Title
Horizons of Observability and Limits of Informal Control in Organizations

Journal
Social Forces, 62(1)

ISSN
0037-7732

Author
Friedkin, Noah E

Publication Date
1983-09-01

DOI
10.2307/2578347

Peer reviewed

Horizons of Observability and Limits of Informal Control in Organizations
Author(s): Noah E. Friedkin
Source: *Social Forces*, Vol. 62, No. 1 (Sep., 1983), pp. 54-77
Published by: Oxford University Press
Stable URL: http://www.jstor.org/stable/2578347
Accessed: 06-04-2017 20:43 UTC

Horizons of Observability and Limits of Informal Control in Organizations*

NOAH E. FRIEDKIN, *University of California, Santa Barbara*

Abstract

There are various views on the relationship between the interpersonal communication networks within organizations and informal social control. The relative merits of some of these viewpoints can be assessed by examining the distribution of interpersonal observability in communication networks. In a study of six communication networks, it is demonstrated that there is a "horizon" to observability (a distance in a communication network beyond which persons are unlikely to be aware of the role performance of other persons). Observability tends to be restricted to persons who are either in direct contact or who have at least one contact in common. It is shown, moreover, that the number of contacts shared by two persons is a powerful predictor of the probability that one person is aware of the role performance of another, according to a simple stochastic function. Based on this evidence, some viewpoints on informal control structures are more plausible than others. A theory is presented that is consistent with both the present evidence and current thinking on the relationship of communication network structure and informal control. It is hoped that the theory will provide a useful starting point for future studies of this relationship.

Most conceptions of social systems allow for gaps in the network of interpersonal relations within a system (i.e., places where face-to-face communications are absent), suggesting that these gaps do not necessarily impede the integration of a system. Social network analysis has developed various methods and concepts for describing the structure of such networks. But these studies have been less effective in ferreting out the implications of various structures for other substantively important phenomena. This paper addresses the relationship between communication network structure and informal social control. Informal control is defined as con-

*For their contributions to this paper I am indebted to members of the social network groups at the University of Toronto and the University of California at Irvine and Santa Barbara, to anonymous referees, and to James Pellegrino. The research was supported by funds from the University of Chicago, the University of California at Santa Barbara, and a Spencer Fellowship from the National Academy of Education.

sisting of two processes: (1) a process for monitoring and evaluating performance, and (2) a process for influencing the monitored and evaluated performance. Network structure is often described and its implications for informal control discussed. Over time, a variety of different structures have been suggested as possible bases of effective informal control. Which of these proposals are most plausible? Can a general viewpoint be developed?

Speculations on the relationship of interpersonal communication network structure and informal control fall into two major groupings, each of which can be described by a general orienting proposition and certain subsidiary statements. The two orienting propositions are:

1. Informal control exists only in the presence of high levels of structural cohesion in interpersonal communication networks; and
2. Informal control may exist in the absence of high levels of structural cohesion in interpersonal communication networks.

In these propositions, structural cohesion is considered to be a positive function of the number of communication channels that join the average dyad in a network, where the contribution of a communication channel to structural cohesion is inversely related to the length of the channel (i.e., a short channel contributes more to structural cohesion than a long one). The second proposition, unlike the first, argues that a high level of structural cohesion in these terms is not a necessary condition of informal control.

Under the first proposition we have these subsidiary statements:

1A. Informal control exists in small-scale groups with high densities of direct interpersonal contact.
1B. Informal control is absent between two groups that lack large numbers of intergroup contacts.
1C. Increased contact between two groups leads to greater intergroup control.

Under the second proposition we have the following subsidiary statements:

2A. Informal control may exist in large-scale groups with low densities of direct interpersonal contact, depending on the communication structure of the group.
2B. Groups that are reachable in a communication network structure, regardless of network cohesion, are not necessarily "out of control" with respect to each other.

Arguments that bridges and liaisons between groups are sources of intergroup coordination are pertinent here. The emphasis is placed on reachability (the presence of some channel of communication) between groups and on *strong components* which consist of sets of mutually reachable persons.

2C. Informal control in differentiated systems requires insulation from prevalent intergroup contacts.

Thelen has suggested that the stability of a highly differentiated system requires that its subunits be insulated from a free flow of information between subunits. In an information-rich environment, the occurrence of continual, diverse reactions to subunit behavior reduces the ability to achieve stability in the system as a whole. Subunits will not have the chance to settle into a stable accommodating connection with their environment. Some restricting and narrowing of the influences affecting subunit behavior is therefore highly desirable in systems composed of a large number of subunits.

The differences of emphasis in these two sets of propositions reflect the persisting difficulty of establishing the linkage between micro and macro levels of analysis. The first set of propositions grows out of studies of small groups and the well-documented relationship between the structural cohesion of such groups and informal social control. The second set of propositions grows out of the struggle with the general observation that informal control may integrate large-scale systems as well as small ones and that most large-scale systems do not possess the overall level of structural cohesion found in smaller ones.

The aim of my paper is to develop a general viewpoint on the relationship between interpersonal communication network structure and informal social control, a viewpoint which is based on an internally consistent set of micro- and macro-level propositions. Towards this end, data pertinent to the relationship between communication network structure and informal control are analyzed across six intraorganizational communication networks. These data deal with the distribution of relations of interpersonal observability in different communication network structures.

OBSERVABILITY AND INFORMAL CONTROL

What do relations of observability tell us about informal control? Observability of role performance has been of interest to sociologists since preliminary statements on the subject by Simmel. Simmel used the term, surveyable, to refer to the extent to which the role performance of persons in a system may be scrutinized. While Simmel was concerned with the ability of persons in an aristocracy to observe the behavior of its other members, Merton has generalized this concern to any social system. The interest in observability derives from its relationship to control: This relationship is acknowledged in Ouchi's definition of control as a "process for monitoring and evaluating performance" (96) and in Skolnick and Woodworth's observation, much along the same lines, that

> Awareness of infraction is the foundation of any social control system. Whatever the system of normative standards, whether these are folkways or mores, crimes or rules, a transgression must somehow be observed and reported before sanctions can be applied. The potential efficiency of a social control system, therefore, varies directly with its capacity to observe or receive reports of transgressions (9).

Hence, observability of role performance generally is considered a prerequisite condition of control, in that reactions to an individual's or subunit's behavior cannot occur unless the behavior is first observed.

Now it has been stated that informal control is based on a monitoring process and an influence process. If two persons are in face-to-face contact, monitoring and influence can be direct. If two persons are not in face-to-face contact, control must be indirect and can exist if and only if:

(a) a potential observer is aware of the role performance of the person who is at some distance from him in the network, and
(b) the reactions of the observer are somehow transmitted through intermediaries to the person whose behavior has been observed.

The likelihood that influence will be transmitted through intermediaries is thought generally to decline with the distance between two persons and to increase with the number of channels available for such transmission. Such indirect influence is thought to be most effective when reactions can be transmitted through brokers or shared contacts and to be a positive function of the number of these brokers.

Measurement of the effectiveness of reactions to observed behavior is extremely difficult. Of course, we can easily measure the extent of persons' agreement on different questions. But what we are really interested in is behavioral accord. How does one measure the similarity of behaviors occurring in different subunits of a system? In some cases, standardized measures of output can be used. But what if, as is usual, we want to evaluate qualitatively different activities and the extent to which persons engaged in one have influenced the behavior of persons engaged in another? In such a case, a more sophisticated concept of the behavioral consequences of control than output equivalency must be somehow operationalized: for example, the extent to which persons who have internalized the standards of behavior of one subunit would, if transferred to another subunit, easily adapt to the new standards, other things being equal.

Another approach to measurement of informal control, the approach taken here, is to measure the presence of observability which is a precondition of control rather than its consequence. While this approach avoids the difficult methodological problems just suggested, it does so at a price. We are able to make statements about the conditions under which informal control *does not occur*, but we are not able, strictly speaking, to make statements about the conditions under which effective control actually does occur. Consider two groups between which observability is absent or rare; then it is evident that informal control cannot be extensive since the preconditions of the control process are largely absent. Consider another two groups between which observability is extensive; the preconditions of control are present, but whether effective control also exists is uncertain.

Much that is definite can be learned about the relationship between communication network structure and control by looking for network conditions under which control is *very unlikely*. If one can accept an additional assumption, the analysis of observability becomes even more compelling. This assumption is that the presence of multiple shared contacts between two persons provides opportunities for relatively effective informal control. A shared contact is someone who is in the position both to receive the reactions of the observer and to influence the observed person on the basis of direct face-to-face interactions. The greater the number of contacts shared by an observer and observed, the more likely it is that at least one of these shared contacts will effectively transmit the reactions of the observer to the observed.

For inferences about control in this analysis, I shall rely mostly on the conditions under which observability is unlikely. But it will be useful, when considering the findings of this study, to keep in mind this positive viewpoint about observability and control in the context of multiple shared contacts.

TWO HYPOTHESES

Two hypotheses about how observability is distributed in interpersonal communication networks are explored.

1. *The likelihood of observability declines with the distance between two persons in the network.*

At some point observability must approach zero. At this point, which I have called the horizon of observability, instances of informal control must also be absent or rare. At what distance is the horizon of observability? Is it near or far?

2. *The likelihood of observability increases with network cohesion, defined in terms of the multiplicity of communication channels joining two persons in the network, controlling for channel length.*

Is the presence of a single communication channel associated with a relatively high likelihood of observability, particularly if it is a short one? In general, to what extent does unipathic network structure provide a basis of observability? Is observability only likely in the presence of considerable structural cohesion?

Methods

The present investigation is in line with the graph analytic approaches to social networks (e.g., Barnes; Bavelas; Granovetter; Harary et al.). It asks about the awareness of role performance in dyads. Awareness is treated as a relation of one person to another, that is, u either lacks or has some familiarity with the behavior of v. The analysis centers on characteristics of the network structure in which a dyad is involved and relates these structural characteristics to the probability that one member of the dyad is aware of the behavior of the other member. The depth of a person's understanding and appreciation of another person's behavior is not measured; the concern is with the presence of any degree of knowledge versus the total absence of such knowledge.

The analysis is concerned with interdepartmental dyads in the communication network of organizations whose members are two or more steps removed from each other in the network. The likelihood of observability in these dyads is related to the distance separating the two members of the dyad in the network and, controlling for distance, the number of communication channels of particular length that connect the two members. Thus, the analysis will show the extent to which observability extends to persons, in different subsystems of an organization, who are at various distances from each other in the communication network and who differ in the number of two and three step connections which join them.

THE SURVEY

The communication networks involved in the present study consist of university faculties drawn from two research centers—the University of Chicago and Columbia University. Each network is homogeneous with respect to the broad domain of science in which members work—biological, physical, or social sciences. Each network is heterogeneous in the disciplinary (departmental) affiliation of its members.[1] Six different networks are involved in the analysis, each consisting of faculty members at work in one of the three domains of academic work and in one of the two universities.[2] Thus, one network consists of biological science faculty at the University of Chicago, another of biological science faculty at Columbia, and so on.

Since a probability sample of university organizations is not involved in this study, the extent to which the present results are generalizable to other university science faculties and other types of organizations is unknown. At the same time, the generalizability of the present results should not be underestimated. The dyads examined are from different universities and domains of science; separate analyses are carried out for six networks that are different in university locale, scientific domain, or both. A consistent set of findings will support a conclusion that the findings may hold well beyond the networks examined, while inconsistencies will indicate that the relationships are conditioned by local organization circumstances and/or the domain of science being considered.

Table 1 shows the number of faculty members surveyed in each domain of the universities and the response rate in each domain. The highest response rate was achieved in the biological sciences divisions of the two universities and the lowest in the physical sciences divisions. Not all the dyads in a network can be used as units of analysis; the analysis must deal with dyads in which *u* is a respondent and *v* is one of the other faculty members. This limitation arises from the fact that a nonrespondent cannot report knowing about another faculty member's work.[3]

For each dyad, (*u*,*v*), the survey provided data on whether *u* knows something about *v*'s current work, and whether *u* has talked to *v* about *v*'s current work. The instructions to respondents make it clear that "current work" refers to research that *v* is engaged in at the time of the survey.[4]

CONSTRUCTS

Relations of Observability

If *u* reports talking to *v*, by definition *u* possesses information about *v*'s current work. In the absence of a direct discussion about the current work of *v*, *u* may be informed about *v*'s work: for example, *u* may have read about *v*'s work or have heard *v* present the work before a group. It is also possible that *u* may learn something about *v*'s work through intermedi-

Table 1. THE SURVEY

Network	Number of Network Members	Number of Survey Respondents	Number of Interdepartmental Dyads Analyzed*
University of Chicago:			
Biological Sciences Faculty	142	97 (68.3%)	11,561
Physical Sciences Faculty	141	79 (56.0%)	8,941
Social Sciences Faculty	153	95 (62.1%)	12,118
Columbia University:			
Biological Sciences Faculty	153	105 (68.6%)	14,028
Physical Sciences Faculty	105	59 (56.2%)	5,028
Social Sciences Faculty	157	94 (59.9%)	11,843

*These are the u,v dyads in the faculty which meet the requirements that u and v have their primary appointments in different departments and that u is a survey respondent.

aries. Table 2 shows that roughly half of the observability relations among the interdepartmental dyads are awareness-without-contact relations.

Communication Network Structure
The communication network is measured in the form of a graph of face-to-face communications about research activity. Such a graph can be represented by a $n \times n$ matrix (n equals the number of persons in a faculty) in which the cells are initialized to zero and set to one if, and only if, there is evidence that u and v have been in face-to-face communication about one or the other's current research. Hence, the directed relations which exist between persons are taken as indicators of social structure (i.e., the presence or absence of face-to-face interaction in a dyad and of chains of face-to-face interactions), as opposed to indicators of the direction of information or influence flows. The two components of communication network structure singled out for analysis are the distance separating two members of the network and the number of communication channels of a particular length that connect the two members.

The distance between members in a network is determined by the length of the shortest communication channel connecting them. I refer to the members of dyads as being one step removed, two steps removed, . . . n steps removed in a communication network depending on the number of direct interpersonal communication relations (lines) that are involved in the shortest communication channel connecting them in the graph.

It will be helpful to readers unfamiliar with the graph analytic definition of distance to think of the measure as emerging from the following

Table 2. BASES OF AWARENESS OF CURRENT WORK AMONG THE INTERDEPARTMENTAL DYADS (IN PERCENT)

	Interdepartmental Awareness Relations					
	University of Chicago Faculty			Columbia University Faculty		
Bases of Awareness	Biological Sciences	Physical Sciences	Social Sciences	Biological Sciences	Physical Sciences	Social Sciences
Contact	44.5	46.3	54.1	46.4	50.5	47.7
Awareness-without-contact*	55.5	53.7	45.9	53.6	49.5	52.3
Total	100	100	100	100	100	100
base	(1,309)	(657)	(715)	(995)	(101)	(396)

*Of these awareness-without-contact relations, a small fraction are found in dyads whose members are one step removed; these fractions are 11.3%, 9.9%, 8.2%, 6.8%, 0.0%, and 3.9%, respectively.

series of questions: (1) Is there any evidence to suggest that the members of a dyad have been in direct communication? If so, they are only one step removed from each other in the social structure. (2) If the members of the dyad are not in direct communication, is there any evidence to suggest that they have been in direct communication with at least one and the same third party? If so, the members of the dyads are two steps removed in the social structure. (3) If the members of the dyad are not one or two steps removed, is there any evidence to suggest that they have been in contact with two other persons who are one step removed from each other? If so, the members of the dyad are three steps removed. One can continue in this way ad nauseam.

Table 3 shows the percentage of interdepartmental dyads whose members are at different removes from each other. For example, in the biological sciences faculty at the University of Chicago, 7 percent of the dyads whose members are in different departments are one step removed, 55 percent are two steps removed, 34 percent are three steps removed, and 4 percent are four or more steps removed. With the exception of one network, the members of the majority of interdepartmental dyads are less than four steps removed. The dyads whose members are two or three steps removed represent an important segment of the total population of interdepartmental dyads: in five of the networks over 65 percent of the dyads are of this type, and in three of the networks over 80 percent of the dyads are of this type.

The number of communication channels connecting *u* and *v* of length two and three was determined for each dyad. Members of two-step removed dyads may be connected by any number of communication chan-

Table 3. PERCENT OF INTERDEPARTMENTAL DYADS WHOSE MEMBERS ARE AT DIFFERENT DISTANCES FROM EACH OTHER IN THE NETWORK

Distance (Steps Removed)	University of Chicago Faculty			Columbia University Faculty		
	Biological Sciences	Physical Sciences	Social Sciences	Biological Sciences	Physical Sciences	Social Sciences
One	7.2	4.8	4.3	4.5	1.2	2.0
Two	55.0	32.1	35.9	40.5	10.9	22.6
Three	33.7	34.4	44.3	47.5	28.2	49.3
Four or more	4.0	28.7	15.5	7.5	59.7	26.1
Total	99.9	100	100	100	100	100
base	(11,561)	(8,941)	(12,118)	(14,028)	(5,028)	(11,843)

nels of length two or three; while members of three-step removed dyads are not connected by any communication channels of length two, they may vary in terms of the number of channels of length three which connect them. Of course, dyads whose members are four or more steps removed cannot be connected by any channel of length two or three (see Figure 1).

The number of communication channels of length two which connect *u* and *v* is equivalent to the number of shared contacts, i.e., persons for whom there is some evidence of discussions with both *u* and *v*. Along the same lines, the number of communication channels of length three that connect *u* and *v* is equivalent to the number of different dyads, whose two members are in direct contact and to which both *u* and *v* are directly connected.

Results

The six interorganizational communication networks are based on the social relation "*u* has talked to *v* about *v*'s current work"; therefore, whenever this relation exists between two persons so must observability, "*u* is aware of *v*'s current work." However, observability may also occur in the absence of a social relation; that is, observability may cut across gaps in the network's structure and help to integrate persons in different parts of an organization, between whom direct social relations are lacking. Both network distance and cohesion should be related to some extent to the occurrence of observability between organization subunits.

DISTANCE

Table 4 shows that the likelihood of an awareness-without-contact relation declines as the distance separating *u* and *v* in the communication network increases. There is a dramatic decline in the likelihood of observability associated with increasing distance. The horizon of observability appears in general to extend to persons who are two steps removed in a network; observability is very unlikely among persons who are three or more steps removed.

The awareness relations occurring between persons two or more steps removed represent the vast majority of the interdepartmental awareness-without-contact relations (in general, about 90 percent; see note in Table 2). The remaining analysis is concerned with the structural conditions under which awareness relations occur in those dyads whose members are two or more steps removed in the networks.[5]

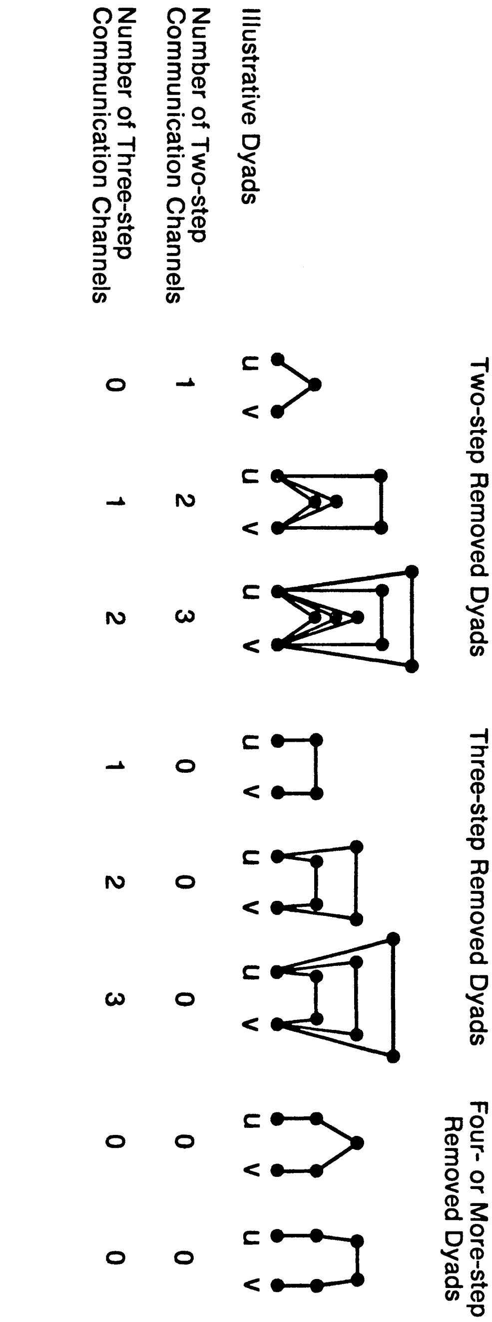
Two-step Removed Dyads
Three-step Removed Dyads
Four- or More-step Removed Dyads
Illustrative Dyads
u v
Number of Two-step Communication Channels
1 2 3 0 0 0 0 0
Number of Three-step Communication Channels
0 1 2 1 2 3 0 0

Figure 1.

Table 4. THE PROBABILITY THAT INDIVIDUAL *u* IS AWARE OF THE CURRENT WORK OF INDIVIDUAL *v* IS A NEGATIVE FUNCTION OF THE DISTANCE WHICH SEPARATES *u* AND *v* IN THE NETWORK

Distance Separating u and v (Steps Removed)	University of Chicago Faculty			Columbia University Faculty		
	Biological Sciences	Physical Sciences	Social Sciences	Biological Sciences	Physical Sciences	Social Sciences
One*	.322 (255)	.289 (121)	.208 (130)	.206 (175)	.000 (8)	.170 (47)
Two	.092 (6,359)	.099 (2,866)	.055 (4,346)	.065 (5,687)	.044 (548)	.054 (2,681)
Three	.014 (3,897)	.007 (3,080)	.010 (5,371)	.018 (6,657)	.008 (1,420)	.008 (5,837)
Four or more	.004 (467)	.004 (2,570)	.003 (1,884)	.009 (1,047)	.005 (3,001)	.002 (3,089)

*The Table is based on dyads in which u reports no discussions with v about v's work; the members of such dyads may be one step removed if v reports having discussions with u about u's work.

TWO–STEP REMOVED DYADS

Table 5 shows that among the dyads whose members are two steps removed in a network, the probability that *u* is aware of the current work of *v* is a positive function of the number of communication channels of two steps in length which connect *u* and *v*. Among the interdepartmental dyads that are connected by a *single* two-step communication channel, an awareness relation is unlikely; generally, it is less than .04. It can be seen that the probability of awareness tends to increase as the number of two-step communication channels (i.e., shared contacts) increases.

There is an orderly relationship between the number of two-step communication channels and the probability of observability in these dyads. To see this relationship, the data of all six faculty populations are summed to obtain a set of overall probabilities. In general, the probability is .035 that *u* is aware of *v*'s current work when *u* and *v* are two steps removed in the network and connected by a single two-step communication channel. If .035 is the probability that *u* is aware of *v*'s work, then $1 - .035$ is the probability that *u* is *not aware* of *v*'s work and $(1 - .035)^n$ is the estimated probability that *u* will not be aware of *v*'s work in the presence of *n* two-step communication channels (the assumption being that each additional communication channel is associated with an equal and independent contribution to the probability of awareness). Therefore, the probability (*P*) that *u* will be aware of *v*'s work is given by

Table 5. AMONG DYADS WHOSE MEMBERS ARE TWO STEPS REMOVED, THE PROBABILITY THAT INDIVIDUAL *u* IS AWARE OF THE CURRENT WORK OF INDIVIDUAL *v* IS A POSITIVE FUNCTION OF THE NUMBER OF COMMUNICATION CHANNELS OF LENGTH TWO WHICH CONNECT *u* AND *v*

Number of Communication Channels of Length Two Connecting u and v	University of Chicago Faculty			Columbia University Faculty		
	Biological Sciences	Physical Sciences	Social Sciences	Biological Sciences	Physical Sciences	Social Sciences
1	.038 (2,451)	.034 (1,312)	.023* (2,029)	.043* (3,058)	.031 (425)	.030 (1,819)
2	.063 (1,576)	.063 (633)	.053* (1,017)	.066 (1,280)	.060 (84)	.072 (543)
3	.110 (876)	.117 (324)	.090 (545)	.097 (657)	.105 (19)	.141 (213)
4	.118 (542)	.177 (226)	.122 (295)	.111 (341)	.000 (5)	.262* (42)
5	.186 (311)	.300* (140)	.139 (180)	.136 (177)	.286 (7)	.139 (36)
6	.174 (207)	.247 (81)	.128 (86)	.099* (91)	.000 (1)	.100 (10)
7	.303 (132)	.265 (49)	.083* (84)	.179 (28)	.667 (3)	.200 (10)
8	.247 (81)	.452* (31)	.170 (47)	.222 (18)	.000 (2)	.000 (2)
9	.408* (71)	.346 (26)	.125 (16)	.294 (17)	.000 (2)	.250 (4)
10-	.455 (112)	.545 (44)	.064 (47)	.200 (20)	-- (0)	.500 (2)

*Significantly different from the expected proportion, given in Table 6, at the .05 level (z-test): $z = (p-P)/\sqrt{P(1-P)/n}$. A significance test was not computed where n is less than 10 or for cases falling in the 10-category. With these data, the significance test is most appropriately viewed as an *ad hoc* measure of fit.

$$P = 1 - (1 - .035)^n.$$

This function generates predicted proportions that are remarkably close to the observed proportions (see Table 6), at least in the range of 2–9 two-step communication channels.[6]

Table 6. A STOCHASTIC FUNCTION PREDICTS THE PROBABILITY THAT INDIVIDUAL *u* IS AWARE OF THE CURRENT WORK OF INDIVIDUAL *v* AMONG DYADS WHOSE MEMBERS ARE TWO STEPS REMOVED IN THE NETWORKS

Number of Two-Step Semipaths Connecting u and v (N)	Observed Proportion in the Total Sample (p)	Expected* Proportion (P)	Basis of Observed Proportion (n)	z**	Significant at .05 Level
1	.035	.035	11,094	--	n.s.
2	.063	.069	5,133	-1.70	n.s.
3	.106	.101	2,634	0.85	n.s.
4	.130	.133	1,451	-0.34	n.s.
5	.183	.163	851	1.58	n.s.
6	.162	.192	476	-1.66	n.s.
7	.225	.221	306	0.17	n.s.
8	.254	.248	181	0.19	n.s.
9	.338	.274	131	1.67	n.s.

*$P = 1 - (1 - .035)^N$

**$z = (p - P)/\sqrt{P(1-P)/n}$. An overall chi-square test was also computed: chi square = 9.48 on 7 df. With these data, the significance tests are most appropriately viewed as ad hoc measures of fit.

COMMUNICATION CHANNELS OF THREE STEPS IN LENGTH AND THREE-STEP REMOVED DYADS

The analysis turns to the consideration of how the number of communication channels of three steps in length is related to the occurrence of observability. Two-step removed dyads are not only connected by communication channels of two steps in length, they may also be connected by channels of three steps in length. Controlling for the number of two-step channels, Table 7 shows how the probability of an awareness relation is associated with increase in the number of three-step communication channels connecting *u* and *v*. For convenience, these data are summed across all six faculty populations. In general, there appears to be very little relationship between the probability of awareness and the number of three-step communication channels connecting *u* and *v*.

This conclusion is supported by the results in Table 8. Variation in the number of three-step communication channels, connecting the mem-

Table 7. AMONG DYADS WHOSE MEMBERS ARE TWO STEPS REMOVED, THE PROBABILITY THAT INDIVIDUAL *u* IS AWARE OF THE CURRENT WORK OF INDIVIDUAL *v* IS UNRELATED TO THE NUMBER OF COMMUNICATION CHANNELS OF LENGTH THREE WHICH CONNECT *u* AND *v*

Number of Communication Channels of Length Three Connecting u and v	Number of Communication Channels of Length Two Connecting u and v									
	1	2	3	4	5	6	7	8	9	10-
0-9	.026 (2730)	.059 (118)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)
10-19	.029 (4014)	.071 (784)	.147 (68)	.000 (6)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)
20-29	.038 (2481)	.053 (1439)	.102 (322)	.098 (41)	.000 (4)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)
30-39	.047 (1086)	.073 (1146)	.102 (557)	.172 (128)	.227 (22)	.333 (3)	-- (0)	-- (0)	-- (0)	-- (0)
40-49	.063 (457)	.069 (787)	.100 (498)	.108 (185)	.152 (59)	.167 (12)	.500 (2)	-- (0)	-- (0)	-- (0)
50-59	.065 (184)	.043 (415)	.103 (447)	.131 (267)	.189 (106)	.200 (10)	.333 (12)	.250 (4)	-- (0)	-- (0)
60-69	.036 (55)	.061 (246)	.113 (336)	.114 (219)	.175 (103)	.067 (45)	.400 (5)	.000 (2)	.000 (2)	-- (0)
70-79	.067 (30)	.085 (129)	.108 (194)	.121 (206)	.174 (138)	.137 (51)	.095 (21)	-- (0)	.167 (6)	-- (0)
80-89	.300 (10)	.026 (39)	.122 (98)	.179 (151)	.196 (107)	.141 (71)	.417 (12)	.375 (8)	1.000 (2)	-- (0)
90-99	.000 (7)	.000 (18)	.059 (68)	.162 (117)	.202 (114)	.162 (68)	.250 (32)	.263 (19)	.167 (6)	.500 (2)
100-	-- (0)	.091 (11)	.171 (41)	.092 (131)	.182 (198)	.190 (216)	.212 (222)	.250 (148)	.350 (120)	.368 (223)

bers of dyads who are *three steps removed* in a network, is not associated with an increase in the probability of an awareness relation.

SUMMARY

The major results of the analysis are these: (1) awareness-without-contact relations are unlikely in dyads that are connected by a single shared contact; (2) the probability of an awareness-without-contact relation increases with increases in the number (n) of shared contacts according to the function $1 - (1 - p)^n$, where p is equal to .035; and (3) the number of connections through two contacts that join u and v has a negligible association with the probability of u being aware of v's current work. (In general,

Table 8. AMONG DYDS WHOSE MEMBERS ARE THREE STEPS REMOVED, THE PROBABILITY THAT INDIVIDUAL *u* IS AWARE OF THE CURRENT WORK OF INDIVIDUAL *v* IS UNRELATED TO THE NUMBER OF COMMUNICATION CHANNELS OF LENGTH THREE WHICH CONNECT *u* AND *v*

Number of Communication Channels of Length Three Connecting u and v	University of Chicago Faculty			Columbia University Faculty		
	Biological Sciences	Physical Sciences	Social Sciences	Biological Sciences	Physical Sciences	Social Sciences
1	.000 (228)	.004 (958)	.002 (853)	.016 (793)	.006 (776)	.002 (1,740)
2	.004 (234)	.005 (375)	.006 (667)	.006 (657)	.006 (175)	.006 (1,151)
3	.009 (232)	.000 (216)	.007 (544)	.032 (634)	.000 (103)	.011 (660)
4	.010 (195)	.000 (190)	.009 (441)	.012 (592)	.000 (54)	.006 (464)
5	.013 (229)	.000 (149)	.008 (357)	.021 (513)	.000 (106)	.016 (383)
6	.004 (254)	.000 (117)	.019 (324)	.018 (513)	.000 (39)	.007 (284)
7	.021 (195)	.000 (109)	.015 (270)	.010 (384)	.000 (27)	.000 (225)
8	.015 (195)	.000 (118)	.012 (250)	.018 (389)	.059 (34)	.000 (180)
9	.005 (219)	.039 (76)	.026 (231)	.006 (334)	.000 (46)	.022 (138)
10-19	.015 (1,228)	.012 (586)	.012 (1,078)	.018 (1,513)	.068 (59)	.022 (541)
20-29	.028 (469)	.024 (126)	.014 (278)	.047 (296)	.000 (1)	.074 (68)
30-39	.019 (155)	.061 (49)	.034 (59)	.027 (37)	-- (0)	.000 (3)
40-49	.000 (37)	.000 (7)	.000 (18)	-- (0)	-- (0)	-- (0)
50-59	.059 (17)	.000 (4)	.000 (1)	.000 (2)	-- (0)	-- (0)
60-69	.125 (8)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)
70-79	.000 (2)	-- (0)	-- (0)	-- (0)	-- (0)	-- (0)

therefore, there is a negligible probability that awareness will extend to individuals who are three steps or more removed in the networks.)

Discussion

In these data, the likelihood of observability nears zero under certain conditions of communication network structure. Persons who are more than two steps removed from each other in a network are unlikely to be aware of each other's current work; in this sense, there is a horizon to observability in the networks examined. Moreover, among the persons who are within this horizon, the number of two-step communication channels is strongly associated with observability; as the number of such channels nears zero, so does the likelihood of awareness relation.[7]

Our conclusion must be that informal control processes rarely include persons who are more than two steps removed from each other in a communication network or who are connected by a small number of shared contacts. With the additional assumption that shared contacts increase the likelihood of effective informal reactions to observed behavior, we may also conclude that informal control tends to occur where there are high levels of network cohesion and tends to be absent where such cohesion is lacking.

These findings support the well-known fact that informal control processes are prevalent in small cohesive groups. They also support the ideas that disconnected groups give rise to problems of control and that increased contact between groups is associated with greater intergroup control. The findings indicate that unipathic communication network structure, of which a bridge and liaison are examples, do not provide for extensive intergroup control. The findings suggest that information about role performances does not freely circulate in a network structure as a contagion. These findings are limited, however, in that they do not permit a judgment on whether large-scale, loosely structured networks are ones in which the informal basis of control of the whole network is weak; nor do they permit a judgment on whether some level of insulation from intergroup observability is a precondition of system stability.

Since the horizon of observability is limited and highly dependent on network cohesion, one might argue that the ability of informal control to integrate a large-scale system is also limited and that *formal* controls must be introduced if a high level of integration is to be achieved. Supporting this viewpoint are the findings in the organizational literature that vertical differentiation and formalization tend to be greater in large than in small organizations. Moreover, while we cannot address the relationship between insulation and system stability, it is evident that subunits will tend to be insulated from most other subunits in highly differentiated, stable systems.

The limitations of informal control, as a basis of total system integration, have not been conclusively resolved, however. A theory is needed that links, in a plausible way, the notion of local informal control based on network cohesion with the outcome of macro-level integration. Can a theory be suggested which is consistent with all of the propositions that have not as yet been disproved? The following theory is suggested as a starting point for future work on the relationship between communication network structure and informal control.

OUTLINES OF A MICRO–MACRO THEORY OF INFORMAL CONTROL

The theory begins with the proposition that:

The more proximate two persons are (in their specialties, functional interdependence, socioeconomic traits, or spatial location) the more likely they are to be in face-to-face communication (Blau).

Communication is more likely between persons in the same or similar specialties than between persons in dissimilar ones. Communication is more likely between persons whose activities are functionally interdependent than between persons whose activities are not. Communication is more likely between persons who share socioeconomic traits than between persons who do not, and communication is more likely between persons who are geographically close than between those who are geographically distant. The proposition implies that face-to-face communication is more likely within a group than between the members of different groups, defined on the basis of these factors. The proposition also implies that face-to-face communication is more likely between groups that are relatively proximate than between more distant groups. This implication is particularly pertinent to the theory being developed.

We can represent the group structure of a system (as in Figure 2a) in the form of a graph consisting of a set of points (the groups) and lines between the points. We can assign a number to each point and line which is a measure of the overall proximity of the members of a group or the members of two groups. On the basis of the first proposition, the likelihood of face-to-face communication will be correlated with these proximity scores.

The proximities between the groups of a system are unequal.

This proposition implies the presence of a nonrandom distribution of face-to-face communications between groups in most systems. Intergroup communications will tend to pile disproportionately on some group interfaces and raise their interface densities above those of other group interfaces in the system (on the relationship between network density and structural cohesion, see Friedkin, b). In large-scale, highly differentiated systems,

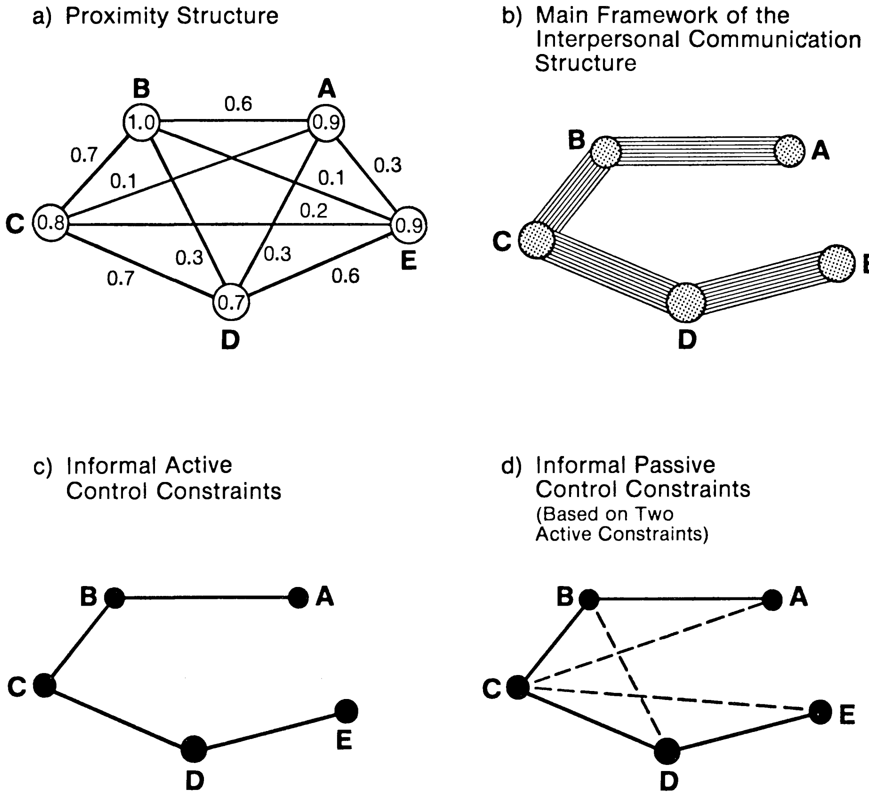

Figure 2.

this nonrandom arrangement of intergroup communications is the essential precondition for the emergence of a communication network consisting of a framework in which groups are connected by a set of cohesive group interfaces (see Figure 2b).

Thus, most large-scale systems are not cohesive in the same terms as a small-scale system. Most dyads in a large-scale system are not in direct contact. Rather than a single cohesive network, there may be a framework based on a subset of cohesive group interfaces among the total set of group interfaces (e.g., see Friedkin, a).

Network cohesion either within a group or at a group interface is associated with effective informal control.

Informal control is parochial, tending to exist only between persons in direct contact and/or persons with a multiplicity of shared contacts. The shared contacts of persons in two groups may be members of either group, or of other groups. In the most limited case, the shared contacts of persons in two groups consist entirely of members in the two groups and not of other groups. In such a case, processes of informal control occur only between the groups that are joined by many face-to-face interactions, such as *A–B*, *B–C*, *C–D* and *D–E* in Figure 2b, and not between groups that are indirectly joined in the group-contact structure (*A–C*, *A–D*, *A–E*, *B–D*, *B–E* and *C–E*). This limited case is represented in Figure 2c as a network of active informal control constraints.

The phenomena of local informal control and a markedly nonrandom distribution of face-to-face communications between groups tend to insulate groups from most other groups in a system.

Most intergroup communications tend to be limited to a few other groups. Isolated communications with other groups do not seriously affect a group's insulation. System stability results from this narrowing and channeling of observability and the informal control processes occurring in the system.

Let us assume that each of the groups in a system is internally cohesive and that effective processes of informal control exist within each group. Then:

Problems of total system integration, based on processes of informal control, result from the arrangement of the active control constraints between the groups. The arrangement of active constraints gives rise to a set of passive constraints by which the total system may be integrated on an informal basis.

What is a passive constraint? If group *A* is actively constrained with respect to group *B*, and group *B* is actively constrained with respect to group C, then group *A* is constrained *passively* with respect to group C. Similarity is transitive: passive constraint is based on the principle of transitivity applied to groups and the set of active constraints that occur between the groups (Figure 2d). The freedom of a group to drift out of control with respect to another group is limited to some extent by their common anchorage on one or more other groups.

The system of passive constraints is built directly on active constraints and on *other* passive constraints. For example, *A* is actively constrained with respect to *B*, and *B* is passively constrained with respect to *D*. Then *A* is passively constrained with respect to *D*, because of the implicit framework of active constraints that has produced the passive constraint between *B* and *D*. However, a passive constraint may be more or less salient to the integration of a total system depending on how far removed it is from the framework of active constraints.

An entire large-scale system will be constrained so long as there is a framework of active intergroup constraints in which all the groups are connected. The degree of constraint will vary with the structure of this framework. Since similarity is transitive, two groups can be similar to one another even though informal control processes do not occur between their members; but for such similarity to occur, there must be some basis for the transitivity that implies their similarity. It is proposed that a necessary condition of such transitivity is a framework of interconnected, structurally cohesive, group interfaces and that the level of similarity between those groups not connected by a structurally cohesive interface depends on the arrangement of the cohesive interfaces comprising the framework. This theory is consistent with the propositions supported by the present analysis and the propositions that have not yet been tested and disconfirmed. It offers a way of bridging micro-and macro-level phenomena in a way that is consistent with local informal control processes.

I believe that an outstanding question now facing us is whether local informal control severely limits the extent of informal macro-level integration, and gives rise to a demand for formal control mechanisms, or whether, on the basis of a theory such as that outlined above, informal control can, under suitable structural arrangements, provide a basis of effective macro-level integration.

Appendix

ANALYSIS OF ONE-STEP REMOVED DYADS

The one-step removed dyads (i.e., dyads in which u and v have been in contact about u's work but not v's work) also are connected by communication channels of two steps in length. An analysis of these dyads shows that the probability of u being aware of the current work of v is a positive function of the number of communication channels of two steps in length which connect u and v. Controlling for the number of communication channels of length two, the probability of u's awareness in the one-step removed dyads is greater than the probability of u's awareness in the two-step removed dyads. The difference is accounted for by the direct contact relation which exists in the one-step removed dyads; once the function (derived from the analysis of the two-step removed dyads) is adjusted to take the contact relation into account, the probability of awareness in the one-step removed dyads is predictable (see Table 9). Thus, the analysis of the one-step removed dyads provides additional support for the previous results.

Table 9. THE PROBABILITY OF AN AWARENESS RELATION IN ONE-STEP REMOVED DYADS IS CONSISTENT WITH THE FUNCTION DERIVED FROM THE ANALYSIS OF TWO-STEP REMOVED DYADS ONCE THE FACTOR OF THE DIRECT CONTACT IS TAKEN INTO ACCOUNT

Number of Two-Step Communication Channels Connecting u and v (N)	Observed Proportion in the Total Sample (p)	Expected* Proportion (P)	Basis of Observed Proportion (n)	z**	Significant at .05 Level
0	.049	.049	61	--	--
1	.108	.082	65	0.76	n.s.
2	.175	.114	80	1.72	n.s.
3	.210	.145	76	1.61	n.s.
4	.268	.175	82	2.22	n.s.
5	.236	.204	72	0.67	n.s.
6	.243	.232	70	0.22	n.s.
7	.380	.259	50	1.95	n.s.
8	.347	.285	49	0.96	n.s.
9	.324	.310	37	0.18	n.s.

*$P = 1 - (1 - .049)(1 - .035)^N$

**$z = (p - P)/\sqrt{P(1-P)/n}$. An overall chi-square test was also computed: chi square = 14.25 on 8 df. With these data, the significance tests are most appropriately viewed as ad hoc measures of fit.

Notes

1. The particular disciplines included in the biological sciences divisions: anatomy, biochemistry, biology, genetics, microbiology, pathology, pharmacology, physiology; in the physical sciences divisions: astronomy, chemistry, geology, statistics, mathematics, physics; in the social sciences divisions: anthropology, economics, political science, psychology, and sociology.
2. A limitation on the size of the networks was necessary; therefore, subsets of the entire faculty within each university were treated separately. It was not realistic to ask a respondent to provide information about relations with the entire university faculty in the three domains, nor was it economically feasible to analyze the university's entire network, even if reliable data on its structure were obtained. Whenever the size of a network is limited (as it always must be for the purposes of analysis), persons may be excluded whose relations with the selected network members make an important contribution to the network structure. This problem is present in all network studies; since it cannot be avoided, one must be clear on the defining characteristics of the network's membership and be attuned to the possibility of a distorted description of the network structure. In the present case, the problem alluded to may not be a concern. To be sure, the network members have relations with non-network members

and these non-network members may be connected directly or indirectly to other network members. I suspect, however, that non-network members rarely have direct relations with two faculty members from different departments of the same university: (a) the number of two-step communication channels is shown to be a powerful predictor of the probability that a network member possesses information about another member's current work; (b) it is found that as the number of two-step communication channels declines, the aforementioned probability approaches zero; (c) were many two-step communication channels missing from the observed network, the probability ought not to approach zero so nearly, but be somewhat above zero by an amount that reflects the contribution of the missing two-step channels. Of course, there are also many longer communication channels, of three steps or more in length, that involve non-network members; however, the analysis further suggests that these channels have little effect on the probability of information flow and, therefore, may be ignored. I conclude that a boundary problem does not severely distort the present results.
3. The effects of nonresponse rates on measurement of social network structure are not well understood, though some useful work has been done on the problem (Holland and Leinhardt). The major effect of nonresponse is to produce missing ties. It should be noted that while nonrespondents cannot send ties, they can receive them and that the analysis makes use of those ties sent to nonrespondents in calculating the number of communication channels. The data which are missing consist of (1) ties between the nonrespondents and (2) asymmetrical ties sent by nonrespondents to respondents. The discussion of the boundary problem applies here also; it would appear that the missing data have not severely distorted the analysis. Moreover, the consistency of the results across networks that differ in their response rates lends support to the study's conclusions.
4. The exact wording of the instructions is as follows:

Below and on the following pages is a list of fellow faculty members. Scan the list, marking those persons for whom the statement "I know something of this person's work" is true. Where the statement is true please respond to the additional statements—"I have read or heard person present his/her work," "I have talked with person about his/her work, . . ." Check as many items as apply. Also, please note that the first four items refer to any research a person had done, whereas the last four items refer only to research a person is engaged in now.

The data of the present investigation are based on the items "I know something of a person's current work," and "I have talked with person about his/her current work."
5. See the Appendix for an analysis of the one-step removed dyads.
6. In an analysis of the variation which exists across the networks (Table 5), each of the observed probabilities was tested for a significant departure from the appropriate expected probability given in Table 6. This significance test is most appropriately viewed as an *ad hoc* measure of fit. The variation across the networks appears to be random for the most part. There is little evidence to support the idea that one or more of the networks do not adhere to the function, since observed probabilities do not *systematically* depart from expectation in any of the networks.
7. If the members of different departments had contacts in common from different universities, then one would expect that the probability of an awareness relation in interdepartmental dyads would not approach zero so nearly. That the probability does approach zero suggests that the university's intraorganizational communication network is the main basis of observability between the faculty members from different departments in the university. This does not imply that the university intraorganizational communication networks are the main basis of interdisciplinary observability among academicians in the sciences.

References

Barnes, J. A. 1972. *Social Networks*. Module 26. Reading: Addison–Wesley Modular Publications.

Bavelas, A. 1950. "Communication Patterns in Task-oriented Groups." *Acoustical Society of America Jouranl* 22:727–30.

Blau, Peter M. 1977. *Inequality and Heterogeneity*. New York: Free Press.

Friedkin, E. a:1978. "University Social Structure and Social Networks Among Scientists." *American Journal of Sociology* 83:1444–65.

———. b:1981. "The Development of Structure in Random Networks: An Analysis of the Effects of Increasing Network Density on Five Measures of Structure." *Social Networks* 3:41–52.

Granovetter, S. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78:1360–80.

Harary, Frank, Robert Z. Norman, and Dorwin Cartwright. 1965. *Structural Models*. New York: Wiley.

Holland, P. W., and S. Leinhardt. 1973. "The Structural Implications of Measurement Error in Sociometry." *Journal of Mathematical Sociology* 3:85–111.

Merton, Robert K. 1968. *Social Theory and Social Structure*. New York: Free Press.

Ouchi, G. 1977. "The Relationship Between Organizational Structure and Organizational Control." *Administrative Science Quarterly* 22:95–113.

Simmel, Georg. 1950. *The Sociology of Georg Simmel*. (Trans. and ed. Kurt H. Wolff). New York: Free Press.

Skolnick, J. H., and J. M. Woodworth. 1967. "Bureaucracy, Information, and Social Control: A Study of a Moral Detail." In D. J. Bordua (ed.), *The Police: Six Sociological Essays*. New York: Wiley.

Thelen, Herbert A. 1960. "Exploration of a Growth Model of Psychic, Biological, and Social Systems." Mimeographed paper. Results reported in Daniel Katz and Robert L. Kahn, *The Social Psychology of Organizations*. New York: Wiley, 1966.