

*Catij:
A New
Sociometric
and Its
Application
to a Prison
Living Unit*

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A new sociometric technique is described which is generally more powerful than prior methods for analyzing the structure of bounded human groups less than about 150 in size. The method is applied to a female cottage of 41 inmates and 11 staff members (counselors and officers). Data from this application are presented and analyzed regarding the dynamics of subgroup formation. Some general findings are considered, including: (1) a numerical definition of the word "clique"; (2) the role of weak links in a social structure; and (3) the number of persons and "spheres of life" used by any individual in a complex society to order his social relationships.

*Catij: un nouveau sociométrique et son application
à une unite d'habitation dans une prison*

On présente ici une nouvelle technique sociométrique qui est, en général, plus puissante que les méthodes antérieures pour analyser la structure des groupes humains liés qui sont d'une taille moins de 120 personnes. La méthode est appliquée à un chalet de 41 prisonnières et de 11 membres du personnel (conseillants, officiers). Les données de cette application sont présentées et analysées en ce qui concerne le dynamique de la formation des sous-groupes. Quelques observations sont considérées, par exemple: (1) une définition quantitative du mot "clique"; (2) le rôle des points faibles dans une structure sociale; et (3) le nombre de personnes et les "sphères de la vie" utilisées par un individu pour ranger ses rapports sociaux dans une société complexe.

*Catij: una nueva sociométrica y su aplicación
a una de las
células de una prisión*

Se describe una técnica sociométrica que tiene generalmente más alcance que los métodos anteriores para analizar la estructura de grupos humanos confinados de menos de 120 en número. El método se aplica a la vivienda de 41 mujeres encarceladas y a 11 empleados (consejeros y guardianes). Se presentan y se analizan los datos de la aplicación del método en relación con la dinámica de la formación del subgrupo. Se consideran algunos hallazgos generales, incluyendo: (1) una definición numérica de la palabra "pandilla"; (2) el papel de los lazos débiles en una estructura social; y (3) el número de personas y las "esferas de vida" utilizados por cualquier individuo en una sociedad compleja para organizar sus relaciones sociales.

THERE ARE TWO traditions in the field of social network analysis: one stemming from the work of American sociologists and sociometrists such as Moreno and associates (1934 and on), Jennings (1942), Katz and Forsyth (1946), and one from the work of British anthropologists J. A. Barnes (1954), Clyde Mitchell (1971), and Elizabeth Bott (1971). This work is aimed at bridging these traditions, using both formal and ethnographic tools.

We have elsewhere introduced a technique, called "catij," for describing and analyzing social networks (Bernard and Killworth 1973). That work concentrated on proving the formal adequacy of the technique. In this paper we will present: (1) a description of catij, its use and its features of superiority over less powerful methods of social network analysis; (2) the network produced by catij for a residence unit of a youth prison; and (3) a consideration of some implications for our understanding of social group structure. Although we find catij to be of immediate value in the fundamental study of human group dynamics, the device is potentially powerful as an aid to management in public and private bureaucracies.

Catij

A sociogram is usually constructed by asking for a respondent's "three best friends," "three people you work with most," or a similar limited choice of persons from a defined group. Sometimes the respondent may be given the open-ended instruction: "choose the people you like best." This is done in order to avoid the limited-choice constraint. However, as Holland and Leinhardt (1973) have shown, the instructions nearly

always bias the resulting data toward a very small number of choices. The "structure" of the social group is usually given in one of two ways: (1) by transforming the data into a matrix in which the row-column entries correspond to the given data (e.g., person A chooses person B if the [A, B] entry is nonzero); or (2) by defining graphical (usually planar)¹ coordinates for each respondent, and connecting pairs of points together in one-to-one correspondence with the choices made. (The two forms of sociogram presentation are shown in Figure 1.)

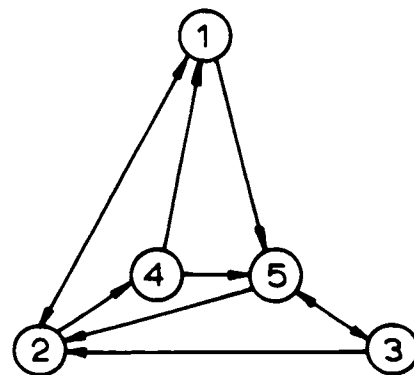
At least four things are wrong with this approach.

- 1) The sociogram obviously never says anything *about* the data other than to reiterate it in graphic form. In other words, the sociogram is not a derived analysis of data; it *is* the data.
- 2) The limited choice format means that the observed sociogram may differ violently from the "perfect, real sociogram" which is assumed to exist. (See Holland and Leinhardt 1974 for a superb demonstration of this effect, and Killworth 1974 for a mathematical demonstration of how this effect manifests itself.)
- 3) It is quite possible that the essential line(s) between two disjoint cliques may be omitted in the sociometric survey. For example, sociograms commonly contain many isolates (Boyle 1969). Granovetter (1973) offers speculation that important links may only involve weak acquaintances. If this is the case, the occurrence of isolates is clearly an artifact of the method.
- 4) The network resulting from a limited choice sociogram usually possesses a certain pristine neatness (cf. Boyle 1969, Figure 3).

Intuitively (and mathematically—see Bernard and

	1	2	3	4	5
1	x	1	0	0	1
2	1	x	0	1	0
3	0	1	x	0	1
4	1	0	0	x	1
5	0	1	1	0	x

Matrix



Sociogram

A one-to-one correspondence exists for sociogram, data, and matrix.

FIGURE 1. EXAMPLE OF MATRIX AND SOCIOGRAM FOR 2-CHOICE DATA

Killworth 1973, Figure 8) one knows that complexity, rather than simplicity, characterizes social relations.² It is probably true that social *structures* are vastly more simple—mnemonically derived, perhaps, from complex relations sets. In other words, it is likely that people carry around a rather limited set of rules and chunks (names or unnamed) of social structures from which they generate the infinitely large variety of social relations observable on the surface. The search for a grammar of social relations has been a pursuit in anthropology since the seminal work of Goodenough (1956) and others in the area of kinship algebra, folk taxonomies, and the like. Such grammars are exceedingly rare (see Wallace 1961, 1965) and are effective only for relatively simple overstructures. The sociogram is, by definition, only part of the data of social relations. It should contain as much of the data as possible rather than attempt to streamline in the cause of comprehension, neatness, or some “structure” which it cannot (by definition) achieve.

An example of what is left out by a sociogram may make this last point more clear. Sociometric analysis sometimes assumes the existence of highly transitive relations among triads. If a L b and b L c, then a L c is likely, according to this assumption. Some intuitive logic and the pioneering work of balance theorists (Heider 1946, 1957; Abelson and Rosenberg 1958) made this assumption appealing. Recently, measuring the data reported here, Killworth (1974) found that intransitivity was at least as important a factor in the structure of social groups as transitivity. Indeed, he observes that intransitivity is the measurable or observable quantity rather than transitivity.

The catij device resolves many of the difficulties cited and may be a step toward producing a grammar for a complex set of social relations. By obtaining the data in an unlimited choice format, catij filters out many of the biases in the traditional sociogram. Since all possible triads can be counted and checked for transitivity or lack of it, the catij matrix provides much more data than the limited choice sociogram. In addition, its “massaging” technique filters out perturbations in the data, such as false rankings. Proof of these statements may be found in Bernard and Killworth (1973). Finally, catij cannot contain isolates—indeed, by definition, the network obtained via catij is strongly connected.

The catij matrix is derived as follows. A group of people ≤ 150 is defined. The original purpose of catij was to describe communications networks in physically closed groups; any definition of closure will do, however. If the definition is spurious, the results will be spurious. A cottage of inmates in a prison proved to be an effectively defined group. The restriction on size of the group is related more to the ability of respondents to

organize the material presented rather than to any restriction in computer capabilities.³

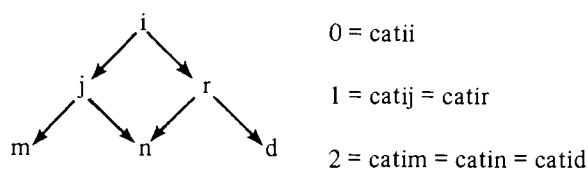
Each person is given a deck of cards containing the names (and nicknames, if appropriate) of all the people in the group. The respondent is asked to sort the cards into four piles: (1) those with whom he/she has *a lot* of communication; (2) *some* communication; (3) *hardly any* communication; and (4) *no* communication. Operationalizing these instructions requires some ingenuity at times. The easiest method we have found is to ask people who they “talk to” a lot, some, etc. “Rap with,” “bullshit with,” and other instructions might be indicated, depending on the situation. Attempts should be made to give each person an idea of what is required and substantially similar instructions should be used. Note that we are interested in *quantity* of interaction rather than quality. A random sample of 80% of the group is required for good results (Bernard and Killworth 1973), and, clearly, the greater the participation, the more valid the results.

The piles are next arranged in order of interaction so that, in the end, an array of N-1 cards is produced for the total group, less the respondent. The arrays for each individual are combined to form a matrix (d_{ij}) so that the columns of the matrix represent distance to each j from each i .⁴ Distance is defined such that, if i ranks j *n*th, the distance from i to j is $(n-1)$. Zeros thus appear in the diagonal signaling that each i is zero units of distance removed from himself. The decision to use unit distance spacing is shown to be valid in Bernard and Killworth (1973).

The distance matrix, d_{ij} , is next transformed into a minimal distance matrix (min_{ij}) as follows: for each i and j in the group, d_{ij} is searched for the absolute minimal distance from i to j , given the possibility of up to N-2 intermediaries. In other words, if $i \rightarrow j = m$ units (i.e. the distance from i to j is m) and if $i \rightarrow k = p$ units and if $k \rightarrow j = q$ units such that $p + 1 < m$ then, we may say we have found a distance from i to j which is less than m , the original distance given by the respondent. While we have found *a* distance less than m , we cannot be sure that it is the *least* such distance from i to j . This is done by continuing to search the matrix. For example, if $i \rightarrow j = m$ units (the original distance) and $i \rightarrow z = a$ units and $z \rightarrow j = b$ units such that $a + b < p + q$ then, we say we have found *another* distance less than m , and less than $p + q$. The process is continued until the minimal distance from i to j is obtained using one intermediary.

We now consider multiple intermediaries, as follows: if $i \rightarrow j = m$, $i \rightarrow l = r$, $l \rightarrow f = s$, and $f \rightarrow j = t$, such that $r + s + t < (a + b <) m$, then we say we have found a two-intermediary distance which is shorter than any one-intermediary distance. The process is continued

for up to $m-2$ intermediaries. (Since each use of an intermediary implies the expenditure of at least one unit, clearly no more than $m-2$ possible intermediaries need be checked.) Recall that this is done for every i and j in the distance matrix. The minimal distances form the new matrix (min_{ij}) which is of itself not of great interest. However, in the process of getting min_{ij} we have kept track of the number of intermediaries used to achieve it. (If there are several possibilities for getting the minimal distance we use the one with the fewest number of intermediaries.) The various numbers of intermediaries used may be represented diagrammatically by



We have here introduced the third and most important of the matrices, cat_{ij} or the category matrix where each ij entry is defined as 1 more than the number of intermediaries used. cat_{ij} , then, is the matrix representation of the taxonomic tree structure for relations in a social group. Obviously, the relations depicted depend on the question used to produce the original distance matrix. We have used "talking to" and "communicating with." An affective question such as "people you like" would result in a structure of affective relations. Evidence to date indicates that the form of such relations may be remarkably similar (Bernard and Killworth, no date). We would not claim that cat_{ij} produces the social structure of a group. There may be more than one social network, but cat_{ij} clearly produces one such structure consisting of (a) a minimal route from each i to each j in a group; (b) one or more paths from each i to each j ; and (c) a listing of the nodes which hold the tree together.

We have not made any claims for the actual route in which the minimal distance is achieved (in fact, several routes typically occur). Nor have we made claims about behavioral interaction. We still do not know whether cat_{ij} represents depth of communication, although it clearly does represent part of some social reality. An informant, given the name of someone he ranked 11th and which cat_{ij} placed on his second row, usually says that he perceives direct communication with that person, and not indirect. However, this seems unlikely. If the human brain is limited as to the amount of similar information it can process (as indicated, for example, by Miller 1956), then it will be impossible for the informant simultaneously to process his relations with too many people. Some must inevitably be compartmentalized into groups attached to one or more of the people he is

capable of processing, corresponding (although not necessarily) to the rows and intermediaries of cat_{ij} . Conversely, if asked point-blank about his 11th person, the informant is not asked to juggle many individuals, but only one; in all likelihood he claims direct communication if he ranked an individual high, and indirect if he ranked the individual lower. Some tests carried out along the above lines seem to support this claim.

Thus, in spite of the fact that cat_{ij} is a more powerful sociometric than previously available there remain a number of uncertainties. For this reason we cannot stress enough the need for serious ethnographic description as part of the technique. When combined with direct observation and with discussion of the results with key informants in the study group, cat_{ij} 's descriptive powers are quite strong. In the prison we studied, for example, all and only the bulldykes (active lesbians) were identified as the power brokers in the female living units. In two cottages we isolated groups of only three individuals, all of whom were known internal drug pushers. In another instance we isolated a group of two Alabama Whites and a White student from Maine. At the time this group made little intuitive sense. About a week later, two of the three members of this group escaped together. As it turned out, the third had been part of the plot and had withdrawn at the last minute. One should, of course, not get the impression that cat_{ij} has the power to discover nefarious activities. In all these examples, interpretation could only be made after the fact using ethnographic evidence.

The program package used to produce and analyze cat_{ij} is called the KBPAK. Program 1 searches the original data for errors and punches the original distance matrix when the data are clean. Program 2 produces and lists the d_{ij} , min_{ij} , and cat_{ij} , and punches cat_{ij} as well. Program 3 describes cat_{ij} statistically, signalling those individuals who are row-one (i.e., direct) or row-two interactors more than others. Program 4 does a row-by-row factor analysis of cat_{ij} , producing the important subgroups in the matrix defined by those members with coefficients for a given factor larger than 0.6. These subgroups may or may not constitute socially real cliques, but do represent groups of people whose outlook on the rest of the group is similar.

To date, strong internal group connectivity has been the rule, precisely because a column-by-column factoring was *not* used. This is because correlating column-by-column compares each individual's placement of two people, and the relation between these placements is a function of the individual making the placement, not the two people concerned. Thus, there is no reason why correlating column-by-column would produce any sensible definition of subgroups. Elsewhere we noted that such a factor analysis produced no better results

than a simple cluster analysis. Row-by-row analysis, however, produces intuitively sensible and powerful results—the reason is that routes from two similar individuals to the same person are being compared. These routes typically involve different collections of intermediaries within the same subgroup followed by a chain of intermediaries which are the same for both individuals. This means that the cat_{ij} row entries for i and j to any k are likely to be of the form $(n, n+p)$ or $(m+q, m)$ where p and q represent the differing numbers of intermediaries used within the subgroup. Hence, a plot of cat_{ik} versus cat_{jk} , for i and j in the same subgroup, will appear as thus giving a high degree of correlation between i and j as required.

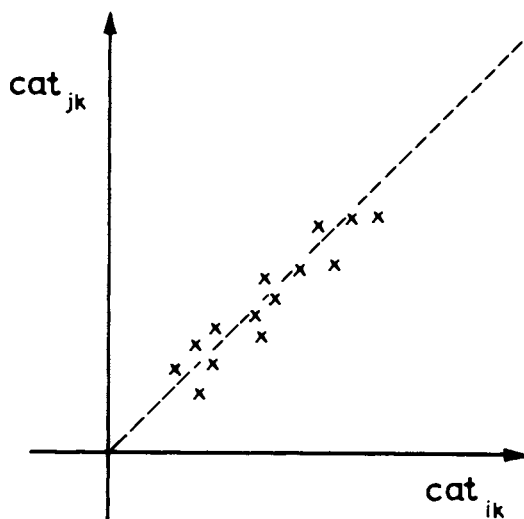


FIGURE 2. TYPICAL PLOT OF CAT_{ik} VERSUS CAT_{jk} , FOR i, j IN SAME GROUP

Finally, program 5 subtracts cat_{ij} matrices from one another, selecting only those elements common to both, and describes statistically the properties of the resultant matrix. This allows for examination of time variation in a nonchanging group, or the effect of new members and exiting members on a group. Multiple matrices from a single group at a single time may also be compared: e.g., two matrices developed by asking respondents “who they talk to” and “who they like.”

The cat_{ij} technique was administered to the inmates of five residence units at a federal youth prison. In the following section we describe the research situation and the result from one of the living units.

The Prison Setting

The Robert F. Kennedy Youth Center in Morgantown, West Virginia was originally built as a minimum

security detention center for male criminal offenders between the ages of 14 and 21. The Center (KYC) was established as a showcase among federal prisons: the grounds were landscaped; the living units were made modern and spacious; the administrative offices were given every facility; the school was equipped for the most modern vocational training; and money was made available for the most extensive and advanced rehabilitation programs known in the field of corrections. The population of KYC was made up of mostly first-time offenders whose crimes were nonviolent and who appeared to be the best-risk recipients of the programs. Between 1968 and 1971, the population structure of KYC reflected the rehabilitation goals of the institution. Unfortunately, those goals remained unattainable and in 1972 inmates appeared who were older (up to 25 years of age), more sophisticated (multiple offenders), and convicted of violent crimes. The most drastic change in the demography of KYC, however, was the introduction of female prisoners. While the men still outnumber the women, two of the five living units (called “cottages”) are female. Sexual relations between inmates (who are called “students”) is forbidden; but, of course, this rule is extensively circumvented as is the law against the use of alcohol or drugs. We have selected the original women’s unit (“C” cottage) for description here for two reasons. (1) On entering KYC, inmates undergo extensive psychometric testing and are segregated into four “behavioral characteristics” or BC groups: juvenile, violent, neurotic, and gang-oriented-manipulators. Plans are underway for testing the women in a similar fashion, but no such psychological segregation of female prisoners has yet occurred at KYC. (2) Although we have obtained generally excellent cooperation from participants in this study (averaging about 90% response), C-cottage has produced our only square matrix (i.e., 100% response from 52 individuals).

At the time of this study (December 1972) C-cottage housed 41 inmates between the ages of 16-22. Twenty-nine were Black, 11 were White and one individual was classified by the institution as “Spanish surnamed.” Not surprisingly, the majority came from Eastern, urban backgrounds (nine were from Washington, D.C. alone, with three more from Maryland suburbs), though many other areas were represented: Houston and San Antonio; Cleveland; Birmingham; Oklahoma City; Detroit; Kansas City; Memphis; Philadelphia. Eighty-eight percent were from urban centers. Convictions were typically for nonviolent crimes (check forgery, mail fraud, car theft, narcotics violations, and prostitution), although some cases of violent offenses were present (illegal use of explosives, bank robbery, armed theft).

The administrative goals of KYC allow each cottage supervisor to design his/her own program for rehabilita-

tion. The program in use during this study followed a behavioral modification approach involving a token economy, soft point rewards, individual counseling, and small group sessions. As in all the units at KYC, a weekly "town meeting" was also used as a focal point for discussion of inmate problems. At one town-meeting it was announced that the cottage had acquired a windfall of five dollars from some accruals. The expenditure was turned over to the inmates.

The discussion lasted 40 minutes. During the first ten minutes it was decided that douche powder would be the object of the purchase. One of the women would be given responsibility for purchase of powder at a local drugstore during a weekend "town trip" to nearby Morgantown. The next 30 minutes resolved the issues of who would be entrusted with the purchase and what brand was to be bought. The supervisor felt the discussion was a "healthy means of engaging in group democracy and cooperation." Inmates were rather less genteel in their description of the exercise.

On entering the cottage each inmate is classified during a meeting with one or more of the four counselors and the supervisor. She is assigned to a counselor and goals are set for her at the level of "trainee." These include the successful completion of some courses in the school, as well as personal behavior and achievement goals such as grooming, maintenance of living area, or punctuality at group sessions. The classification and goals are set according to the counselors' judgment of the inmate's background and requirements. Apprentice goals take about six weeks to achieve if the inmate "accepts the program." Needless to say, the individualized programs do not always jibe with the inmates' own determination of their problems and solutions. Thus, some inmates fail to "achieve their status" (i.e., make "apprentice" level) for two months. Peer pressure, and the sheer lack of privilege at the trainee level, eventually makes even the most obstinate individualist conform. If an inmate simply refuses to "accept the program" (doesn't go to school, keeps reticent at counseling sessions, etc.), she will be sent to the "adjustment center" known as G-cottage or "seg" for obvious reasons. Inmates in seg have virtually no privileges and those sent there for violence are confined to the only locked cubicles on the compound.

Once a trainee makes apprentice she may wear her own clothes (prior to this she must wear prison issue) and she will be assigned a room of her own (until then she lives in a dormitory wing of the cottage). In addition, she may use the soft points she receives for her chores to purchase more free time outside the cottage on the compound, later bedtime, more television viewing, and other privileges. She is entitled to periodic town trips on Saturdays, visits from relatives and friends, and

other rewards. She is also assigned a new set of goals. After about three more months the apprentice may make "honors status." Honors students live in rooms with private toilet facilities and have relatively free run of the "campus" or compound grounds. Honors students are eligible for "work release," in which they work in town (if a job can be found for them) while residing each night at the institution.

The program is administered by a staff of ten in C-cottage, including a secretary, three officers ("guards," "hacks," "screws"), four counselors, a chore officer, and a cottage supervisor whose loyalties are partly administrative and partly to the line-officers and counselors. At the time of this study, C-cottage also had a part-time psychologist, a graduate student in clinical psychology from nearby West Virginia University. KYC makes rather extensive use of the university to buttress its personnel. The psychologist was working on her doctoral thesis; most of the cottages have at least one student intern from the departments of social work or rehabilitation counseling at the university. Those departments require a six-month internship for the M.A., and KYC serves as a convenient vehicle for some of their students.

The structure of the staff follows government service lines. The counselors are traditionally brought up through the officer ranks, while supervisory personnel come up through educational achievement, and are not necessarily from officer backgrounds. The result of this policy is that most counselors come from a law enforcement tradition rather than an academic tradition. Counselors usually have high school diplomas, and possibly a year or two of college. If they attain a bachelor's degree, they follow a different career trajectory which tends to remove them from immediate contact on a counseling basis with the inmates. The influx of female inmates produced a need for women officers and counselors. Some women officers were pushed up rapidly to counselor status. This naturally caused some friction among the male staff. The counseling staff of C-cottage consists of two men (who came up through the ranks) and two young women. All the officers were women, as was the supervisor.

It is not understood why the program at KYC is not as effective as it might be, but the facts are clear. The costs are high (about \$34/day per inmate) and the recidivism rate is not appreciably lower than in more traditional, more secure, and less expensive institutions. A number of problems, typical of penal institutions, continue unabated in C-cottage (and in the institution generally). For example, in spite of the fact that homosexuality is officially defined by the staff as a problem, lesbian activity is common. Heterosexual activity is outlawed, and is patently common. Drugs and

alcohol are forbidden, but periodic "busts" make it apparent that these commodities are in substantial supply. With this short background we may consider the structure of C-cottage as shown by the catij output.

To facilitate understanding of the output, numbers were assigned to the inmates (1-41) and the staff (42-52), although the programs allow arbitrary numbering schemes. For reference, nos. 42, 44, 49, and 52 are officers; nos. 47, 48, 50, 51 are counselors; no 46 is the supervisor; no. 43 is the secretary; and no. 45 is the psychologist-intern.

The first operation performed on the catij output is a simple collection of statistics on the occupants of each individual's first and second rows, as a crude indication of the relative importance of each person to the group structure. The mean number in any first row was 6.44. This may be compared to the data reported by Bernard and Killworth (1973), when catij on 44 informants out of 53 yielded a mean number of 7.17. Incomplete data will invariably lead to more row-1 identifications, and, allowing for this, there is little difference in the two mean numbers. (Note that 6.44 is the lowest mean found in any cottage at KYC, most of which lie in the range 7-8.) The numbers on any individual's first row lie between 4 and 9 (standard deviation 1.35).

However, if we analyze instead the position of any individual in all the others' hierarchies, large variations occur—the range is now from two occurrences on any first row (by no. 45, the cottage psychologist, whose doctoral work resulted in little communication) to 18 occurrences (by no. 35, one of a group of power brokers to whom reference will be made later). The mean number of occurrences is, of course, 6.44, but now with a standard deviation of 3.35. Four inmates and four staff occur on over ten first rows. Eight inmates and two staff occur on three or less first rows.

More tangible information is obtained by factoring the rows of catij. By this process eleven groups, or "cliques" were obtained, each containing from two to seven people. Only occasionally are the groups completely connected internally, and in three cases (groups 9, 10, 11—all of three or less people) are not strongly connected; recall that the entire network is strongly connected. The groups are always "well connected" in the sense that many links do exist between the members of the group, and no group is less than weakly connected. Figure 3 shows the 11 groups, with links to other groups shown by the rosettes about each member of the group. Note immediately the remarkable number of connections between any group and the other groups. Only in a few cases, discussed below, is there any serious lack of communication between two groups—in fact, on the average, each group has links (to and from counted indiscriminately) with

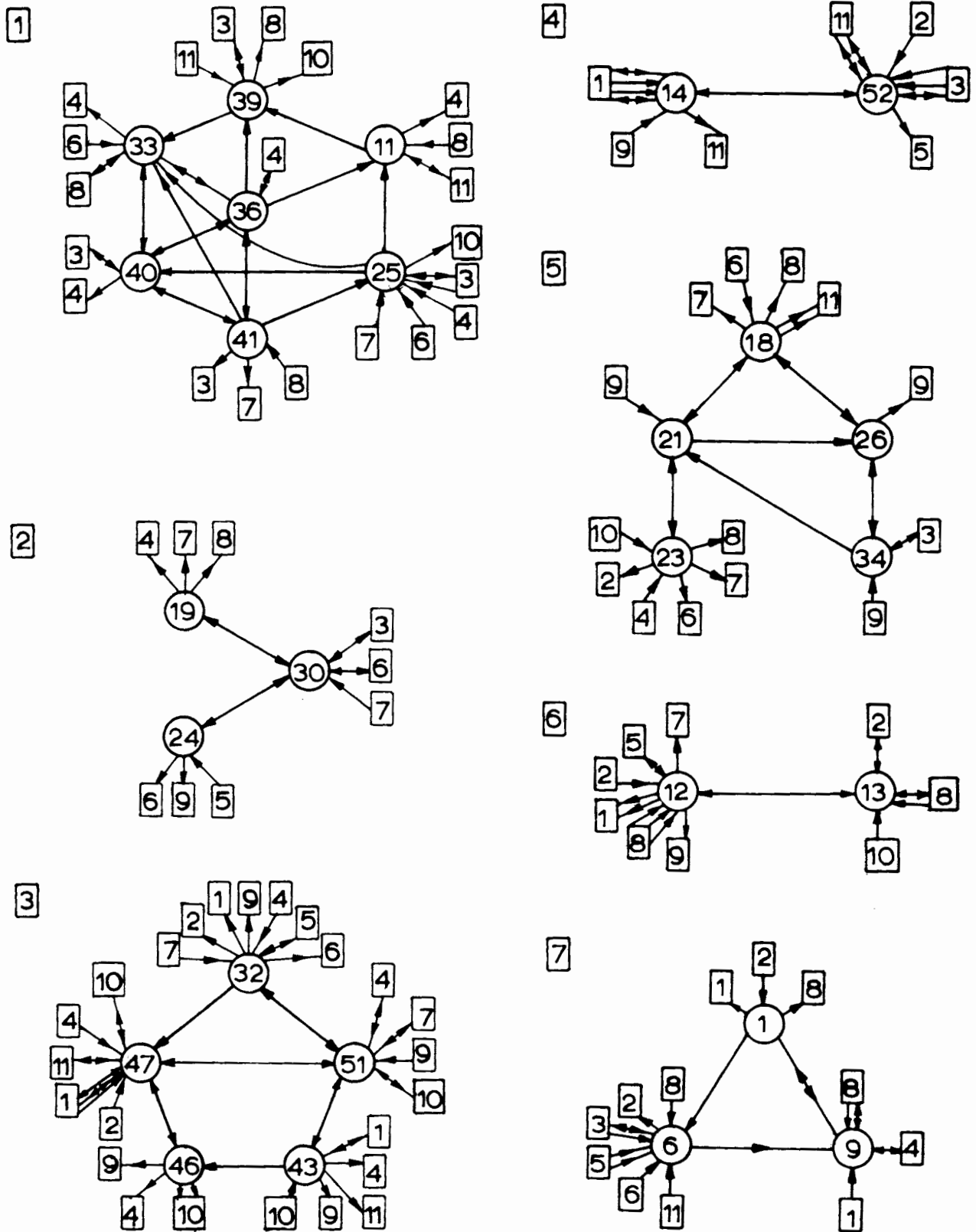
7.64 other groups, out of a maximum of ten.

These eleven groups do not exhaust C-cottage, accounting as they do for only 38 people. Seven other people, serving as between-group intermediaries, are also important to the description of the group, leaving seven people which fall into neither category. These latter, namely nos. 2, 3, 8, 37, 38, 42, and 44 are mainly individuals who occur on few first rows, with the exception of 42 and 44 (seven and eight occurrences respectively). There are reasonable grounds for adding 42 to group three, but this will not be done here. Henceforth we shall consider only the other 45 people.

Group one, the largest group, consists of seven Black inmates. All are from urban centers—five from the southeastern area, and two from Kansas City. There is some evidence that regional origin may be a factor in social grouping (see Theoretical Implications), but the argument is strongest for persons from the same city. In this group, for example, the two from Kansas City were the only natives of that city in the cottage. The same is true for the two members of the group from Memphis. Group two is a mixed group—one each of White, Black, and Brown inmates. Note that 30, (Black) serves as an intermediary between 19 (Brown) and 24 (White). Each serves as an exit point to a differing subset of the other groups. Group three is all White, and all but 32 are staff. Forty-six (supervisor) has connections exclusively to other staff groups; 43 (secretary) has a similar pattern, plus links to two groups of inmates. Fifty-one (counselor) is strongly connected to the staff groups, while 47 (counselor) appears to have excellent connections to staff and inmates alike. Note that 51 possesses links to both 32 (who seems an excellent intermediary from the staff to many inmate groups, both White and Black) and to 28 (not shown), a powerful intermediary between groups of inmates.

It is not at all surprising to find the supervisor on the margins of the cottage structure rather than a central focus; it is important that she have good links to her staff and that they have good links to the inmates. In fact, from Figure 3, it is obvious that counselor 47 is the buffer between the supervisor and the inmate population. It is worth noting that the supervisor agreed with this description.

Group four contains the rare combination of a mutual link between 14, a Black inmate, and 52, a Black day-officer. This reflected a strong personal bond between the two which later dissolved when the inmate betrayed the relationship by not "shaping up." The officer was a very unusual staff member. She had direct links from only three of the other ten staff and had no direct ties to them. By contrast, 11 inmates had direct links to 52. She and 47 had among the highest number of links to them in the cottage. The difference is that 47



Links shown within group, and schematically to other groups. Persons are circled, groups enclosed within a square.

FIGURE 3. GROUPS WITHIN C-COTTAGE, TIME 1

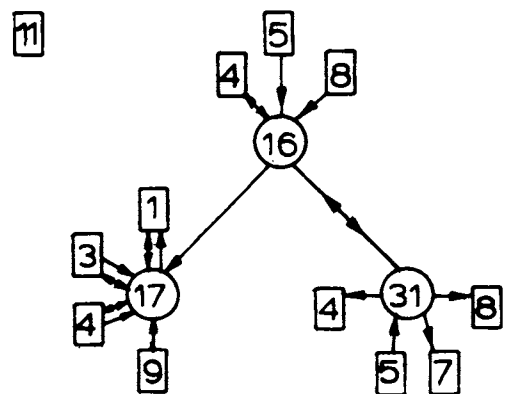
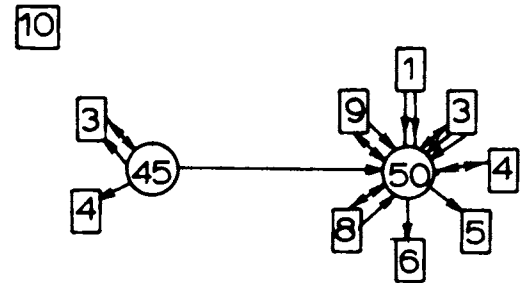
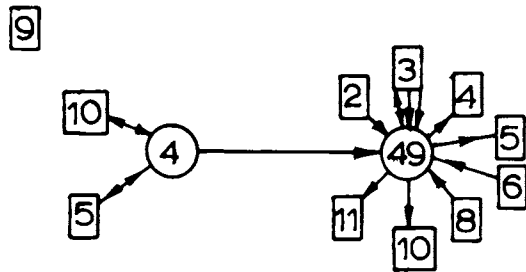
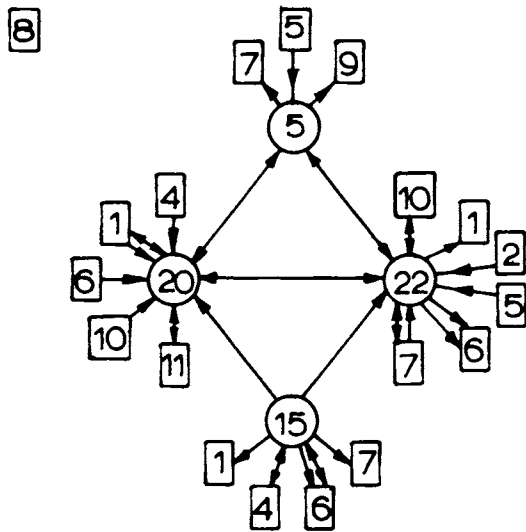


FIGURE 3. (cont'd) GROUPS WITHIN C-COTTAGE, TIME 1

had four links *to* other staff. This reflected a genuine difference in their views of the institution and their careers in it. Fifty-two was disillusioned with the idea that KYC could provide effective help for young inmates, while 47 felt quite positively toward the program and his role in it.

Group five contains White inmates of urban background. The dichotomy between White and Black is shown most tellingly by the fact that only one Black inmate had any member of group five on her first row. Group six contains Black, northern, urban inmates, as does group seven. Group eight contains three Blacks (5, 20, 22) and a White (15) who is not on the first row of any of the other members of the group. Curiously, 15 is on the first row of only three people, all of them Black, and all of her first row are Black. Group nine is a White inmate (4) with the chore officer (49) on her first row. This is not reciprocated.

At first glance it may seem odd that a staff member and an inmate find their way into a group together. In the case of group four the link was mutual and reflected a genuine social bond. In group nine this is not the case. The factoring of the catij matrix produces groups by finding persons who see their relationship to the rest of the universe in a similar fashion. It is almost certain that they will have links to one another, but this may not be the case in a group of very few people. Forty-nine placed 4 on her second row, not her first; but persons 4 and 49 both interacted strongly with the staff.

Other difficulties exist when a group is patently too large to be a "clique" in the normal definition of the word. In B-cottage one factored group contained 18 persons. Thirteen of the 18 members of the group were Whites from Tennessee, Kentucky, North Carolina, and Florida. It just happened that the living unit had an unusually large component of southern Whites at that time and this was reflected in the matrix. In sorting their relationships with others in the cottage, the White southerners exhibited a similarity identified by the row-by-row factoring.

Another group in B-Cottage was composed of seven staff and one marginal inmate who was "never friends with anyone" and was "just used by the other Black students whenever they want anything." Inmate scuttlebutt had it, moreover, that he "never took a bath except when his counselor couldn't stand to have him in the same room with him." Now this marginal student who shows up in the staff group is disowned equally by staff and inmates alike. He shows up in the staff group only because he has (1) many row-1 contacts with the staff and (2) very poor communications links with his fellow inmates, just like the staff. The fact that he is a row-1 communicant for many of the staff is not indicative of any affection for him by the staff. He ingratiates him-

self, constantly makes minor requests of the staff for bandaids, cigarettes, etc., and is "generally a nuisance." Thus, in spite of his lack of personal appeal, he does communicate. "Some people," a counselor said, "communicate because they're a pain in the ass."

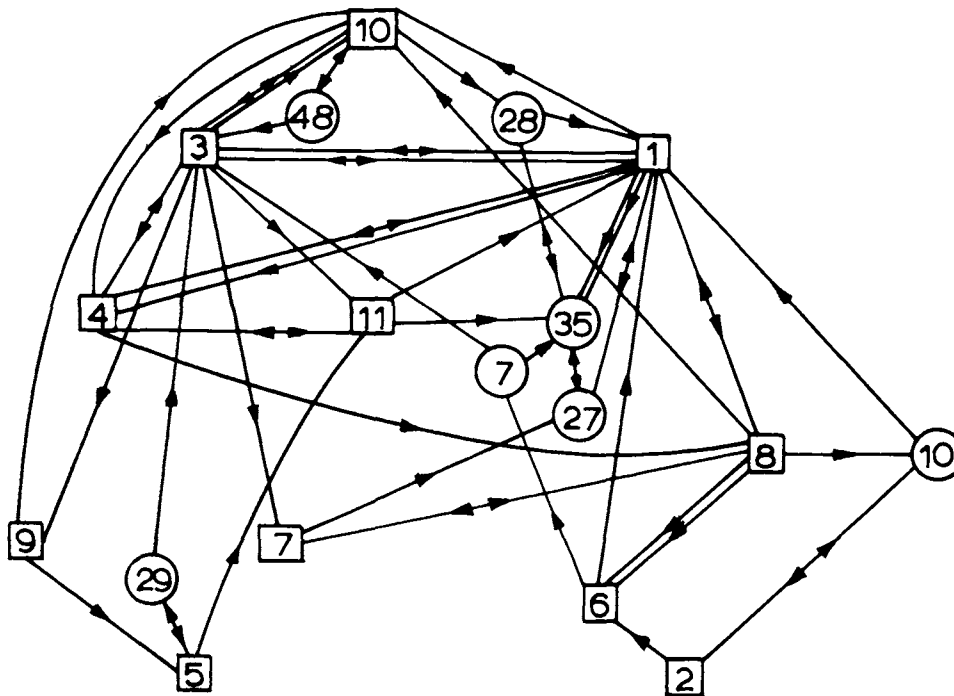
The word "clique" then, appears in quotes here, because there may be no social cliquing effect in the groups identified by the factoring of catij, but rather only a mathematical cliquing. It is up to the investigator to determine the cause of the grouping and, indeed, the group may be an artifact of independent but highly similar views of the social universe by a small number of people. As group size goes up (even to three persons) it becomes very unlikely that clumping is an artifact; but the possibility requires consideration. It is for this reason that we can not stress too highly the need for ethnographic investigation as an integral part of the catij methodology.

Group ten is another staff group, and group 11 another Black, urban group. We may graphically illustrate the relative importance of each group as in Figure 4, where the members of each group have been submerged into a square box. Note that each line represents two row-1 connections. To improve the connectivity, the intermediaries mentioned previously have been added. The intermediaries are completely disconnected if 35 is removed from the diagrams—and, indeed, 35 is not an intermediary between groups, only

between certain intermediaries. The lack of connectivity between intermediaries is in agreement with the theory proposed by Killworth (1974) from numerical grounds, that in any large social group (1) there will be subgroups; (2) there will be a group of "knowers" of people in the various subgroups; (3) these "knowers" will not be part of the subgroups themselves; and (4) these intermediaries will not know each other and in general would not be placed by a factoring into a common subgroup.

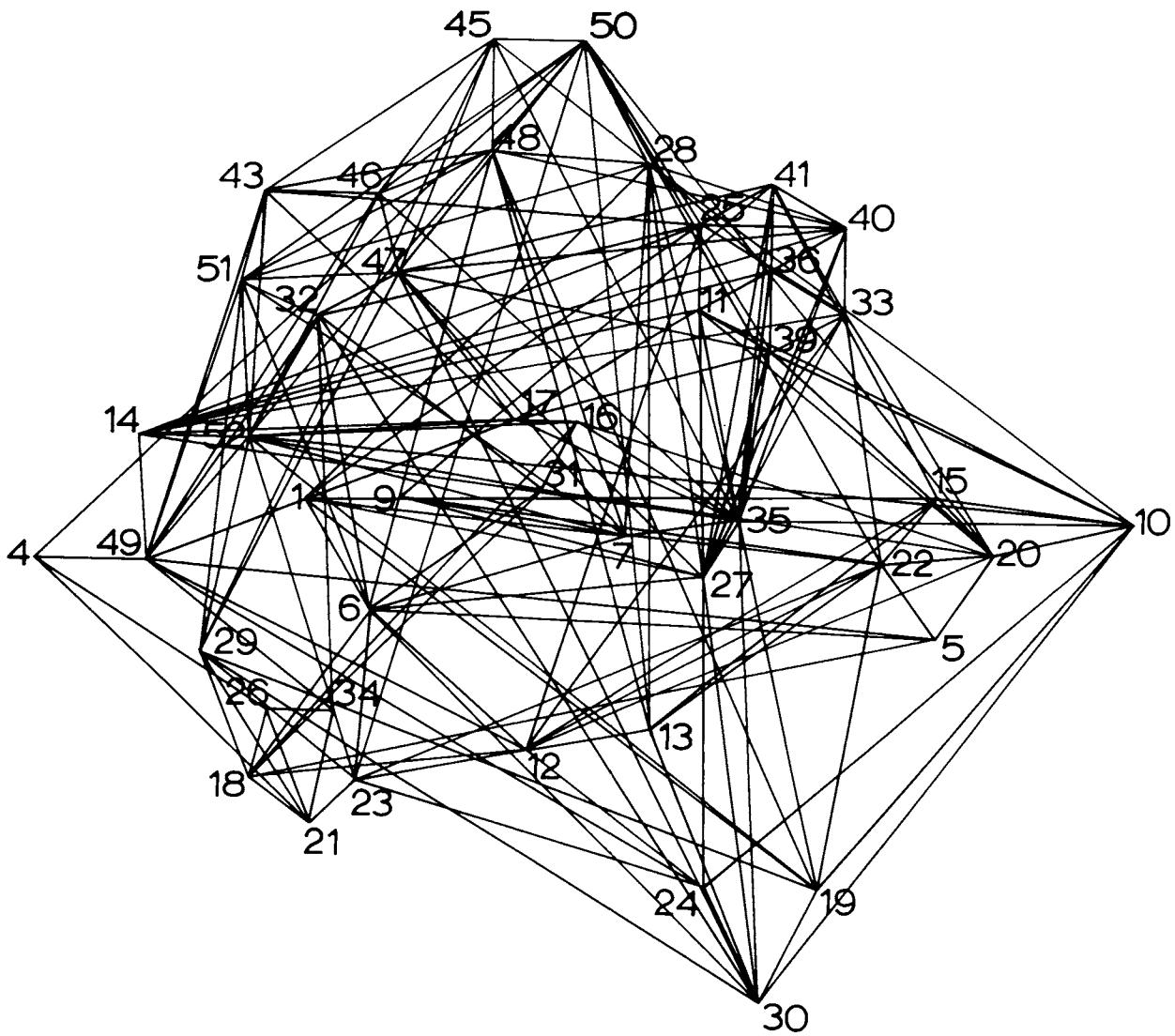
The picture presented of the network in Figure 4 is, of course, highly oversimplified. For comparison, Figure 5 shows the entire network (with directionality omitted for clarity). We cannot overstate the complexity of such a diagram; *any* selective treatment must inevitably result in possible important links being omitted. However, selectivity is important for the comprehension of all but the smallest networks, for complexity exists at all levels. Consider Figure 6. This shows, in block format, merely *some* of the possible routes from groups two to ten and vice versa. Note that directionality is very important—typically between-group links are not reciprocated, whereas within-group links are. Some interpretations of this are given in Theoretical Implications.

Of all the inmate intermediaries, only 29 is White, and serves as intermediary solely between White groups. Forty-eight is a staff member and serves only as an intermediary between staff groups. Intermediaries 27, 28, and 35 were all recipients of very large row-choices



Each line represents two links, single connections omitted. Some intermediaries have been added. Persons are circled, groups enclosed within a square.

FIGURE 4. SCHEMATIC DIAGRAM OF C-COTTAGE, BETWEEN-GROUP LINKS



Directionality is omitted. Placement of persons corresponds approximately to Figure 4.

FIGURE 5. TOTAL COMMUNICATION WITHIN C-COTTAGE

(e.g., 18 for no. 35) although, as seems to be common, they possess no more than the mean number of row-1 entries themselves. It is significant that these three are all and the only bulldykes (active female homosexuals) in C-cottage.

In fact, observation and interviews with staff and inmates in C-cottage showed these individuals to be the most socially powerful inmates in the group. Consider these power brokers' relationship with the staff. Twenty-eight has four row-1 links from the staff and reciprocated only one; person 27 has one non-reciprocated link to a staff member (her counselor); and 35 has two links from staff but neither are reciprocated. The implications are serious. One is that the staff is ignorant of the role of these individuals. When we briefed the staff on our initial findings they professed

little knowledge of the social control exercised by persons 27, 28, and 35. On the other hand, since homosexuality is defined as a severe problem, we have no way of knowing if the staff's professed ignorance was not evasive. For example, when asked "Who are the most powerful and important inmates?" they did not mention 27, 28, or 35. When we showed them our results, however, they agreed with us and offered cavils regarding the way in which we had phrased our original question.

Another implication of the position of 27, 28, and 35 and the failure of the staff to recognize this position, is that staff control over the inmate section of the social structure is thereby diminished. The power brokers simply do not communicate well with the staff. On the basis of our observations at KYC in general, it appears

that the power of inmates (vis-a-vis their peers) is eroded by such reciprocating communication as occurs with the staff. The strength of inmate culture is thereby emphasized, even in this enlightened institution (cf. the work of Grosser 1970; Cressy 1961; Sykes 1958; Berk 1966; Street, Vinter, and Perrow 1966).

Theoretical Implications

Having presented a numerical technique and the details of a social group described by that technique, we may now consider some of the more basic sociological implications. Conclusions are drawn from data collected in five cottages (two of them on two occasions) and from an analysis of the case-management staff of KYC. The latter included a senior executive who is considered part of the institution's top management group. Below him were a series of "lieutenants" and a "captain" (local jargon for senior watch supervisor and his group). Below them were all the officers on duty, all the counselors in the cottages, and the secretaries for the cottages, records department, and senior personnel.

1. It is of interest to inquire what observable social factors effect the formation of subgroups within KYC. The question of sex enters by definition only incidentally. Male counselors in female cottages are obviously associated with female inmates and vice versa, but this is hardly significant. The role of the bulldykes in C-cottage has been noted. There is no equivalent role played by male homosexuals in any of the male cottages.

Color seems to be the main driving component in cliques, and typical examples have been given. In virtually every group within five cottages, the Black-White split was significant at the one percent level or better. The position of Brown inmates is somewhat ambivalent. Within the confines of color, geographical location is important. We coded hometown of inmates by a single North or South and examined the subgroups for evidence of significant structuring within the limits set by the color of the inmate. Several cottages contained such uneven ratios of Whites to Blacks or North to South that comparison was invidious; however, on four occasions (i.e., in four groups from the factoring process) we found splits between North and South significant at the 6.0, 2.7, 2.0, 0.1% levels. Attempts to include the effects of urban versus rural backgrounds gave no significant results; nor did the crime for which inmates were convicted seem to play any part in their social grouping.

Since the number of links between Black and White is scarce, how many inmates serve as cross-color intermediaries? For this purpose, define an intermediary to be an informant who allows two-way communication

between a Black and a White group; he may or may not be a member of either group. Then the following applies to all the cottages tested: such intermediaries are extremely rare—usually two to a cottage at most. The same intermediary may be used between various groups. If the intermediary is not a member of either group, he is White; if he is a member of one group, then he is Black (this statement fails only four times in all the cottages). Intermediaries do not usually communicate. It is tempting to hypothesize that these statements imply that Whites make more effort to communicate than Blacks (since a position as an intermediary between White and Black groups presumably implies greater diplomatic tensions than a Black on the edge of a group communicating with Whites).

Granovetter (1973) noted that envelopes in the small-world problem were lost more frequently during or after the crossing of a strong Black-White link than a weak one. We shall define a strong link between i and j to be one for which d_{ij} is "small" in some sense. Then it turns out that Black-White intermediaries are no weaker than more general intermediaries in the various cottages. The relative strengths of intermediaries may be summarized as follows: the mean ranking between those in a group who had row-1 links was 2.59; the mean ranking between all members of a group, regardless of whether they are linked or not, was 10.58; and the mean ranking between a member of one group and a row-1 communicant in another group was 5.42. In other words, the only weak parts of the network are those non-links *within* groups, whereas links *between* groups are strong (although not as strong as links within a group). The definition of a "small" d_{ij} is of course subjective, but it seems to us that, for these networks at least, Granovetter's (1973) speculation concerning the importance of weak links is unfounded. This is not to say, however, that for larger networks we would continue to find this pattern. If, as we will suggest below, an individual has 20-30 other people on the first row of his total ego-centered network (i.e., including all aspects of his life) then it may be plausible that it is weak links which connect various sectors of his network. More numerical evidence is necessary if this is to be confirmed.

2. A frequently occurring problem is that of defining a "suitably closed" group to which cat_{ij} can be administered. Naturally occurring, physically closed groups, such as a large-scale mountaineering expedition, ships, nuclear submarines and the like, are rare, and study of completely closed groups has been of necessity confined to artificially formed groups (e.g., the NASA-sponsored Penthouse experiments). In this case, the members of the group are usually paid for their services, and hence the group hardly counts as a naturally occurring system.

In general, then, any individual is a member of several different social systems simultaneously: work, family, or social life. These may or may not be intersecting. Presumably, people are able to process all these systems simultaneously precisely because they are never asked to do just that. We compartmentalize the various sectors of our life and recall them when necessary. For example, when we administered catij to each of the KYC cottages, the staff placed about seven people on their first row, some staff, some inmates. Later we administered catij to the case management staff (over 100 people) of all the cottages; a mean first row of about eight people was found—some staff from the individual's own cottage, some from other cottages. From Miller's (1956) classic article on the subject, it is unlikely that we process the (say) 12 people involved, in addition to the (say) seven people involved in family life and the further (say) seven involved socially—at least not simultaneously. On the other hand, the "small world" experiments of Milgram (1967) indicate that the passage of an envelope between any two individuals in the U.S., via personally-acquainted intermediaries, can be achieved by the use of five such steps on an average. A crude estimate, of the number of such intermediaries possessed by any individual can be obtained by assuming the U.S. to have a population of 200 million random individuals, each of which has N intermediaries. Then, neglecting the effects of clustering, physical constricture of environment, etc. (some of which are dealt with by Shaw 1964), an envelope released from one individual could reach any of N individuals after one step, N^2 after two steps, and N^r after r steps. If N is reasonably large (> 10 , say) then overlapping effects are negligible. Then, putting $N^r = 2 \times 10^8$, we have $N = (2 \times 10^8)^{1/r}$. For $r = 6$, this gives $N = 24$; for $r = 5$, $N = 46$, for $r = 7$, $N = 15$. If we take the median value of $N = 24$ as an order of magnitude estimate, this would indicate that an average individual is involved in three to four pseudo-closed networks, each of which contain seven to eight intermediaries. This agrees with the suggestions made above; furthermore, the theory of random groups given in Bernard and Killworth (1973) predicts 27 direct communicants for a random individual in a population of 2×10^8 , which also agrees with the estimates above. At this stage however, this remains little more than a guess.⁵

Hence, the problem of defining a closed system is difficult. Social and family life are apparently unclosed, and problems remain even in work-oriented situations. For example, consider again the case of management data versus the cottage data. These are both part of the work system of a staff member of a cottage. Would we obtain differing answers if we asked such a staff member to arrange cards for both the administration and his cottage simultaneously? Assume that the relative

rankings (i.e., within case management or within the cottage) remained unaltered. It is then probable that there will be a difference between the occupants of (a) the first row derived from the full card sort (case management \cup cottage) and (b) the first row from case management \cup the first row from the cottage. Even though there is a variety of cases in which set (a) will be a subset of set (b) or vice versa, how will we know which set to believe? Which represents, in some sense, the social structure we are trying to measure?

The answer, in general, must inevitably depend on ethnographic and other evidence. For example, we feel that results from both sets of data referred to above are valid, although the union of the two may overestimate the number of row-1 communicants perceived by a staff member.

3. We have noted previously (see Prison Setting) the existence of a two-culture system in C-cottage, and our results indicate that such a structure is the rule, not the exception, for all the cottages. When links between staff and inmate occur (as they must) they are usually one-way. In a very few cases, a guard or counselor would score high row-1 scores as a direct communicant with the inmate population, typically through personal bonds of some form. In all such cases, however, the staff member would not score well as a communicant with the other staff. For example, Table 1 shows the correlations between two sets of row-1 scores: (a) the correlations between the number of times a staff member occurs on the first row of other staff and the number of inmates on his first row, and (b) the correlations between the number of inmates on a staff

TABLE 1. CORRELATIONS ON STAFF-INMATE INTERACTION

Cottage	(a) from staff—to inmates	(b) to inmates—to staff
J	-0.42	-0.37
B(time 2)	-0.59	-0.83
B(time 1)	-0.60	-0.71
C(time 2)	-0.09	-0.73
D	+0.38	-0.67
C(time 1)	+0.12	-0.81
A	+0.01	-0.82

member's first row and the number of staff on his first row. Thus, only in D-cottage was there any evidence that communication with inmates was accompanied by communication from staff. In J and B cottages (on both occasions of data collection from the latter) the evidence points strongly to the opposite: namely that a staff member who communicates well with the inmate

population is not perceived frequently as a direct communicant by the other staff. Further evidence is given by column (b), which shows that if a staff member communicates with inmates, he is unlikely to communicate with staff, and vice versa. However, it is worth noting that such high correlations are caused partly by the limitation imposed psychologically upon each person. If, for example, every staff member had exactly Q members on his first row, divided arbitrarily between staff and inmates, then the correlation would be exactly -1 . Because differing individuals perceive differing numbers of row-1 intermediaries, this correlation is reduced.

The general result concerning the lack of communication by staff to one of their number who knows many inmates is strengthened if we consider the case management study. A similar correlation to (a) in Table 1 can be computed for the staff in each cottage, using now *all* the case management staff. Correlations of almost the same order are obtained for J, B-2, and B-1 (-0.49 , -0.50 , -0.52 respectively). Hence, in these cottages, at least, we are led to the conclusion already shown by other techniques for C-cottage: namely that despite the efforts by the staff, the inmates produce their own discrete social system.

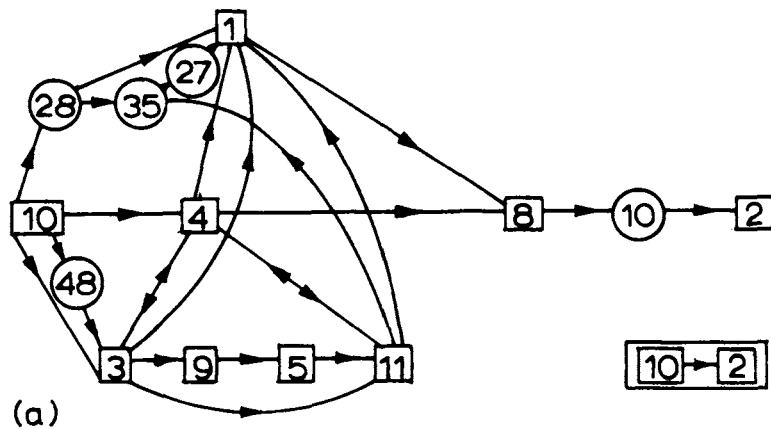
Another interesting split in the social system of the prison occurs in case management. The range of times for which an individual showed up as a row-1 communicant for all others in the group perfectly reflected the bureaucratic hierarchy imposed on the group, with the exception that the senior officer—who was part of the “central administration”—did not do any better than high average on this raw score. The four lieutenants and the captain scored between 19 and 28. Ten low-ranking officers, counselors, and secretaries scored from one to three. Significantly, 50% (five) of the lowest-ranked personnel were women; only 30% of the total group were women. The trend continued on up through the distribution of the ten persons scoring four: 50% were again women. Taking the extremes, the top 30% of the group scored ≥ 9 , with six women and 25 men. The lowest 30% scored ≤ 5 with 13 women and 17 men. A Chi square of 4.92 shows this distribution of women to be significant at beyond the .05 level, with one degree of freedom. This level would be exceeded if all N were accounted for. The 30% scoring between five and nine, however, were intentionally removed in order to be as severe as possible on the data. The descriptive statistics show exactly what might be expected in this type of bureaucracy. Recall the grounds for jealousy by men incurred after the need for women counselors and officers appeared with the opening of female cottages at KYC.

4. Figure 6 represents the possible “routes” from anyone in group 2 to anyone in group 10. As in Figure

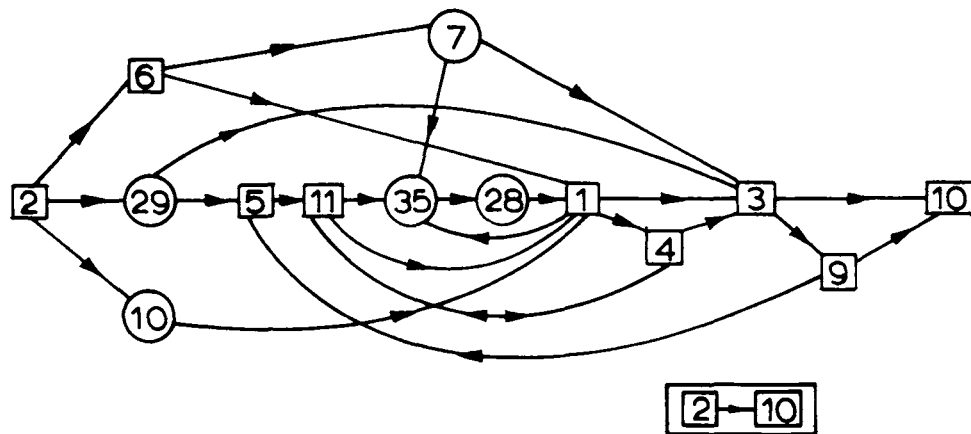
4, each link represents two real links, and single links have been suppressed. Hence, routes other than those shown in Figure 6 are also possible. Any nonlooping circuit may be followed to get from anyone in two to anyone in ten. Now the language we have used here is definitely misleading in the sense that we really have no idea what a social network “route” means. Although it is very disconcerting, we must admit that the phrase “get from anyone in two to anyone in ten” has no operational definition, save the algorithm required to trace the nonlooping paths between individuals. Of course, no more could be said for any other sociometric. But, as we have shown above and elsewhere (Catij section and Bernard and Killworth 1973) catij is obviously measuring *something* more than would be found by standard sociometric methods. In terms of a small world problem, then, we would expect an envelope to be delivered directly—if for no other reason than the spatial and temporal conditions in a small, closed social system make any other behavior improbable. We might hypothesize that a rumor would follow one of the plausible routes between persons in groups 2 and 10. But this is impossible to test. So, in the end we are still stuck with the same disturbing question: What does Figure 6 (and the larger picture of the whole cottage shown in Figure 4) mean? Here is our answer, thus far.

Conclusion

- 1) We believe that a social structure exists in established groups, such that it is stable to minor fluctuations at the local level within the system.
- 2) Perception, or intuition about one’s own place in the structure, is limited to (a) one’s own direct communicants (i.e., about 7 ± 2 people) and about 70% of one’s secondary communicants. In fact, some surprises occur to people for the other 30%; these result from a simple lack of knowledge about who one’s primary communicants have as *their* primary communicants.
- 3) We believe the perceived social network of an individual to be a subset of the total network (a physical entity) which is, by definition, describable.
- 4) Catij describes the physical entity referred to as the social structure. Admittedly, the description is crude, but it is less crude than any other description of which we are aware.
- 5) If catij is, indeed, measuring and describing social structure in closed groups, it has potential as a useful management tool. For example, in the study of the prison bureaucracy discussed above, catij provided evidence for evaluating the relative importance of Black and White staff in the



(a)



(b)

Each line represents *two* or more links. Persons are circled, groups enclosed within a square.

FIGURE 6. POSSIBLE ROUTES FROM (A) GROUP 10 TO GROUP 2; (B) GROUP 2 TO GROUP 10. (NOTE THE ASYMMETRY).

communications network. In addition, catij showed how women (officers and secretaries alike) were systematically and significantly underused as communications links in the system—all the loose talk about secretaries being great brokers of information notwithstanding.

We are continuing our work in an effort to develop greater applied uses of the catij technique. In the near future we will be studying more open-ended systems; catij should be useful in analyzing communications nets in hospitals, small police forces, commercial bureaucracies, and task-oriented work groups such as mine crews, movie set crews, research stations, and others. Sociometric studies have long been useful in applied sociology. Dealing with small groups and relying on ethnographic and informant feedback techniques for analysis, we feel catij is an appropriate tool for applied anthropology as well as sociology.

NOTES

1. On rare occasions, three-dimensional displays are attempted. A particularly imaginative example from multi-dimensional scaling (and hence, not a sociogram) may be found in Steffle (1972).
2. Various possible effective communications patterns have been suggested in the literature—e.g., the wheel vs. the circle (Leavitt and Knight 1963). Buried in the complexity of various prison cottage networks (see *Prison Setting*) one may find both wheels and circles, each garnished with extra links. Curiously, these occur among the inmates (who possess no common goal or reason for being in prison) as well as among the task-oriented staff. The implication appears to be that social groups may ensure effective communication by combining such shapes as the wheel and circle modes of interaction.
3. Current work is aimed at increasing the size of the group describable by catij; however, this requires sampling procedures which have not been fully developed. In fact, the primary disadvantage of catij compared with the

sociogram is the increased time necessary to administer the instrument. Work currently in progress has eased this disparity. Empirical testing is still very limited, but it appears that catij can handle groups of about 200 in size. For groups of about 40, the full catij matrix is obtained by sorting only the top 15 persons. For groups of 200, about 25 should suffice with no loss of generality of information.

4. The basic algorithm (which is, of course, much neater than that described here) for producing the minimal distance from i to j is given in Acton (1970).
5. While we are guessing, though, we would venture that anthropologists doing network studies would find that primary contacts cluster around two dozen. This calculation becomes very important for the small world problem. Milgram (1967) noted that people have about 500 acquaintances from whom they might choose in order to initiate a small-world folder path. Our hunch is that experimentation will show people using the same seven or so initiators for the most wildly divergent kinds of problems; and in any case, no more than about 24. Experiments are currently planned to test this hunch.

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