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Norm formation in social influence networks☆

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Abstract

I propose a mechanism of norm formation and maintenance that combines classical theory in social psychology on attitudes and social comparisons with a formal network theory of social influence. Underlying the formation of norms is the ubiquitous belief that there is a correct response for every situation and an abiding interest for persons to base their responses on these correct foundations. Given such a belief, a normative evaluation of a feeling, thought or action is likely to arise when persons perceive that their positive or negative attitudinal evaluation is shared by one or more influential others. If interpersonal agreements validate attitudes and transform attitudes into norms, then the development of a theory of norm formation may draw on extant "combinatorial" theories of consensus production that describe how shared attitudes are produced and maintained in groups. The network theory of social influence that I employ is one such combinatorial approach. An important sociological implication of this network theory is that the content of norms must be consistent with the social stratification (or more general pattern of inequality) of interpersonal influences in a group. I illustrate the theory with an analysis of Roethlisberger and Dickson's (1939) classic observations on the Bank Wiring Observation Room.

Keywords: Bank Wiring Observation Room; "Combinatorial" theories; Anderson's weighted averaging model

1. Introduction

Explanations of individual behavior have drawn heavily on the observation that persons frequently define particular feelings, thoughts, or actions as appropriate or inappropriate for certain persons (including themselves) in some situations and that these *norms* importantly affect conduct. However, theories that emphasize the normative foundations of conduct have been criticized for discounting the amount of uncertainty and conflict that persons' experience, and for exaggerating the extent to which a preexisting set of internalized norms is readily applicable to the variety of situations in which persons find themselves (e.g. Merton,

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1968, 1976; Moscovici, 1985; Wrong, 1994). Furthermore, it has been noted repeatedly, most recently by Jasso and Opp (1997), that the development of a theory of norm formation has been pursued in a surprisingly small number of studies (Bettenhausen and Murnighan, 1985, 1991; Coleman, 1990, chapters 10–11; Feldman, 1984; Krebs and Miller, 1985, pp. 17–28; Opp, 1982).

Coleman (1990, p. 244) describes four broad theoretical tasks that a theory of norm formation and maintenance might address:

> First is the task of establishing the conditions under which a norm with a particular content will arise. This includes determining why a norm does not always arise when the existence of an effective norm would be in the interests of all or most persons. Related to this are the tasks of specifying who will come to hold the norm and whose actions will be the target of the norm.
>
> Another task is determining the strength and prevalence of sanctions, recognizing that applying a sanction may entail costs for the sanctioner. Related to this is determining what kinds of sanctions will be applied, since there are a variety of sanctions that may be applied (and it is empirically evident that various kinds of sanctions are applied, ranging from those that damage or enhance reputations to those that impose physical damage or provide material benefits).
>
> In addition, there are theoretical tasks concerning the internalization of a norm. Why do persons attempt to induce internalization in others in the first place? Under what conditions will those who hold a norm attempt to induce internalization, and under what conditions will they use only external sanctions? Why will a person be receptive to attempts by others to internalize norms?
>
> Finally, there is the task of describing and accounting for interconnections among norms. What kinds of relationships exist among norms, how do those relationships arise, and how is the role that norms play in a social system affected by these relationships?

The first set of questions is the focus of the present paper, and I will approach these questions from the perspective of social psychological theory on the formation of attitudes and production of interpersonal (attitudinal) agreements. [1]

In this article, I advance work on a theory of the formation of norms that builds on a classical line of work in social psychology concerned with mechanisms of interpersonal communication and influence (Festinger, 1950, 1954; Sherif, 1936; Strauss, 1978; Stryker, 1981; Stryker and Statham, 1985). I seek to advance this line of work with a formal network theory of social influence that details a possible mechanism by which shared norms can arise in situations where there is substantial initial uncertainty or disagreement in a group about what are the appropriate feelings, thoughts, or actions for certain persons. In this

[1] I should point out that this is *not* the approach to these questions that Coleman chose to develop. He describes a *rational choice* approach to a theory of norm formation in games, markets, and social groups. The development of rational choice theory has received a lot of attention from sociologists, especially with respect to the problem of the formation of norms of cooperation in social dilemmas; see Yamagishi (1995) for a review of this literature.

theory, a sense of what is appropriate or correct under particular circumstances (i.e. what ought to felt, thought or done) emerges from a process of interpersonal influence in which uncertainty and conflict are reduced by the development of a shared attitude. It is widely recognized that norms are formed and maintained by networks of interpersonal interaction; however, a mechanism has not been specified that shows precisely how interactions among group members operate to transform persons' uncertainty and conflict into the *interpersonal agreement* that appears to be fundamental to the development of a norm. In order to advance work on the formal specification of this process, I assume that a norm is a special case of an attitude for which the positive or negative (attitudinal) evaluation of a feeling, thought or action has become a shared normative evaluation, and I link the norm formation process with a theory of the formation of attitudes and the development of consensus. I apply this theory to the puzzling case of the Bank Wiring Observation Room, described by Roethlisberger and Dickson (1939), where a work performance norm was formed and maintained despite marked interpersonal cleavages in the work group.

2. Attitudes, networks and norms

Given the various conceptions of norms that have appeared in the literature, it is useful to begin with a statement of what I will be dealing with. I follow Homans (1961, p. 46) and posit that a norm exists when a person perceives that a feeling, thought or action is appropriate, optimal, or correct (or inappropriate, suboptimal, or incorrect) for one or more persons in particular circumstances. This definition permits *idiosyncratic* norms that are held by only one person in a group. However, because of the difficulty in maintaining a perception that a particular response is correct in the presence of disagreement among significant others, norms are usually based on an interpersonal agreement. Hence, most norms are *shared* norms by virtue of the process that links the development of *normative content* to the recognition that it is a *shared perception*. I will return to this idea in a moment.

It is apparent that there is a close conceptual relationship between a norm (as defined above) and an attitude. Most social psychologists define an attitude as a positive or negative evaluation by a person of some "object" (e.g. an issue, event, or person). Thus, a norm is a special case of an attitude for which the attitudinal "object" is a feeling, thought, or action of a person or persons in particular circumstances, and for which the positive (favorable) or negative (unfavorable) attitudinal evaluation takes the form of perception that the "object" is appropriate (correct) or inappropriate (incorrect) under the circumstances.[2] There are two theoretical advantages in dealing with norms in this way. First, it is more parsimonious to conceptualize a norm as special case of an attitude than it is to maintain the idea that a norm is entirely different from the sort of attitudinal evaluations that persons make about "objects" in general. Second, the linkage of attitudes and norms makes the large literature

[2] This is surely not a novel idea. The intimate relationship between these two theoretical constructs is evident in the work of Fishbein and Ajzen (1975), in the assertion of Eagly and Chaiken (1993, p. 671) that "to decide on any particular course of action, a positive attitude must form toward this act," and in the analysis of Schuman (1995, p. 81) where norms are treated as the "conceptual cousins" of attitudes. Attitudes are implicated in many opinions and judgements by virtue of the acceptance (positive evaluation) and rejection (negative evaluation) of alternative positions (Sherif et al., 1965).

on attitude formation and change potentially relevant to the development of a theory of norm formation and maintenance, and it suggests that such a theory need not spring from entirely new foundations.

2.1. The development of shared attitudes and the formation of norms

Sherif (1936) and Festinger (1950, 1954) are the classical pillars of the social psychological approach to norm formation. Sherif (1936) demonstrated that persons' judgments about the characteristics of an ambiguous phenomenon tend to converge when their disagreements are voiced (i.e. made visible) and that such emergent agreements shape persons' judgments about the same phenomenon when they experience it at a later point in time. Sherif's study confirms a widely held assumption in the literature of social psychology and sociology that norms can arise from interpersonal interactions that resolve uncertainty and conflict via changes in persons' attitudes and opinions. In this social psychological tradition, persons are information integrators, who seek to resolve uncertainty and conflict in a variety of ways, that include weighing and possibly revising their own attitudes in light of information about the feelings, thoughts, and behavior of other persons. Festinger (1950) suggests that Sherif's mechanism of norm formation is not merely one of a number of theoretically possible mechanisms that might be studied in laboratory settings, but the *key* mechanism by which persons validate their attitudes under conditions of uncertainty and conflict.

Festinger's (1950, 1954) social comparison theory is seminal for a theory of norm formation, because it posits that interpersonal interactions and agreements are ubiquitous features of groups and fundamental to an understanding of how persons form their attitudes. Persons frequently assume that there is a correct or appropriate response (feeling, thought, or action) for them, or particular others, in situations of uncertainty and conflict. Festinger posits that persons form their attitudes via social comparisons, in which they weigh and integrate the attitudes of others, and he posits that interpersonal agreements anchor and validate the attitudes developed in this process. Attitudes tend to be unstable in the absence of interpersonal agreements, because persons are unlikely to be confident that their attitudes are correct when there are no influential others who agree with them.

The postulates of social comparison theory open the door for an account of norm formation and maintenance that is based on a theory of how interpersonal interactions produce shared attitudes and consensus. Interpersonal agreement validates an attitude and secures the sense of appropriateness that is the distinctive signature of a norm. The social validation of an attitude creates a norm by *transforming* the content of a positive (favorable) or negative (unfavorable) attitudinal evaluation of some feeling, thought, or action into a positive (appropriate) or negative (inappropriate) *normative* evaluation. Although persons can hold idiosyncratic norms, norms are usually based on *shared* attitudes and anomy (the absence of norms) is usually coupled with unstable idiosyncratic attitudes, because of the process that links the development of *normative content* to the recognition or perception that a given attitudinal evaluation is shared with one or more influential others. Therefore, elucidating the mechanisms by which shared attitudes are produced and maintained in groups appears to be pivotal to the development of a theory of norm formation.

2.2. Combinatorial theories consensus formation

There is a line of work in social psychology on so-called "combinatorial" theories of consensus formation and group decision-making, that focuses on how agreements are formed in groups when there is an initial state of disagreement on an issue (Davis, 1973; Friedkin and Johnsen, 1990, 1999; Latane, 1981, 1996; Laughlin, 1980; Stasser et al., 1989; Witte and Davis, 1996). A theory of norm formation can be informed by these combinatorial approaches, because they deal with a process — the reduction of interpersonal disagreement and the production of consensus — that appears to be heavily implicated in the emergence of norms. I work with one of these combinatorial theories — social influence network theory (Friedkin, 1991, 1998, 1999; Friedkin and Johnsen, 1990, 1997, 1999).

Social influence network theory includes, as special cases, French's formal theory of social power (French, 1956; Harary, 1959) and DeGroot's consensus formation model (DeGroot, 1974; Chatterjee and Seneta, 1977; Berger, 1981). The theory has close formal relationships with the rational choice model of group decision making proposed by Lehrer and Wagner (Wagner, 1978, 1982; Lehrer and Wagner, 1981), the social decision scheme model for quantitative judgments proposed by Davis (1996), and the information integration model of group decision making proposed by Graesser (1991). The theory is formally consistent with Anderson's weighted averaging model of information integration (Anderson, 1981, 1991; Anderson and Graesser, 1976). Social influence network theory also has a close formal relationship with an interdisciplinary tradition in statistics that includes work in geography, political science, and sociology on models of the interdependence of persons and spatial units (Duncan et al., 1968; Ord, 1975; Duncan and Duncan, 1978; Erbring and Young, 1979; Doreian, 1981; Anselin, 1988; Friedkin, 1990; Marsden and Friedkin, 1994).

Social influence network theory describes an influence process in a group of *N* persons in which the members' attitudes and opinions on an issue change as they revise their positions by taking *weighted averages* of the influential positions other members:

$$y_i^{(t+1)} = a_i(w_{i1}y_1^{(t)} + w_{i2}y_2^{(t)} + \cdots + w_{iN}y_N^{(t)}) + (1 - a_i)y_i^{(1)} \qquad (1)$$

for $t = 1, 2, \ldots$ and each of the *N* persons in the group, $i = 1, 2, \ldots, N$. The opinions of the persons at time *t* are $y_1^{(t)}, y_2^{(t)}, \ldots, y_N^{(t)}$ and their initial opinions are $y_1^{(1)}, y_2^{(1)}, \ldots, y_N^{(1)}$. The set of influences of the group members on person i is $\{w_{i1}, w_{i2}, \ldots, w_{iN}\}$, where $0 \leq w_{ij} \leq 1$, and $\sum_j w_{ij} = 1$. The *susceptibility* of person i to the influence of others is a_i, where $0 \leq a_i \leq 1$ and $a_i = 1 - w_{ii}$. Thus, a person's susceptibility is equated to the aggregate weight of the interpersonal influences on him or her (i.e. $a_i = \sum_{j \neq i} w_{ij}$). Social influence network theory rests on a model of how individuals cognitively integrate conflicting opinions, Eq. (1), but the outcome of this process depends on the *social structure* in which the process occurs. This social structure consists of the *set* of members' initial positions, interpersonal influences, and susceptibilities to influence.

In a group of *N* persons, the system of equations described by Eq. (1) can be represented as

$$\boldsymbol{y}^{(t+1)} = \boldsymbol{AWy}^{(t)} + (\boldsymbol{I} - \boldsymbol{A})\boldsymbol{y}^{(1)} \qquad (2)$$

for $t = 1, 2, \ldots,$ where $\boldsymbol{y}^{(t)}$ is an $N \times 1$ vector of persons' opinions on an issue at time t, $\boldsymbol{W} = [w_{ij}]$ is an $N \times N$ matrix of interpersonal influences, and $\boldsymbol{A} = \mathrm{diag}(a_1, a_2, \ldots, a_N)$ is an $N \times N$ diagonal matrix of the persons' susceptibilities to interpersonal influence on the issue. Under suitable conditions, this process transforms persons' initial opinions into a set of equilibrium opinions:

$$\boldsymbol{y}^{(\infty)} = \boldsymbol{V}\boldsymbol{y}^{(1)} \tag{3}$$

where $\boldsymbol{V} = [v_{ij}]$ is a matrix of reduced-form coefficients, describing the total or net interpersonal effects, that transform the initial opinions into equilibrium opinions.[3] The coefficients in $\boldsymbol{V}$ are nonnegative ($0 \leq v_{ij} \leq 1$) and each row of $\boldsymbol{V}$ sums to unity ($\sum_j v_{ij} = 1$). Hence, v_{ij} gives the *relative weight* of the initial opinion of person j in determining the final opinion of person i for all i and j.

Equilibrium opinions may settle on the mean of group members' initial opinions; they may settle on a compromise opinion that differs from the mean of initial opinions; they may settle on an initial opinion of a group member; or they may settle on altered opinions that do not form a consensus. All equilibrium opinions will be in range of the group member's initial opinions. When a consensus is formed in a group, $\boldsymbol{V}$ will commonly have the form of a stratification of individual contributions:

$$\boldsymbol{V} = \begin{bmatrix} v_{11} & v_{22} & \cdots & v_{NN} \\ v_{11} & v_{22} & \cdots & v_{NN} \\ \vdots & \vdots & \vdots & \vdots \\ v_{11} & v_{22} & \cdots & v_{NN} \end{bmatrix}$$

in which each person's initial opinion makes a particular relative contribution to the emergent consensus.[4]

3. Methods

In this article, I apply social influence network theory to the classic and puzzling case of the Bank Wiring Observation Room that was described by Roethlisberger and Dickson

[3] If $\boldsymbol{I} - \boldsymbol{A}\boldsymbol{W}$ is nonsingular, then from Eq. (2), $\boldsymbol{V} = (\boldsymbol{I} - \boldsymbol{A}\boldsymbol{W})^{-1}(\boldsymbol{I} - \boldsymbol{A})$. More generally, since $\boldsymbol{V}^{(t)} = (\boldsymbol{A}\boldsymbol{W})^t + \left[\sum_{k=0}^{t-1} (\boldsymbol{A}\boldsymbol{W})^k\right](\boldsymbol{I} - \boldsymbol{A})$, for $t = 1, 2, \ldots,$ $\boldsymbol{V}$ can be estimated numerically for a sufficiently large t when $\lim_{t\to\infty} \boldsymbol{V}^{(t)}$ exists.

[4] Horowitz (1962, p. 182) suggests that "any serious theory of agreements and decisions must at the same time be a theory of disagreements and the conditions under which decisions cannot be reached." Interpersonal influences may reduce but not eliminate differences of opinion; and they also may operate to *increase* the variance of opinions in a group. Abelson (1964) was frustrated to find that consensus was an *inevitable* outcome in the broad class of mathematical models that he examined, and he turned to simulation models in order to account for equilibrium disagreements. Similarly, the most prominent combinatorial theories in psychology today either do not deal with an account of disagreement (Davis, 1996) or they rely on simulation models (Gigone and Hastie, 1996; Latane, 1996; Stasser, 1988). It is one of the more useful prejudices of the scientific community that simulation models should be maintained as a last resort, after analytical approaches have been exhausted or appear to be intractable. In this light, it is an important contribution of social influence network theory that it explains how both consensus and disagreement are consistent with a tractable mathematical model.

(1939). Roethlisberger and Dickson's analysis of the Bank Wiring Observation Room is among the most famous case studies in the field of organizational research, and it presents a *puzzle* about the origins of norms that remains unsolved. In this section, I describe the setting of this case study and the measures of persons' initial positions, interpersonal influences, and susceptibilities to influence.

3.1. The setting

The setting is 1931–1932 at an industrial plant in Chicago, the Western Electric Company's Hawthorne Plant, where a group of employees were observed continuously over a 6-month period while they wired, soldered, and inspected switchboards. The original study of these workers was designed to explore findings that had come to light in previous studies of the Hawthorne Plant. The investigators had noticed that "social groups in shop departments were capable of exercising very strong control over the work behavior of their individual members" (Roethlisberger and Dickson, 1939: 379). In some groups, the wage incentive systems appeared to be defeated by informal practices that restricted output and maintained a norm on what constituted a "day's work." To elucidate the formation of these norms, a small number of workers were selected, separated from the larger shop department of which they were a part, and relocated to a room — the Bank Wiring Observation Room — where they could be studied. The idea was that, over a 6-month observation period, the contours of the social structure of the work group would stabilize and the key social control processes would appear by which work performance norms are formed and maintained.

Roethlisberger and Dickson (1939) confirmed that the workers in the Bank Wiring Observation Room monitored each others' performance, engaged in social control activities, and maintained substantial conformity to an informally established level of normative performance. However, Roethlisberger and Dickson also found that the workers were differentiated into two distinct subgroups between which there were few interpersonal ties. The existence of a shared performance norm in the Bank Wiring Observation Room is remarkable given this social cleavage (i.e. the social structure of the work group was more consistent with a state of *subcultural differentiation* than with a state of *normative integration*), and it remains a puzzle how any shared norms could have been formed and maintained within such a differentiated pattern of social relations (Homans, 1950; White et al., 1976). My aim is to address this puzzle with the "combinatorial" approach offered by social influence network theory.

3.2. Measures of social influence and social positions

Lines of research in social network analysis on structural cohesion, centrality, and equivalence (Wasserman and Faust, 1994) support an approach for the operationalization of the three theoretical constructs of social influence network theory — the initial positions of the workers, their susceptibilities to interpersonal influence, and the relative influence of other workers — that is based on the *structural* features of the communication network (Friedkin, 1993, 1998). In groups where a stable network of interpersonal communications has been formed, the pattern of network ties indicates channels of interpersonal influence, the centrality of a person's position in the network structure indicates the person's power and susceptibility to influence, and the similarity of network relations indicates shared social positions (including persons' positions on attitudes and opinions). This structural approach is especially useful when, as in the present case, the only available information on the group is the network of communication ties.

I base my analysis on the network of positive interpersonal attachments, $\boldsymbol{R} = [r_{ij}]$, among 13 workers in the Bank Wiring Observation Room:

$$\mathbf{R} = \begin{array}{c} \begin{array}{ccccccccccccc} \mathrm{I1} & \mathrm{W1} & \mathrm{W2} & \mathrm{W3} & \mathrm{W4} & \mathrm{W5} & \mathrm{W6} & \mathrm{W7} & \mathrm{W8} & \mathrm{W9} & \mathrm{S1} & \mathrm{S2} & \mathrm{S4} \end{array} \\ \begin{bmatrix} 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 1 \\ 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 \end{bmatrix} \end{array}$$

In this network, the presence of a tie indicates that a friendly or playful (non-antagonistic) relationship exists between two workers and the absence of a tie indicates that no such relationship exists.[5]

3.3. Susceptibility to interpersonal influence

The structural measure of a worker's susceptibility to influence is based on the worker's centrality in the communication network. Centrality is a well-established indicator of interpersonal influence, and I draw on the most elementary measure of centrality, the indegree of the worker, for the measure of susceptibility:

$$a_i = \left[1 - \frac{1}{1 + \mathrm{e}^{-(d_i - 2\bar{d})}}\right]^{1/2}$$

where $d_i = \sum_j r_{ji}$ is the indegree of worker i in $\boldsymbol{R}$ and $\bar{d}$ is the mean indegree of the workers. The workers' derived susceptibilities to interpersonal influence, $\boldsymbol{A} = \mathrm{diag}(a_1, a_2, \ldots, a_N)$,

[5] This network is based on four networks described by Roethlisberger and Dickson (1939) consisting of playmates (p. 501), helpmates (p. 506), friends (p. 507), and antagonists (p. 507). The presence of a tie from worker i to worker j in $\boldsymbol{R}$, indicates that there was no observed antagonism between them and that i either played games with, helped, or was friendly with j. The original data consisted of 14 workers. I have eliminated one worker (I3) who had no friendly or playful interactions. This worker's isolation may have been a result of his age difference — 14 years older than anyone else in the group whose ages ranged from 20–26 years.

are: 0.997, 0.947, 0.992, 0.872, 0.947, 0.999, 0.992, 0.992, 0.992, 0.979, 0.979, 1.000 and 0.997 for $a_1, a_2, \ldots, a_N$, respectively. In this case, the susceptibilities are relatively high and homogeneous.

3.4. Interpersonal influences

The structural measure of interpersonal influence is based on the idea that the relative influence of worker *j* on worker *i* is a function of conditions that foster a positive interpersonal attachment from worker *i* to worker *j*:

$$w_{ij} = \frac{a_i c_{ij}}{\sum_k c_{ik}}$$

for $i \neq \{j, k\}$, where c_{ij} is an estimate of the probability of an interpersonal attachment from worker *i* to worker *j*. A matrix of probabilities, $\boldsymbol{C} = [c_{ij}]$, is estimated from the logistic regression of r_{ij} (i.e. the ordered pairs in $\boldsymbol{R}$) on variables that describe the local network environment in which workers *i* and *j* are situated; these predictor variables are the presence of a tie from worker *j* to worker *i* (reciprocity), counts of the number of ties sent and received by workers *i* and *j* (indegree and outdegree), and counts of four types shared ties that workers *i* and *j* may have with other workers, i.e. $i \rightarrow k \leftarrow j$ and $i \leftarrow k \rightarrow j$ (similarity), $i \rightarrow k \rightarrow j$ (transitivity) and $i \leftarrow k \leftarrow j$ (circularity). The resulting estimates provide a measure of the conditional density of a tie, i.e. the probability of a tie from worker *i* to worker *j* under the conditions of the local network environment in which the two workers are embedded. See Friedkin (1998, pp. 73–78) on the theoretical foundations and validation of this measure, and Wasserman and Pattison (1996) on the employment of logistic regression in network analysis. The matrix of direct interpersonal effects ($\boldsymbol{AW}$) in the Bank Wiring Observation Room, is

$$\boldsymbol{AW} = \begin{bmatrix}
0.003 & 0.324 & 0.004 & 0.324 & 0.324 & 0.000 & 0.006 & 0.000 & 0.000 & 0.000 & 0.012 & 0.000 & 0.000 \\
0.134 & 0.051 & 0.134 & 0.134 & 0.134 & 0.134 & 0.001 & 0.000 & 0.000 & 0.094 & 0.134 & 0.000 & 0.000 \\
0.001 & 0.245 & 0.008 & 0.245 & 0.245 & 0.000 & 0.004 & 0.000 & 0.000 & 0.000 & 0.245 & 0.000 & 0.000 \\
0.124 & 0.131 & 0.130 & 0.112 & 0.131 & 0.063 & 0.051 & 0.000 & 0.000 & 0.000 & 0.131 & 0.000 & 0.000 \\
0.128 & 0.128 & 0.128 & 0.128 & 0.051 & 0.000 & 0.079 & 0.076 & 0.000 & 0.000 & 0.128 & 0.000 & 0.100 \\
0.000 & 0.360 & 0.001 & 0.360 & 0.007 & 0.001 & 0.266 & 0.000 & 0.000 & 0.000 & 0.003 & 0.000 & 0.000 \\
0.000 & 0.000 & 0.000 & 0.218 & 0.007 & 0.000 & 0.008 & 0.000 & 0.366 & 0.394 & 0.000 & 0.000 & 0.000 \\
0.000 & 0.007 & 0.000 & 0.069 & 0.000 & 0.000 & 0.021 & 0.008 & 0.222 & 0.222 & 0.222 & 0.000 & 0.221 \\
0.000 & 0.001 & 0.000 & 0.000 & 0.001 & 0.000 & 0.246 & 0.246 & 0.008 & 0.246 & 0.000 & 0.000 & 0.245 \\
0.000 & 0.058 & 0.000 & 0.002 & 0.010 & 0.000 & 0.271 & 0.267 & 0.270 & 0.020 & 0.003 & 0.000 & 0.077 \\
0.000 & 0.191 & 0.191 & 0.191 & 0.191 & 0.000 & 0.003 & 0.191 & 0.000 & 0.000 & 0.020 & 0.000 & 0.000 \\
0.000 & 0.000 & 0.000 & 0.085 & 0.164 & 0.000 & 0.745 & 0.000 & 0.000 & 0.006 & 0.000 & 0.000 & 0.000 \\
0.000 & 0.001 & 0.000 & 0.009 & 0.048 & 0.000 & 0.021 & 0.305 & 0.305 & 0.305 & 0.000 & 0.000 & 0.003
\end{bmatrix}$$

3.5. Initial positions

Workers' initial positions on issues that arise in the Bank Wiring Observation Room are indicated by their locations in the multidimensional social space that is defined by their structural equivalence in the influence network. This structural measure of initial positions assumes that the greater the profile dissimilarity of two workers in the influence network, the greater is their expected difference of opinion on issues related to the job. I base the measure on the row normalized influence matrix, $\boldsymbol{A}^{-1}\boldsymbol{W}$, described in the previous section and employ a standardized measure of structural equivalence (Friedkin, 1998, p. 102). The stress values for metric multidimensional scaling solutions in 1–8 dimensions are: 0.213, 0.085, 0.054, 0.036, 0.029, 0.022, 0.016 and 0.013, respectively. Although these stress values suggest that a 2- or 3-dimensional solution might be adequate for a visual representation of the social space, I require a precise estimate of the *coordinates* of the workers' positions. I base the measure of initial opinions on the solution in 8 dimensions. These coordinates are

$$\boldsymbol{Y}^{(1)} = \begin{bmatrix} 0.000 & 0.615 & 0.649 & 0.493 & 0.498 & 0.298 & 0.516 & 0.334 \\ 0.108 & 0.045 & 0.273 & 0.440 & 0.330 & 0.432 & 0.555 & 0.455 \\ 0.013 & 0.470 & 0.691 & 0.400 & 0.323 & 0.468 & 0.358 & 0.357 \\ 0.137 & 0.107 & 0.200 & 0.326 & 0.507 & 0.421 & 0.516 & 0.400 \\ 0.114 & 0.214 & 0.353 & 0.377 & 0.451 & 0.430 & 0.158 & 0.592 \\ 0.154 & 0.855 & 0.420 & 0.507 & 0.398 & 0.250 & 0.524 & 0.637 \\ 0.680 & 0.264 & 0.428 & 1.000 & 0.615 & 0.439 & 0.437 & 0.458 \\ 0.852 & 0.251 & 0.630 & 0.443 & 0.182 & 0.270 & 0.348 & 0.408 \\ 0.964 & 0.467 & 0.373 & 0.244 & 0.550 & 0.342 & 0.393 & 0.457 \\ 0.908 & 0.540 & 0.398 & 0.250 & 0.644 & 0.386 & 0.430 & 0.456 \\ 0.140 & 0.440 & 0.688 & 0.263 & 0.529 & 0.684 & 0.445 & 0.507 \\ 0.513 & 0.911 & 0.003 & 0.466 & 0.261 & 0.598 & 0.410 & 0.372 \\ 0.924 & 0.334 & 0.711 & 0.427 & 0.351 & 0.556 & 0.601 & 0.512 \end{bmatrix}$$

3.6. *Equilibrium positions and total interpersonal influences*

The foregoing constructs permit the determination of the equilibrium positions of the workers that arise from the social influence process and the relative contribution of each worker to the equilibrium positions of the other workers. The equilibrium positions of the persons that arise from the social influence process are determined by $\boldsymbol{Y}^{(\infty)} = (\boldsymbol{I} - \boldsymbol{A}\boldsymbol{W})^{-1}(\boldsymbol{I} - \boldsymbol{A})\boldsymbol{Y}^{(1)}$ and the coordinates of these positions are:

$$\boldsymbol{Y}^{(\infty)} = \begin{bmatrix} 0.226 & 0.182 & 0.302 & 0.360 & 0.472 & 0.431 & 0.450 & 0.449 \\ 0.227 & 0.178 & 0.303 & 0.363 & 0.466 & 0.431 & 0.456 & 0.449 \\ 0.226 & 0.185 & 0.307 & 0.359 & 0.471 & 0.433 & 0.449 & 0.449 \\ 0.219 & 0.174 & 0.291 & 0.355 & 0.477 & 0.431 & 0.458 & 0.443 \\ 0.232 & 0.189 & 0.309 & 0.360 & 0.472 & 0.431 & 0.435 & 0.456 \\ 0.236 & 0.183 & 0.301 & 0.360 & 0.474 & 0.430 & 0.455 & 0.446 \\ 0.269 & 0.199 & 0.314 & 0.358 & 0.476 & 0.429 & 0.450 & 0.448 \\ 0.281 & 0.203 & 0.314 & 0.358 & 0.479 & 0.428 & 0.450 & 0.448 \\ 0.284 & 0.206 & 0.314 & 0.357 & 0.481 & 0.428 & 0.450 & 0.448 \\ 0.233 & 0.191 & 0.313 & 0.357 & 0.474 & 0.436 & 0.449 & 0.450 \\ 0.260 & 0.195 & 0.308 & 0.361 & 0.479 & 0.429 & 0.449 & 0.448 \\ 0.277 & 0.202 & 0.315 & 0.358 & 0.478 & 0.429 & 0.450 & 0.448 \end{bmatrix}$$

The total interpersonal influences of each worker are determined with $\boldsymbol{V} = (\boldsymbol{I} - \boldsymbol{AW})^{-1}(\boldsymbol{I} - \boldsymbol{A})$, and the matrix of these influences is

$$\boldsymbol{V} = \begin{bmatrix}
0.006 & 0.164 & 0.014 & 0.482 & 0.150 & 0.001 & 0.018 & 0.022 & 0.023 & 0.066 & 0.050 & 0.000 & 0.005 \\
0.004 & 0.202 & 0.014 & 0.455 & 0.137 & 0.001 & 0.018 & 0.022 & 0.023 & 0.068 & 0.051 & 0.000 & 0.005 \\
0.004 & 0.161 & 0.022 & 0.476 & 0.147 & 0.001 & 0.018 & 0.023 & 0.023 & 0.066 & 0.055 & 0.000 & 0.005 \\
0.003 & 0.041 & 0.013 & 0.545 & 0.128 & 0.001 & 0.017 & 0.020 & 0.021 & 0.060 & 0.047 & 0.000 & 0.005 \\
0.004 & 0.150 & 0.014 & 0.451 & 0.186 & 0.001 & 0.019 & 0.024 & 0.024 & 0.070 & 0.051 & 0.000 & 0.006 \\
0.003 & 0.163 & 0.013 & 0.491 & 0.131 & 0.002 & 0.021 & 0.023 & 0.025 & 0.072 & 0.049 & 0.000 & 0.006 \\
0.003 & 0.042 & 0.013 & 0.470 & 0.127 & 0.001 & 0.031 & 0.029 & 0.033 & 0.094 & 0.050 & 0.000 & 0.007 \\
0.003 & 0.146 & 0.013 & 0.460 & 0.131 & 0.001 & 0.023 & 0.037 & 0.032 & 0.091 & 0.056 & 0.000 & 0.008 \\
0.003 & 0.143 & 0.013 & 0.456 & 0.128 & 0.001 & 0.026 & 0.032 & 0.041 & 0.098 & 0.052 & 0.000 & 0.008 \\
0.003 & 0.144 & 0.013 & 0.451 & 0.127 & 0.001 & 0.025 & 0.031 & 0.034 & 0.112 & 0.052 & 0.000 & 0.008 \\
0.003 & 0.157 & 0.015 & 0.467 & 0.143 & 0.001 & 0.019 & 0.025 & 0.024 & 0.070 & 0.072 & 0.000 & 0.006 \\
0.003 & 0.143 & 0.013 & 0.473 & 0.137 & 0.001 & 0.028 & 0.027 & 0.031 & 0.087 & 0.050 & 0.000 & 0.007 \\
0.003 & 0.144 & 0.013 & 0.455 & 0.131 & 0.001 & 0.024 & 0.032 & 0.035 & 0.098 & 0.053 & 0.000 & 0.010
\end{bmatrix}$$

My findings on the influence system in the Bank Wiring Observation Room are based on these equilibrium positions and net interpersonal influences. A social influence process that produces agreements entails the movement of persons from their initial positions in the social space of their group to a shared equilibrium position in that space. Although data that tracks such movements would be fascinating, these data are not available for the workers in the Bank Wiring Observation Room. Hence, the analysis focuses on the equilibrium outcomes of the influence process.

4. Results

In this section, I describe the social differentiation, culture, and interpersonal influences of the workers in the Bank Wiring Observation Room. For an account of how work performance norms may have been formed and maintained among the workers, I draw upon the results of my formal analysis of the influence system and the observations of Roethlisberger and Dickson (1939).

4.1. Social differentiation

Although the work group was small, the social differentiation among the workers was striking. Their social differentiation was based on the division of labor, social ecology and prestige of the different activities in the work group. The workers were divided into soldering and inspection units as shown in Table 1: “W” is a wireman, “S” is solderman, and “I” is an inspector. Workers W5 and S2 are assigned to both of the inspection units: one-half of the work done by W5 and S2 was inspected by I1, and the other half of the work was inspected by I3. The wiremen also were divided into two groups that dealt with different types of switchboards: connector and selector bank wiring. Connector bank wiring was considered the more demanding and prestigious of the two activities. The connector wiremen are indicated with a boldface W. The spatial locations of the workers were such that

Table 1
Division of labor in the Bank Wiring Observation Room[a]

Soldering unit A	Inspection unit A
W1	**W**1
W2	**W**2
W3	**W**3
S1	**W**4
	W5 (also in unit B)
Soldering unit B	S1
W4	S2 (also in unit B)
W5	I1
W6	
S2	Inspection unit B
	W5
Soldering unit C	**W**6
W7	W7
W8	W8
W9	W9
S4	S2
	S4
	I3 (isolate)

[a] Note: connector wiremen are in boldface.

the connector wiremen were located toward the front of the room and the selector wiremen toward the rear:

> An individual's location in the workroom roughly reflected his relative standing in efficiency, earnings, and the esteem of his supervisors. The connector wiremen represented the elite. Indeed, some of the wiremen looked upon "going on connectors" as a promotion even if their hourly rates were not changed. Conversely, some of the connector wiremen felt injured if they were "put back on selectors" and regarded such a change as a demotion even though their hourly rates were not changed. Here, then, a minor technical distinction had become so elaborated that it provided a basis upon which the wiremen were in some measure socially differentiated (Roethlisberger and Dickson, 1939: 496).

The social status of the soldermen was somewhat lower than that of the wiremen; inexperienced workers usually began with soldering and later moved on to wiring. The inspectors had a different set of supervisors than the wiremen and soldermen, and they were considered outsiders; although the inspectors were in a superordinate position to the other workers by virtue of their role, they had no direct authority over these workers.

Roethlisberger and Dickson (1939: 509) describe the social structure of the group as consisting of two *cliques* plus workers who were members of neither clique: clique A is {W1, W3, W4, W2, S1, I1}, clique B is {W7, S4, W8, W9, W6}, the non-clique members are S2 and W5, and the isolate is I3.[6] Each clique (A and B) corresponds to an Inspection Unit in the Bank Wiring Observation Room and, therefore, also corresponds to the ecological organization of the workers (work locations toward the front vs. back of the room) and to

[6] Roethlisberger and Dickson considered W2 and W6 to be marginal members of these cliques.

the type of switchboard with which the workers dealt (connector vs. selector switchboards). The two non-clique workers, S2 and W5, are the only workers who are members of both Inspection Units.

Roethlisberger and Dickson's conclusion that the work group is divided into two cliques has been supported by others analysts (Homans, 1950; White et al., 1976). My hierarchical cluster analysis (diameter method) of the Euclidean distances between the initial positions of the workers, given by the measure $\boldsymbol{Y}^{(1)}$, also indicates that the two cliques are located in different regions of the social space of the work group:

```
          W.W.W.S.W.I.W.S.W.W.W.W.S
          8.9.7.4.6.1.2.1.1.3.4.5.2

0.14551   B-B......................
0.24270   B-B.............A-A......
0.34124   B-B.......A-A...A-A......
0.45183   B-B.B-B...A-A...A-A......
0.47967   B-B.B-B...A-A...A-A-A....
0.53805   B-B.B-B...A-A-A.A-A-A....
0.64354   B-B-B-B...A-A-A.A-A-A....
0.72819   B-B-B-B...A-A-A.A-A-A.X-X
0.73659   B-B-B-B...A-A-A-A-A-A.X-X
0.84402   B-B-B-B-B.A-A-A-A-A-A.X-X
1.02367   B-B-B-B-B.A-A-A-A-A-A-X-X
```

where A signifies membership in clique A, B signifies membership in clique B, and X signifies non-clique membership.

When the network of ties (positive interpersonal relations) among the workers is permuted into blocks that correspond to the two cliques and the non-clique members, it becomes apparent that there a major structural cleavage between the two subgroups that is bridged by a small number of boundary-spanning ties:

$$
\begin{array}{c}
\begin{array}{ccccccccccccc} \mathrm{W8} & \mathrm{W9} & \mathrm{W7} & \mathrm{S4} & \mathrm{W6} & \mathrm{I1} & \mathrm{W2} & \mathrm{S1} & \mathrm{W1} & \mathrm{W3} & \mathrm{W4} & \mathrm{W5} & \mathrm{S2} \end{array} \\
\tilde{\mathbf{R}} = \left[\begin{array}{ccccc|cccccc|cc}
0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 0 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\
1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\
1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\
\hline
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 \\
0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 \\
0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 \\
\hline
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0
\end{array}\right]
\end{array}
$$

The density of ties within the two cliques is 0.80 or higher, while the density of ties between the cliques (A $\rightarrow$ B and B $\rightarrow$ A) is 0.10 or lower; unlike the ties within cliques, the ties between cliques are mostly unreciprocated. In these data, friendships and antagonisms were mutually exclusive; but there were instances of playmates who also were antagonists. All but one of the friendship ties (W7-S1) are confined to members of the same clique, and the interpersonal tensions (antagonisms) are concentrated on the non-clique members and inspectors. There were no antagonisms among the wiremen in clique A; there was one such relationship among the wiremen in clique B; and there also was some tension between one of the wireman in clique A (W2) and three of the wiremen in clique B (W7, W8, and W9).

Beyond the evidence of these social relations, the social differentiation of the work group was manifested by the development of different subcultures. Clique members participated in games (gambling, horseplay, etc.) with members of their own clique (or with the non-clique worker W5) and not with members of the other clique: the members of clique A preferred to gamble while the members of clique B tended to "horse around". Clique members often pooled their money and bought candy, but these purchases were made separately by each clique, and the type of candy that was purchased by the two cliques differed in quality.

Hence, the pattern of social differentiation among the workers in the Bank Wiring Observation Room is straightforward. The work group is comprised of two clusters; these clusters are based on the division of labor, social ecology, and prestige of the activities in the work group; the workers within each of these clusters are cohesively connected; the two clusters are connected by a small number of boundary-spanning ties; and each cluster developed distinctive patterns of behavior and attitudes.

4.2. Normative consensus

The theoretically puzzling feature of this work group is that the differentiated social structure allowed the development and maintenance of shared norms on job-related issues. Given the social differentiation among the workers, it would not have been surprising if Roethlisberger and Dickson had reported conflict rather than consensus on these norms. In fact, although the cliques had distinctive behaviors and attitudes, the workers as a whole also had shared standards of work performance and conduct. Roethlisberger and Dickson describe these norms as

> You should not turn out too much work. If you do, you are a "rate-buster." You should not turn out too little work. If you do, you are a "chiseler." You should not tell a supervisor anything that will react to the detriment of an associate. If you do, you are a "squealer." You should not attempt to maintain social distance or to act officious. If you are an inspector, for example, you should not act like one (1939: 522).

Workers believed that sustained productivity near the official minimum level (the so-called "bogey") would result eventually in a management reaction unfavorable to the workers:

> If we exceed our day's work by an appreciable amount, something will happen. The 'rate' might be cut, the 'rate' might be raised, the 'bogey' might be raised, someone might be laid off, or the supervisor might 'bawl out' the slower men (Roethlisberger and Dickson, 1939: 417).

Table 2
Average hourly output (AHO)[a]

Wireman	AHO	AHO-825
W1	724	−101
W2	860	+35
W3	823	−2
W4	757	−68
W5	804	−21
W6	822	−3
W7	651	−174
W8	710	−115
W9	416	−409

[a] Note: Roethlisberger and Dickson (1939: 434).

To preclude such a reaction by management, workers' production was restricted to a shared conception of a "day's work" that was considerably lower than the "bogey" and that was viewed as an acceptable *upper limit* for a person's output. This norm was a working rate of 825 outputs per hour.

The *actual* average hourly output for the wiremen is reported in Table 2. The average output of the four wiremen in clique A (791 outputs per hour for W1–W4) is considerably closer to the "bogey" than the average output of the four wiremen in clique B (650 outputs per hour for W6–W9). Roethlisberger and Dickson delve into the question of whether non-attitudinal factors (intelligence and dexterity) might account for these differences and conclude that they do not. With the possible exception of W9, these outputs reflect workers' *attitudes* or choices about their own level of productivity rather than workers' limitations or capabilities. The workers paced themselves in different ways; some worked at a steady rate throughout the day and others worked more rapidly in the morning and slacked off in the afternoon. It appears that most of the workers could have easily met the "bogey," which was considerably higher than the informal norm of 825 outputs per hour. Hence, it is an indication of the successful maintenance of the informal norm of 825 outputs per hour that all of the workers (except for W2) did not exceed it. By the same token, the variation among the workers (i.e. the degree to which they departed from this norm) is a reflection of the extent to which informal social controls did not reduce individual and subgroup (clique) differences.

Hence, social differentiation and normative consensus *co-existed* in the Bank Wiring Observation Room, a fact that has not been emphasized or explained in previous analyses of the workgroup:

> When it is said that this group was divided into two cliques and certain people were outside either clique, it does not mean that there was no solidarity between the two cliques or between the cliques and the outsiders. There is always the danger, in examining small groups intensively, of overemphasizing differentiating factors. Internal solidarity thus appears to be lacking. That this group, as a whole, did have very strong sentiments in common has already been shown in discussing their attitudes toward output (Roethlisberger and Dickson, 1939: 510).

Roethlisberger and Dickson's analysis stops short of an account of how the common sentiments among the workers were formed; their analysis does not explain why the workers settled on the norm of 825 outputs per hour as opposed to some other level of output; and their analysis does not account for the workers' varying compliance with the norm. I will show how the network theory of social influence addresses these issues.

4.3. The influence system

Fig. 1 details the pattern of direct interpersonal influences ($\boldsymbol{AW}$) among the workers in the Bank Wiring Observation Room. The work performance of fellow workers was carefully monitored:

> One of the most interesting things about the group was that each man seemed to know just where he stood at any time. The men could tell not only how much they had accomplished at a given time, but also, and with a startling degree of accuracy, how much their neighbors had accomplished (Roethlisberger and Dickson, 1939: 428).

Such interpersonal visibility is a prerequisite of interpersonal influence and social control. The social controls exercised by the workers were varied and manifest, and they indicate that work-related attitudes were being continuously formed and reinforced. The most important of these controls were sarcasm, "binging" (forcefully hitting another worker on the arm), and ridicule (Roethlisberger and Dickson, 1939: 523).

Not surprisingly, Fig. 1 indicates that there are noteworthy interpersonal influences within each of the two cliques and among particular clique members and the two marginal members (S2 and W5). However, there also are noteworthy influences *between* the cliques. The average magnitudes of the direct interpersonal influences among the two cliques (A and B) and the non-clique members (X) are:

$$\overline{\boldsymbol{AW}} = \begin{bmatrix} & \text{A} & \text{B} & \text{X} \\ \text{A} & 0.822 & 0.101 & 0.033 \\ \text{B} & 0.132 & 0.859 & 0.000 \\ \text{X} & 0.490 & 0.508 & 0.001 \end{bmatrix}$$

In this blockmodel, an entry in the *ij* cell is the sum of the direct effects upon the persons in block i from the persons in block j divided by the number of persons in block i. The members of cliques A and B have strong direct effects on fellow clique members (A: 0.822 and B: 0.859) and substantially weaker effects on each other (B $\rightarrow$ A: 0.101 and A $\rightarrow$ B: 0.132). Both cliques have moderate effects on the non-clique members (A $\rightarrow$ X: 0.490 and B $\rightarrow$ X: 0.508). The non-clique members have negligible effects on the cliques.

The influence network, shown in Fig. 1, describes various pathways for a flow of interpersonal influence via intermediaries in the work group. The systemic implications of the influence network are apparent in a blockmodel of the total interpersonal effects ($\boldsymbol{V}$) that

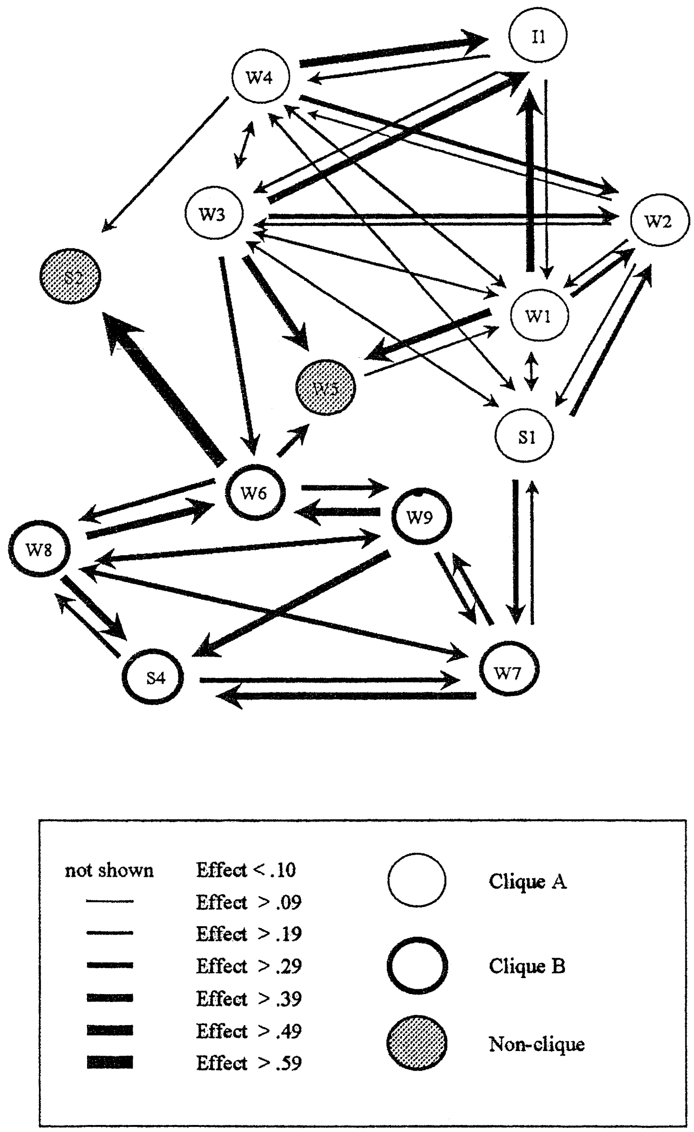

Fig. 1. Direct effects among the workers in the bank Wiring Observation Room.

arise from the flows of influence:

$$\overline{V} = \left[\begin{array}{cccc} & \text{A} & \text{B} & \text{X} \\ \text{A} & 0.864 & 0.136 & 0.001 \\ \text{B} & 0.800 & 0.200 & 0.001 \\ \text{X} & 0.836 & 0.163 & 0.001 \end{array}\right]$$

Table 3
Mean interpersonal influence of each worker on all other workers[a]

Worker	Mean direct effect	Mean total effect
I1	0.032	0.003
W1	0.121	0.150
W2	0.049	0.013
W3	0.147	0.466
W4	0.105	0.135
W5	0.016	0.001
W6	0.143	0.021
W7	0.090	0.026
W8	0.097	0.027
W9	0.106	0.078
S1	0.073	0.051
S2	0.000	0.000
S4	0.054	0.006

[a] Note: mean direct effects are based on the columns of $\boldsymbol{AW}$ in Eq. (2). Mean total effects are based on the columns of $\boldsymbol{V}$ in Eq. (1). The self-weights in $\boldsymbol{AW}$ and $\boldsymbol{V}$, i.e. $\{a_{ii}w_{ii}, v_{ii}\}$, are excluded in computing these average effects.

In this blockmodel, an entry in the *ij* cell is the sum of the total interpersonal influences upon the persons in block *i* from the persons in block *j* divided by the number of persons in block *i*. Clique A dominates the work group. Inspection of the total effects matrix ($\boldsymbol{V}$) upon which this blockmodel is based indicates that most of the influence of clique A is based on the interpersonal influences of workers W3 and W4.

Table 3 describes several summary features of the influence system in the Bank Wiring Observation Room and highlights the relative influence of the individual workers. In the first column of the table are the identifications of the thirteen workers. In the second and third columns are, respectively, the mean direct ($\boldsymbol{AW}$) and mean total interpersonal ($\boldsymbol{V}$) effects of each worker on other workers. The results indicate that worker W3 has the most influence; on average, his initial opinion determines 46.6% of the content of the settled opinions of the group's members. According to Roethlisberger and Dickson, this worker was on "good terms with every person in the group" (p. 464). The soldermen and inspectors, S1 and I1, asserted that W3 was the best wireman they had ever worked with. Roethlisberger and Dickson note, "His superiority was demonstrated not only by the fact that he usually won out in arguments but also by the way in which he advised and cautioned the men ... [for instance,] if he thought an argument was going too far, he tried to put a stop to it" (pp. 464–465). Although W3 had only *one* interpersonal tie with the members of the other clique, his influence ramified throughout the differentiated social structure.

My findings suggest that interpersonal influences in the Bank Wiring Observation Room operated to substantially reduce disagreements and conflicts based on the workers differentiated positions in the social space of the work group, and that this process moved all of the workers toward a consensual position in this social space. In the social space of *initial* positions, the two closest workers, W8 and W9, were separated by a distance of 0.145. At equilibrium, the largest distance between any two workers is 0.077. Hence, the workers have converged to a region in which the maximum distance between any two workers is approximately one-half of the distance which separated the two *closest* initial positions of the workers. Moreover, because of the substantial total effects of W3 on the other workers, the workers have converged to a region of the social space that is in the vicinity of the *initial* position of W3. The average hourly output of W3 is 823, which conforms almost exactly to the informal (below the "bogey") performance norm of the group. My findings indicate that W3 not only exemplifies the work group's informal performance norm, but also shapes this norm via his direct and indirect interpersonal influences on other workers.

Social differentiation and normative integration can co-exist in the Bank Wiring Observation Room, because interpersonal influences operate to reduce the disagreements that are based on the workers differentiated social positions in the work group. However, the normative integration of the workers was not complete and did not entirely eliminate individual differences in conformity to the work group's standards and inter-clique conflict concerning the appropriate standard of work performance. Both W2 and W6 were the focus of particular concern because of the speed of their work (W6 was called "Speed King" and W2 was called "Phar Lap," after a well-known race horse). The informal controls succeeded in bringing W6 close to the group norm, but were less effective for W2, the only wireman whose average hourly output exceeded the norm (Table 2). Roethlisberger and Dickson (1939: 443) describe W2 as a "very difficult person to deal with" and state

> W_2, as interviews with him indicated, was not the type of person to conform to another's wishes. He was hard, enigmatic, self-reliant, and entered very little into relations with other people. In the observation room he tended to isolate himself, and his attitude toward his associates was one of mild contempt. This found expression in his output. By keeping his output high, he was expressing his disregard for the sentiments of the group. He knew he was doing something the others disliked and commented on it in his interviews (Roethlisberger and Dickson, 1939: 519).

In addition to these individual differences, Roethlisberger and Dickson (1939): 520 argued that the performance records of the workers reflected their social positions in the group. They suggested that the selector wiremen kept their output relatively low to express their opposition to the connector wiremen. "By keeping their output low, they not only lowered the earnings of the connector wiremen but at the same time they themselves managed to draw a wage quite out of proportion to their own contributions" (Roethlisberger and Dickson, 1939: 521).

An influence process that has moved the group toward a shared conception of an appropriate day's work is not inconsistent with *variation* in the workers' output (as shown in Table 2). Such variation occurs because the workers did not *entirely discount* their own attitudes, although they were embedded in cliques and heavily influenced by their peers. I find that the differences among the workers in their outputs are significantly associated with the distances between the workers' equilibrium positions, $\boldsymbol{Y}^{(\infty)}$ ($r = 0.26$, prob $=$ 0.04).[7] Hence, like the performance norm to which the workers are oriented, the equilibrium

[7] The performance difference in the average hourly output of two wiremen is computed as the square of the difference between them. The $N \times N$ matrix of these performance differences is compared to the $N \times N$ matrix of the equilibrium distances between the workers. The comparison of these two matrices is accomplished with the quadratic assignment paradigm (Hubert and Baker, 1978; Hubert and Schultz, 1976).

deviations from the norm appear to be an outcome and characteristic feature of the social structure in the Bank Wiring Observation Room.

5. Discussion

I have suggested how the role performances of workers in the Bank Wiring Observation Room may have been shaped by interpersonal influences. Previous research on the Bank Wiring Observation Room revealed that the workers were informally divided into two cliques connected by a small number inter-clique ties. Roethlisberger and Dickson report that standards of conduct were maintained *within* and *between* these subgroups. It is intuitively clear that the dense social ties within each clique are a basis of social controls that formed and maintained these standards; but the same type of intuition does not explain the broader agreements that encompassed the subgroups. The boundary-spanning ties that bridge the cleavage in this group must be crucial to the formation and maintenance of such agreements (Granovetter, 1973), but it has not been clear how the consensus was achieved. The mere presence of some inter-clique ties is not a sufficient structural basis of boundary-spanning agreements. The present paper contributes an explanation of the co-existence of social differentiation and normative consensus in the Bank Wiring Observation Room and serves to elucidate the possible structural foundations of the boundary-spanning agreements about work performance that occurred in the group.

My analysis suggests that, as a result of the influence of the workers in clique A, the attitudes and behaviors of the workers in clique B came to be more consistent with a social position that they did *not* occupy (i.e. the position of W3) than with their *own* social positions. This status-substitution effect is an implication of an influence network that fosters the disproportionate influence of particular social positions in a differentiated social space. Indeed, it is fascinating to speculate that, in the absence of these interpersonal influences, the productivity of the workers in clique B might have been closer to the *industry standard*, which was substantially *lower* than the productivity level of the bank wiring department at the Hawthorne Plant (Roethlisberger and Dickson, 1939: 537). I suspect that the mean productivity of the workers was maintained at a level *above* the industry standard, in part, because of the ramifying informal influences of worker W3, who was both extraordinarily competent and respected by his associates.

Durkheim (1893) recognized that differentiated social positions are a source of interpersonal conflict but an unreliable basis upon which to draw conclusions about the extent of the group's social integration. Social differentiation is not inconsistent with social structures and mechanisms that can produce agreements and coordinate behaviors among persons who occupy different positions. Thus, it cannot be assumed that persons who occupy markedly different social positions will have dissimilar equilibrium opinions or uncoordinated behaviors at equilibrium, because an integrative social structure that serves to maintain or form boundary spanning agreements, including consensus, may or may not be present. Nor can it be reliably assumed that persons in proximate (nonidentical) social positions will maintain or increase their similarity of opinions over time, because such persons may be influenced by different subsets of persons who pull the persons apart and increase their initial difference of opinion. In short, the definition of social positions does not suffice to describe the behavior of the system of social positions. Networks of interpersonal influence mediate the effects of social differentiation.

The contribution of the present article is to show how a formal network theory of social influence can contribute to the account of norm formation and maintenance. The normative consensus in the Bank Wiring Observation Room was maintained through social interaction, but the mechanism by which this was accomplished has not been clear. The implications of a pattern of social differentiation and influence are not always transparent even in small groups. The difficulty in assessing these implications derives from the complexity of indirect influences (influences via intermediaries) that arise from the repetitive responses of persons to the changing attitudes and opinions of their significant others. A formal network theory of the influence process is useful in these circumstances because it provides a way of (a) assessing the net impacts of persons that arise from influence flows and (b) forecasting the final destinations of persons (equilibrium attitudes and behaviors) that are a joint product of persons' social positions and interpersonal influences. The theory that I have employed in this paper is in an early stage of theoretical development, but it has proved useful in explaining the puzzling combination of social solidarity and social differentiation that was present in the Bank Wiring Observation Room.

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