quantities in all the cells. Here we have the first example of the arithmetic identities underlying our tie-accounts tables. This is a general result based on the fact that there is only one degree of freedom in a two-category system of numerically symmetric interaction when the category sizes and the total number of ties per category are known. Thus, any assumption that determines a value for one cell in our tie-accounts table will in fact determine the entire table. For example, an assumption that 3 out of 1,000 of the possible ties from blacks to whites indeed exist (this assumption determines OUT_j) would define figure 3. So would the statement (determining IN_i) that whites send 97% of their ties to members of their own group, or the assumption (determining IN_j) that blacks would have to decrease their rate of in-choosing by 88% to achieve random mixing. Similarly, we could have noted that blacks are 8.4 times as likely to share a tie as whites and reasoned back to any and all

Origin of Ties	Number of Persons in Category	Destination of Ties: To Blacks	To Whites	Average Number of Ties
From Blacks	5,000	215	285	500
From Whites	95,000	15	485	500
Population Total 100,000		$d_{BB} = .0430$	$d_{WW} = .0051$	

FIG. 3.—Tie-accounts table displaying in-choosing

of these assumptions. The fact that each of these assumptions defines the same tie-accounts table means not only that they are equivalent but also that to make any one of them is, by definition, to have made them all. Our tie-accounts table is the schematic representation of a system of tautologies which allows us to assign any given assumption to a large set of mutually implied assumptions.

As we have noted, we will want substantive indices that summarize our tie-accounts tables. The first index, our measure of category salience, I, which increased from 0.0 to .40, corresponds to the initial assumption of segregation that we used to define figure 3: the percentage decrease in out-group interaction in comparison with random mixing. This index ranges from 0.0 or no category salience (under random mixing), to 1.0 or complete salience (with all ties sent within categories); it assumes a negative value when more ties are sent to out groups than would have occurred under random mixing.

A second index, our measure of group cohesion, will be based on the probability that two randomly selected members of a category share a tie. Formally, this is the network density, or the proportion of all possible ties that in fact exist (shown as d_{ii}, etc., for the specific cells, and D for the total population). Under random mixing, the probabilities for contact across the category boundary or within either category are the same as the probability of contact in the population as a whole (.005 in fig. 2). When category salience is positive, ties will be transferred from the two OUT cells to the corresponding IN cells, creating higher densities within categories than in the total population. But, as the 8.4 ratio between d_{jj} and d_{ii} in figure 3 shows, the probability of within-category contact will increase more rapidly in the minority than in the majority. In this example, every unit decrease in OUT_i corresponds to 19 fewer ties for OUT_j and produces increases in d_{ii} and d_{jj} of 1/95,000 (or .00001) and 19/5,000 (or .0038), respectively. (Note that this result, and thus the 8.4 ratio, holds independently of the assumption of 500 or any other number of ties for both categories.)

These differences in changes in density occur in any categorization that pairs a numerically large majority with a small minority. It is reminiscent of adjusting a teeter-totter to balance two very different weights: the "heavier" majority will be very near the center, while the small minority will be a great distance from the fulcrum; even slight changes in the "weight" of the majority will produce extreme shifts in the position of the minority. Both out-contact rates and their complement, cohesion, rotate around the fulcrum. With this analogy in mind, we use the term "leverage" to refer to the magnified effect that differences in tie distributions have on the cohesion and out-contact rates of numerically smaller minorities.

To complete this nontechnical summary, we wish to relax one of the assumptions made to simplify our presentation so far: that both categories have the same number of ties per member. In figure 4, whites distribute their ties as in figure 3, but we have increased their ties per person by 200. Several points can be made. First, there is still only one degree of freedom in the table. That result requires only that we know the average total number of contacts for members of each category (T_i and T_j). Second, the difference in numbers of contacts leads each category to have its own salience. Because whites distribute their contacts as in figure 3, the salience of their category does not change, but because blacks devote proportionately fewer of their ties to their own category, it has a lower salience. Third, once again we see forms of leverage in our cohesion (or density) indices for the two groups. The small increase in the majority's group cohesion is matched by a much larger decrease in cohesion for the minority. Finally, the extent to which we have lowered IN_j should warn us that there are some sets of assumptions that cannot be made. If we had doubled the number of ties per white to 1,000 without changing our assumptions about how ties were distributed, OUT_j would be 570, which is more than the total number of ties we have allotted to blacks. When real data are organized into a tie-accounts table, such inconsistencies can never occur; but, if the table is being used to model a set of substantively motivated assumptions, analysts must take it upon themselves to avoid assuming that $2 + 2 = 5$.

		Destination of Ties		
Origin of Ties	Number of Persons in Category	To Blacks	To Whites	Average Number of Ties
From Blacks	5,000	101	399	500
From Whites	95,000	21	679	700

Population Total 100,000

$d_{BB} = .0202$ $\quad d_{WW} = .00714$

$I_B = .16$ $\quad I_W = .4$

FIG. 4.—Tie-accounts table displaying unequal tie totals

MECHANICS 2

Assume that a population of size N can be classified into two categories of sizes n_1 and n_2, where $n_1 + n_2 = N$. Assume that an average member of category 1 has T_1 contacts, and that these are allocated as IN_1 (average contacts from members of category 1 to each other) and OUT_1 (average contacts from members of category 1 to category 2), with $IN_1 + OUT_1 = T_1$. A corresponding statement may be made about category 2, with the average member assumed to have T_2 contacts.

If contacts are numerically symmetric and the totals at origin and destination are identical, then

$$n_1{}^*OUT_1 = n_2{}^*OUT_2 , \tag{1}$$

or

$$n_1/n_2 = OUT_2/OUT_1 , \tag{2}$$

so that the rates of out contact are in inverse proportion to the relative sizes of categories.

If n_1, n_2, T_1, and T_2 are known, then a knowledge of any one of IN_1, OUT_1, IN_2, and OUT_2 is sufficient to determine the other three. Thus there is only one degree of freedom for the configuration.

Let I be an index of salience while k $(= 1 - I)$, its additive complement, is an index of segregation. Define k_i as

$$k_i = \frac{OUT_i/T_i}{n_j/N} , \tag{3}$$

or equivalently

$$k_i = \left(1 - \frac{IN_i}{T_i}\right) \Big/ \left(1 - \frac{n_i}{N}\right) , \tag{4}$$

so that knowledge of either IN_i or OUT_i suffices to determine I or k.

Next consider the relation between the configurations of the categories. From equation (1) note that

$$OUT_1 = \frac{n_2{}^*OUT_2}{n_1} . \tag{5}$$

Substituting equation (5) into equation (3) yields

$$k_1 = \frac{n_2{}^*OUT_2/n_1{}^*T_1}{n_2/N} = \frac{OUT_2/T_1}{n_1/N} = \frac{T_2 k_2}{T_1} . \tag{6}$$

This substitution reveals that, first, the k's are in inverse proportion to the tie totals so that the better endowed category has higher salience (smaller k) and, second, the saliences are equal in the special case of equal tie totals.

Equation (5) also reveals a first sort of leverage. Since the out contact totals are in proportion to inverse sizes, any change in the total of the larger category corresponds to a proportionately greater change in the total of the smaller category.

As noted in the previous section, the salience index is directly related to the cohesion measure, density. Density is defined as

$$d_{ii} = \frac{n_i \mathrm{IN}_i}{n_i(n_i - 1)} \simeq \frac{\mathrm{IN}_i}{n_i}, \tag{7a}$$

$$D = \frac{\mathrm{NT}}{N(N - 1)} \simeq \frac{\mathrm{T}}{N}, \tag{7b}$$

where d_{ii} is the within-category density and D is the population density. Unless categories are quite small, the approximations make a negligible difference.

To get a readable expression describing the relation of size and salience, we assume the simplification that $T_1 = T_2 = T$, substitute $P_i = n_i/N$ and $I + (1 - I)P_i$ for IN_i, and calculate the relative density

$$\frac{d_{ii}}{D} = \frac{I}{P_i} + 1 - I, \tag{8}$$

which describes the extent to which the within-category density exceeds the population or random mix density. Figure 5 displays the relationship of relative density and proportional size for several different values of salience.

Either figure 5 or inspection of equation (8) yields three generalizations. When salience is positive, relative density increases as relative size decreases. The rate of increase is greater when salience is greater. Conversely,

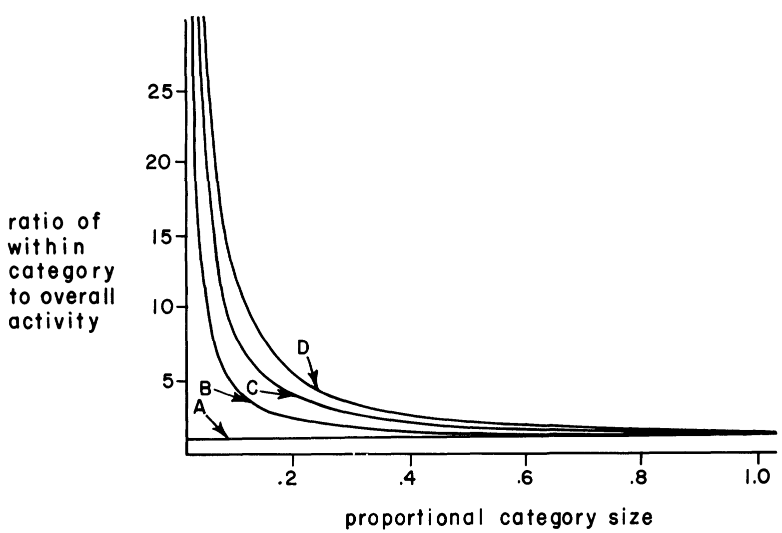

FIG. 5.—Ratio of within-category density to overall density as a function of proportional category size and salience. The lines A, B, C, and D refer to saliences (I) of 0.0, .33, .67, and 1.0, respectively.

the leverage effect is that the result of a change in salience is in inverse proportion to category size.

SUBSTANTIVE APPLICATIONS

In this section we will demonstrate how to convert the information in tie-accounts tables into substantive interpretations. Our strategy for representing and interpreting network flows in social settings begins with a numerical simulation of the given setting and then proceeds to a series of inferences about what is promoted or prohibited within this simulation. This includes, as we shall see, the possibility of "testing" alternative interpretations via appropriate modifications of our assumptions.

Consider a high school with 2,000 students, serving a community in which the total population over age 15 is 50,000. While there is undoubtedly some tendency for Americans to concentrate their social contacts among age peers throughout the life cycle, we believe that the nature of high schools as institutions heightens this separation for adolescents. The social density among students is increased both by their segregation from the adult community and by their self-selection based on specialized activities. In figure 6, we have assigned the usual 500 ties per person to adults but only 300 to students because they are younger. An assumption of $I = .65$ for students completes the definition of the table, that is, they withhold about two-thirds of the ties that would have gone to adults under random mixing. (Note that

Origin of Ties	Number of Persons in Category	Destination of Ties: To Students	Destination of Ties: To Adults	Average Number of Ties
From Students	2,000	200	100	300
From Adults	48,000	4.17	495.83	500
Population Total 50,000				
		$d_{SS} = .1$	$d_{AA} = .01$	
		$I_S = .65$	$I_A = .79$	

FIG. 6.—Tie-accounts table displaying adolescent-adult relations

because of the difference in tie volumes, adults actually have a higher category salience; see eq. [6].)[5]

Students, in this simulation, activate one in ten of 2,000,000 possible ties ($2{,}000 \times 2{,}000/2$), a rate which is almost 10 times higher than the density for adults. If anything, we underestimate within-category contacts of the average student, for we have distributed ties randomly within this group, while high schools are typically differentiated according to one's year in school and, within year, by program of studies. Just as segregation and self-selection pushes the social density of students to .1, well above the value of .01 for the total community, so will selection within the school further increase densities there. Thus if our simulation included a division between 600 seniors and 1,400 juniors and sophomores, with seniors having a salience of .67, the internal density for the latter would be .20, twice that of the school as a whole.

The result is something with which we are all familiar: individuals attached to peer groups and peer groups connected into a distinctive segment of the community: the so-called adolescent society (Coleman 1961). Here, the result is generated by social and institutional factors involving age grading, not by unavoidable aspects of adolescents' psychosocial development, etc.

Let us consider some general inferences about situations such as that modeled in figure 6, beginning with the widespread visibility of persons and their activities under conditions of high density. On the one hand, density may create disadvantages due to lack of privacy, especially when privacy is conceived of as maintaining the separation among role performances before different audiences. On the other hand, when access to a variety of informants and their information is desirable, there are certain advantages to high density. It means that an individual's contacts are likely to penetrate a relatively diverse set of social circles, and the range of information which is potentially available is quite large. The fact that this situation differs sharply from the experience of those in the surrounding community can lead to serious misperceptions by the majority. For example, parents might perceive a variety of troubling activities to be statistically more common (if not socially more acceptable) among adolescents than among adults. In reality, if such activities were no more common,

[5] Anybody looking at such a table might take issue with some of its entries as unrealistic. One reader felt that the 4.17 contacts from the average adult was unrealistically low. First, it should be noted that such a number is an average. Boy Scout leaders and guidance counselors know more adolescents, but the cell entry depicts the average for all adults. Second, and more important in this context, the cell entry is a function of other entries in the table. If 4.17 is unrealistically low, so is the 100 that describes student-to-adult contacts since the two entries summarize exactly the same reality. A more realistic 10 adult-to-student contacts implies a less realistic 240 student-to-adult contacts. One point of the present exposition is that the intuition that sees 4.17 as low but 100 as high is not sufficiently guided by the numerical logic of the situation.

they would still be more visible. The adolescents are more likely to hear about and have contact with activities that the average adult can unthinkingly avoid. Even "morally sound" adolescents will have more awareness of the rationales, occasions, and likely participants for deviant routines than their adult counterparts.

A related set of interpretations concerns the difficulty of maintaining social differentiation: when density is high, large differences in social background, preferred activities, etc., are not as readily translated into small probabilities for contact. In our example, two randomly selected students are no more likely to be socially similar than any two randomly selected adults, yet the two students are far more likely to be in contact.[6] Further, categories which combine relatively small size and high density interfere with the use of selectivity to control one's range of contacts: an adult in the simulated community of figure 6 can reject 99% of his fellow adults and still have 480 potential adult acquaintances, while an equally selective student has only 20 potential acquaintances among students. This threat of relative isolation may be one component of peer pressure among adolescents. Not only are violations of values and standards more visible, but the violator may be both cut off from valuable sources of information and forced to limit associations to a smaller subset of the student minority.

Instead of pursuing the content of tie-accounts tables for high schools (which is after all an empirical matter), we wish to point out some of the more general features of this substantive example. In particular, we wish to return to one of the issues used to introduce this paper: the ways in which groups correspond to an overlap between categories and networks. Readers well versed in Merton's (1968) theory of reference groups may already have recognized the redevelopment of some of the central tenets of that theory in our substantive interpretations. We believe that categories which are sufficiently salient and sufficiently dense, such as the students in this example, contain many of the features of groups that are associated with the notion of reference group.

Merton's minimal defining characteristic for membership in a group was that interaction with group members must be more common than with nonmembers, that is, category salience must be greater than zero. As strengthening conditions, he added, members must be defined as such by themselves and by outsiders. Either our arithmetic or Blau's axiomatics can be used, however, to show that these should not be thought of as independent criteria, for the existence of a highly salient category means both

[6] Strictly speaking, the identical dissimilarity of random student and adult pairs applies only to family social characteristics. Obviously excluded are such characteristics as age. But included are such things as religion, family social status, and all the myriad differences in manners and mores for which the more general terms stand proxy. And the argument extends to any variable. The proportion of total subpopulation variety included in an average contact net will be far greater in the minority population.

a literal separation of its members from the larger population and a greater likelihood of connection between members.

The greater likelihood of connection is equivalent to the condition of mutual visibility that Merton thought crucial for the enforcement of distinctive norms and practices. While it is shared orientation to such norms and practices that distinguishes a group from a mere aggregate, the foregoing analysis shows that the mutual visibility that buttresses a shared orientation is contingent on category size, salience, and amount of contact. The structural properties are independent of the specific contents or meanings of membership; therefore the structural analysis is of general applicability. Potential reference groups vary over a wide range in these structural properties, and it follows that their effects on individuals should vary in a parallel fashion.

If Merton is correct in his attribution of importance to visibility, the potency of reference group phenomena should depend on category size. The number of contacts and degree of segregation have effects of comparable magnitude. Relatively large, highly segregated, and gregarious aggregates should be comparable with smaller, less segregated, and less gregarious aggregates. And the effects operate across a very wide range of scales. Quite small minorities, such as Kanter's tokens (1977*a*, 1977*b*), can combine substantial out contact with near total saturation within the category. Much larger minorities, such as residents of ghettos and urban villages (Gans 1962; Liebow 1967), can be substantially segregated yet lack sufficiently extensive contacts to unify the group.

It is useful analytically to separate segregation and saturation. When size is constant, the contrast arises as a result of differences in contact frequency. If individual isolation parallels aggregate isolation, a segregated but unsaturated aggregate is the result. But a gregarious aggregate may be saturated without necessarily being highly segregated. Membership in a segregated aggregate means that role performances are played out mainly in front of other category members. Standards that are uniform across the category, such as longstanding cultural traditions, will be strictly enforceable. Membership in a saturated aggregate means that performances are visible to all other members even if nonmembers figure prominently. Even innovative or newly fashionable standards can be enforced. One might expect the sharpest difference under the highly demanding conditions of conflict. A segregated aggregate can enforce traditional responses, while a saturated group can respond flexibly to the exigencies of the particular struggle. Gregarious aggregates can be saturated without being completely segregated and can maintain a given degree of saturation with a larger size so that their conflict capacity will be greater.

The mutual visibility within a saturated aggregate facilitates an informal solution to Olson's (1965) problem of the "free rider" since sanctions of shame and esteem can be more effectively employed. And if such authors as Brecher (1972), Oberschall (1973), and Piven and Cloward (1977) are correct about the inhibiting effects of formal organization, the informal solution is conducive to radical or violent strategies. In short, a gregarious aggregate is a potentially angry actor.

Not all aggregates are aggrieved and not all reference groups are membership groups. Another important type is the nonmembership group whose standards are emulated by others. In Merton's analysis, emulation rests on aspirations toward membership as captured in the concept of anticipatory socialization. But this useful notion is too limited. Emulation without reasonable hope of acceptance is not only imaginable but quite common. In the next example, we shall consider a configuration of contacts conducive to style setting by a minority.

The obvious explanation of style setting by a minority is the possession by the minority of greater prestige or resources than are possessed by those who conform without being accepted into the minority. Our task is to indicate how a contact configuration that is probably quite common can point toward the same result. Although prestige and resources would no doubt help, our structural variable is the quantity of connections.

The setting is a government bureaucracy with 10,000 employees. Most of them were drawn to their present positions from diverse geographic and social origins. But a minority of 1,000 are drawn from elite backgrounds of exclusive suburbs, private schools, Ivy League colleges, and a highly selective set of postgraduate educational centers. In effect, such individuals were on the track toward their ultimate career destination at an earlier stage in the life cycle than others drawn from more diverse origins. As a result, more of their contacts are carried over from past experience into that destination. Such contacts not only are more numerous; they also have more of the depth that comes with longevity. But the first assumption, numerical abundance, is the important one. To make it concrete, suppose that each of the "old boys" has contact with 250 other old boys. The group of more diverse origins has shared less life history with other members of the bureaucracy so that only 100 ties to others in their category are assumed (see fig. 7).

This is insufficient to determine a tie-accounts configuration without a further assumption about the quantities in the between-category cells. But the given information does determine the density for the two categories. The rather modest difference in contact rates of 2.5 to 1 implies an immodest difference in densities of 22.5 to 1. (This is the product of the ratio of ties and the ratio of sizes.)

Another difference is even more striking. If two randomly selected old boys examine their acquaintance circles, the expected number of mutual others (EMO), or shared acquaintances, is 62.5. That is, each old boy

Origin of Ties	Number of Persons in Category	Destination of Ties: To Old Boys	Destination of Ties: To Arrivistes	Average Number of Ties
From Old Boys	1,000	250	100	350
From Arrivistes	9,000	11.1	100	111.1
Population Total 10,000				
		$d_{OO} = .25$	$d_{NN} = .014$	
		$I_O = .68$	$I_N = 0.0$	
		$EMO_{OO} = 62.5$	$EMO_{NN} = 1.11$	

FIG. 7.—Tie-accounts table for old boys in bureaucracy displaying modest out-group demand.

has contact with 25% of each other old boy's 250 contacts within his own group. For the other bureaucrats, this expected mutuality for a random contact is only 1.11 shared acquaintances. This large difference is entailed by the original assumptions and in a strict sense gives no additional information. But this more striking expression of the original assumptions highlights the contrast in the conditions of the two categories.

A major implication of these differences is that the quality and quantity of information available to old boys about each other is vastly greater than that available to the others. A further implication is that old boys are in a far better position to make arrangements with each other on the basis of mutual trust and to enforce obligations and reciprocity within their circle. Access to the collective history makes it easier to anticipate reliability and to avoid the untrustworthy. As a result, such a densely interconnected group is a suitable arena for the secure extension of social credit and, resource differences aside, this greater liquidity makes old boys better partners in bureaucratic barter. More extensive knowledge of opportunities and intentions would facilitate the formation of larger, more effective coalitions.

Since no actual bureaucracy would function with complete segregation between different social segments, the implications of contacts between the groups must be examined. Old boys' access to coalitions makes them highly desirable interaction partners. But rather modest additions of arriviste demand have a dramatic effect. One contact per arriviste translates through leverage into nine new contacts per old boy; 11.1 contacts per arriviste translates into 100 contacts per old boy. This configuration is illustrated in figure 7. The relative densities are as stated above, but a great contrast in salience is apparent. Arrivistes have a random mix salience of 0.0 while old boys have the much higher salience of .68. Further modest additions to arriviste contacts produce the configuration of figure 8, where arrivistes are assigned 20 intergroup contacts. At that rate they are overchoosing old boys, and the salience for arrivistes is —.67. The old boys retain a positive salience of .53. They are highly connected and mutually visible, and yet each has more contact with the majority group than majority group members have with each other. Thus the minority combines greater cohesion and positive selectivity with an abundance of out-group ties. The majority has negligible cohesion and negative selectivity; only their out-group ties connect them to an arena of mutual visibility. And only the old boys, with their twin advantages of contact frequency and a small group, can maintain such an arena.

Other dynamic paths generate the same cross-sectional configuration. For example, in voluntary associations, including political organizations, the number of contacts presumably increases with time spent in the service

Origin of Ties	Number of Persons in Category	Destination of Ties: To Old Boys	Destination of Ties: To Arrivistes	Average Number of Ties
From Old Boys	1,000	250	180	430
From Arrivistes	9,000	20	100	120
Population Total 10,000				

$d_{OO} = .25$ $\quad d_{NN} = .011$

$I_{NN} = .53$ $\quad I = -.67$

FIG. 8.—Tie-accounts table for old boys in bureaucracy depicting negative salience

of the association. It probably also increases with desirability as an interaction partner which, in turn, increases with social status. Thus higher status members and more active members are likely to have an abundance of contacts relative to lower status and less active members. That higher status members are more likely to be more active renders the configuration more likely. If such people collectively combine the size of a minority, modest self-selection, and an abundance of contacts, the result is a connected core and a disconnected collection of hangers on.

As in the previous example, the core group enjoys the advantages of mutual visibility. Its members' advantage in contacts and the higher quality of their contacts (with others having parallel advantages) result in a dominant position with respect to insider information. If the desirability of core contacts is great enough, the typical insider even knows more hangers on than does the typical member of the less active majority. Therefore insider information is more readily disseminated. That differential interests of insiders are more readily realized is a plausible conclusion. And that this configuration corresponds to many social arenas where rates of participation vary sharply is logically inescapable.

Such an example does not prove that insiders always dominate since it rests on assumptions that, though plausible, are obviously not general. But such a demonstration was not the purpose. All we wished to show was that modest assumptions about size, contacts, and in-choice can imply striking contrasts when the implications of aggregation into categories are considered. In the next section we will use data on an elite network to show that many of our assumptions about size, contact rates, and in-choices are reasonable. And the presentation of the data will provide a further illustration of the numerical transformations of the previous discussion.

EMPIRICAL APPLICATIONS

Any empirical applications of our techniques would require estimates of the two groups' sizes and the four contact rates, T_{ii}, T_{ij}, T_{ji}, and T_{jj}. The means of data collection must depend largely on the number of ties in the network. For either small populations with many ties per person (e.g., a high school) or large populations with few ties (e.g., ethnic intermarriage), a complete enumeration of the network is feasible. When both the size of the population and the number of ties per person are large, some form of sampling is necessary. Sampling techniques involving surveys (Granovetter 1976) have been described but not systematically tested.

Our own examples utilize data on 200 members of the northeastern metropolitan elite. These data were originally collected in 1969 by Delbert Miller, who used a modified reputational approach (Miller 1975). Each respondent was given a list of the 200 members of the sample and was questioned about the range of contacts he or she had had with each of the others. This provides us with the data to estimate contact rates within and between various subsets of the elite. The survey placed a special emphasis on the position of black leaders in the region, and a substantial proportion (18%) of the respondents were black. This provides us with our first application: an opportunity to examine the aggregated networks of a potentially dense minority within a larger population. For an empirical illustration of our work on the network configuration of elites, we investigate a categorization of the same sample which distinguishes the best known respondents from the others.

In order to convert the raw data to tie-accounts tables, we must first confront the problem of symmetry, that is, our assumption that T_{ij} and T_{ji} both imply the same total number of cross-category contacts. In the present case, we have calculated the total number of ties implied by both of the contact rates and used their average as the basis for estimating the amount of cross-category contact. In sociometric terms, this can be shown to be equivalent to an assumption that one-half of all the asymmetrically claimed ties are present.[7] This technique assumes that the rates derived from either category are equally reliable. In the absence of better evidence, we believe that this is the safest assumption; if, however, data are collected with predetermined categories in mind, the analyst would do well to build in checks for differential reliability, for example, upward bias in friendship choices.

A final consideration, which is specific to this data set, concerns the problem of missing data. As is not uncommon with large-scale surveys of elites, this study was subject to a 50% nonresponse rate. This means that 100 members of the elite have given us data about their contacts with the full set of 200. We thus have two options for constructing our estimates of the contact rates: we can use either the 100×100 matrix of ties among respondents to the survey or the 100×200 matrix of ties sent (Miller used the latter). We have in fact constructed tie-accounts tables corresponding to both of these approaches, and we find that using the more restrictive data set does not meaningfully alter the conclusions reached by using the full data available to us. Because the larger data set is more directly comparable to Miller's original work, we will proceed with the estimates based on a N of 200.

Figures 9 and 10 show the exchange of ties between blacks and whites for the two relations that were most likely to produce symmetric contact: joint membership on committees and close personal friendship. In our

[7] Traditional sociometric techniques of symmetrizing data treat all asymmetric ties as either completely present or completely absent. Because we are dealing only with rates of contact, we do not have to decide which ties are present or absent, so we may define any proportion of the asymmetric ties as present.

Origin of Ties	Number of Persons in Category	Destination of Ties: To Blacks	Destination of Ties: To Whites	Average Number of Ties
From Blacks	36	8.22	16.8	25.02
From Whites	164	3.69	17.41	21.10

Population Total 200

d_{BB} = .235 d_{WW} = .107

I_B = .18 I_W = .02

FIG. 9.—Tie-accounts table depicting racial distinction in elite sample for the tie "served on a committee with."

Origin of Ties	Number of Persons in Category	Destination of Ties: To Blacks	Destination of Ties: To Whites	Average Number of Ties
From Blacks	36	6.50	7.50	14.00
From Whites	164	1.55	8.27	9.82

Population Total 200

d_{BB} = .18 d_{WW} = .05

I_B = .35 I_W = .12

FIG. 10.—Tie-accounts table depicting racial distinction in elite sample for the tie "close personal friend."

earlier discussion of category inbreeding, we noted that even when T_{WW} was higher than T_{BB}, the minority would still have a higher density if the size differential were large enough. The minority is indeed denser for both types of ties examined here. In fact, two randomly selected black members of the elite are twice as likely to serve on the same committee as are two randomly selected whites. Close personal friendships are more than three times more probable between pairs of blacks than between whites. An important factor here is that blacks have more ties per person (approximately 25 vs. 21 for committees and 14 vs. 10 for friendships). This leads the two categories to exhibit different saliences (see eq. [7]). Surprisingly enough, the whites' salience of .02 (fig. 9) and .12 (fig. 10) indicate that they distribute their ties in a nearly random manner. Blacks, on the other hand, use their advantage in number of ties to overchoose their own group, resulting in both the higher density and higher category salience proposed in our earlier model.

Substantively, we may ask why black members of this elite seem to pay more attention to the category boundary. One strong possibility is the subcultural nature of this segment of the elite: they have and have had their own committees and constituencies. It is thus quite likely that the increasing number of ties sent by whites to black leaders in the late sixties came in addition to an already well-developed network within the black elite. The higher tie volume for black leaders lends some support to this hypothesis. If this were true, it would be of some interest to see whether black leaders have been able to sustain the higher level of activity necessary for any minority to be both internally dense and highly connected to the majority.

It will be recalled that just such a higher level of activity was one of the hallmarks of our old boy model. In that model, the upper elite was active enough not only to show high internal density but also to absorb so many cross-boundary contacts that the lower category exhibited negative salience. As shown in figures 11 and 12, this is precisely what happens for both committee memberships and close friendships when we split the elite at the median with regard to how often each member has been heard of by other members of the elite. Even this conservative definition of the upper elite shows all the characteristics of our old boy model.[8] Members of the upper elite are also more likely to share either of the relations with each other. Indeed, the lower elite send ties to the upper elite at a higher rate than they send ties to their own category—in violation of Blau's axiom of positive in-choice.

[8] Note that our upper elite differs from the smaller "top of the top" category used by Miller. We explored several techniques for defining a more exclusive set of upper elites but did not pursue them because of severe missing-data problems.

Origin of Ties	Number of Persons in Category	Destination of Ties: To Uppers	Destination of Ties: To Lowers	Average Number of Ties
From Uppers	102	19.16	9.96	29.12
From Lowers	98	10.37	6.44	16.81
Population Total 200				

$d_{UU} = .19$ $d_{LL} = .066$

$I_U = .30$ $I_L = -.21$

FIG. 11.—Tie-accounts table depicting status distinction in elite sample for the tie "served on a committee with."

Origin of Ties	Number of Persons in Category	Destination of Ties: To Uppers	Destination of Ties: To Lowers	Average Number of Ties
From Uppers	102	9.37	4.70	14.07
From Lowers	98	4.88	3.52	8.40
Population Total 200				

$d_{UU} = .0928$ $d_{LL} = .036$

$I_U = .32$ $I_L = -.14$

FIG. 12.—Tie-accounts table depicting status distinction in elite sample for the tie "close personal friend."

SUMMARY OF SUBSTANTIVE PROPOSITIONS

The smaller and more segregated a category is, and the more numerous its within-group contacts, the greater is its sociometric density. The greater the density, the harder it is for subgroups to maintain social isolation or privacy. As a result, any activities within the group, including deviant activities, will be more widely known and accessible to other group members.

The greater the density of a category, the greater the mutual visibility of its members. Therefore violations of group standards are more easily known and informal sanctions are more easily applied. Rewards for upholding group standards are more certain. Thus the extent to which a category has the impact of a reference group depends on size, segregation, and number of contacts.

The more gregarious an aggregate's members, the more size and saturation can be combined. Since this pattern facilitates informal coordination of contributions to collective goals, and since informal coordination is less temperate than formal coordination, a gregarious aggregate is a potentially angry actor.

If some participants in a setting have a longer shared history, in feeder institutions or in the setting itself, they will have more contacts. If they are in the minority, they will have far greater cohesion. To the extent that mutuality enhances bargaining, they will be in greater demand as contacts. The result is a minority that combines vastly greater internal cohesion with extensiveness of contacts with the majority. Access to an arena where trustworthiness is readily enforced, together with breadth of contacts, facilitates minority domination in such a setting.

CONCLUSIONS

Although the empirical example presented above used conventional network data, we hope to encourage another realm of applications for the ideas developed in this paper. Simple assumptions about size, contacts, and in-choice rates can imply striking differences when the implications of aggregation into categories are considered. The aggregation principle is a tautology, but its application can suggest new interpretations by depicting the same phenomenon from a different point of view.

One major theme is that given divergences in individual level configurations may look quite different from the group point of view. A second is that the conditions of two groups united in interaction are interdependent and that to hypothesize about one group while ignoring its complement is to comprehend only part of the hypothesis. To hypothesize about each independently is to risk logical inconsistency. With experience, the different viewpoints of individual and group or minority and majority are recognized as a single whole, but the shift in angle of vision can stimulate the imagination.

A still grander shift in viewpoint is provided by Blau, with whom we share a concern for size, contact rates, and in-choices. The exposition above reveals the underlying quantitative relations that are at the heart of his primitive theory of social structure. We did not follow his lead into macro theorizing but instead attempted to demonstrate the usefulness of these notions in a more modest concern for less complex social settings of the middle range. Although we relaxed his assumption of equal contact rates and provided examples of categories that display negative salience, we do not disagree with his adoption of these reasonable and highly powerful simplifying assumptions for his larger enterprise.

But our hope is to encourage another line of applications. The concepts of size, contact rates, and even in-choice can often be guesstimated or even estimated. Consideration of implications at the design or interpretation stage of research can suggest new questions and different insights. The simple relationships presented here are only a starting point and will hardly overwhelm other substantive considerations. But they are simple, they are very broadly applicable, and they can suggest social facts worthy of attention.

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