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Communication and Stability in Social Collectives

Raymond Trevor Bradley and Karl H. Pribram

ABSTRACT

A theory of social communication is developed to explain the endogenous processes by which stable organization is achieved in social collectives. The theory shows how two orders of social relations, *flux* (the distribution of energy) and *control* (spatial and temporal constraints on behavior) activate the potential energy of the collective's members—their capacity for physical and social behavior—and directs the expenditure of this energy towards collective ends. The work is divided into two parts and begins inductively, in Part 1, with an empirical analysis using existing data from a longitudinal study of 46 social collectives. Sociometric measures of flux and control are developed and their relationship to stability (group survival) is investigated. Results from statistical analyses, including multivariate discriminant analysis, show that the interaction between the two relational orders is a strong predictor of stability, while measures of the collective's normative and structural organization and of the members' social characteristics have no predictive power. Building on these results, Part 2 draws on the concepts of energy and information from the natural sciences to show how the interaction between flux and control operates as an information processing system. The interaction between the two orders effects stability by gathering and communicating information about internal organization throughout the collective. The interaction informs (gives shape to) the members' expenditure of energy and results in stable, effective collective organization. The work concludes with a theoretical model that shows how different patterns of endogenous communication, different configurations of flux and control, produce various states of functional and dysfunctional organization.

I. Introduction

Explaining how social collectives are organized to function as stable, effective units has long been one of the primary goals of social science (Comte, 1851–54). An understanding of stability, the means by which structural integrity and functional viability are sustained, is of primary importance for social theory in that a stable platform of organization is a necessary prerequisite for any kind of effective collective action.

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information processing system. However, because the dynamics of energy relationships and regulatory processes in social systems are still only poorly understood (Abraham & Gilgen, 1995; Dendrinos & Sonis, 1990; Kauffman, 1995), we draw on concepts and insights from non-linear dynamics—so called "chaos theory"—(Nicolis & Prigogine, 1977; Prigogine & Stengers, 1984) and from the physics of signal processing (Gabor, 1946) to help explain the endogenous movements of energy and information that generate stable collective organization. The report concludes with a theoretical model relating different patterns of endogenous communication to various states of collective action.

2. Part 1: Communication in Social Collectives

The concept of communication we develop in this paper focuses on an elemental order of information processing, an order that is different from, though related to, the concept of (human) communication ordinarily used in social science. Emphasizing the cultural basis of human sociation, the term is normally used to denote interaction which involves the exchange of normatively defined meanings and understandings among purposeful social actors (Cherry, 1966). Irrespective of whether it occurs in an interpersonal or a collective context, communication is viewed as centered on the individual—transpiring between or among self-conscious actors, either in the pursuit of their own goals or in the roles they play as agents for collectives (Rogers & Kincaid, 1981; Jablin, Putnam, Roberts, & Porter, 1987)—and as localized to certain purposefully selected bonds rather than distributed through all connections in the collective.

Our concept is similar to the notion of communication that underlies the "connectionist" computational models of "brain-style processing" (Rumelhart, 1992, p. 69). In these models synchronous parallel distributed processing among densely connected artificial "neural networks" is shown capable of encoding and "learning" quite complex knowledge patterns (see Rumelhart, McClelland, & PDP Research Group, 1986; McClelland, Rumelhart, & PDP Research Group, 1986, for examples). Here, information processing (computation) occurs in the pattern of excitatory and inhibitory relations that interconnect all of the nodes of the "neural network;" it does not occur in any single "neuron" or node. This is the same core idea in our concept: a field of relations in which it is the interpenetration—the conjunctive interplay—between two different orders of social connection that processes and transmits information throughout the collective. However, as described below, the field concept implies a harmonic rather than a discrete operation of interaction among the individuals composing the collective. Thus, rather than being centered on particular social actors or certain subsets of bonds, as in the "blockmodel" analyses (e.g., Freeman, White, & Romney, 1989; White, Boorman, & Brieger, 1976) and "system dynamics" models of social systems (Forrester, 1968; Legasto, Forrester, & Lyneis, 1980), the locus of communication in our concept is the interpenetration of networks of social relations connecting all members. Block models and systems dynamics models become subsets of the field of communication under specified constraints.

2.1. *Conceptual Foundations*

Social science has long recognized the importance of two basic patterns of social organization. Conceptualized by classical social theorists as a distinction between gemeinschaft and gesellschaft social organization (Toennies, 1957), or between organic and mechanical social solidarity (Durkheim, 1949) etc., modern social observers have found the two patterns in a wide variety of social contexts and have used a number of different terms to describe them—informal versus formal organization (Roethlisberger & Dickson, 1939), natural versus rational systems (Selznick, 1948), socio-emotional versus socio-technical systems (Trist & Bamforth, 1951), expressive versus instrumental leadership (Bales, 1958), communitas versus structure, (Turner, 1969), nominal versus graduated parameters of structure (Blau, 1977), markets versus hierarchies (Williamson, 1975), and most recently flat structure (networks) versus hierarchical networks (Burt, 1992), among others. Underlying these conceptualizations is a deeper (often implicit) dimensionality. They make a distinction between field-like and hierarchical forms of organization,[2] respectively: between a pattern of social relations that is fluid and transitory, based on an equivalence among individuals, and a pattern that is ordered and stratified based primarily on relations of social status and social control.

By "field-like" we mean an order of social connection that, like the structure of a market economy, is distributed over the whole region of a social space. Because it is the intermediary for the continuous flow of all interactions and transactions among individuals, encompassing verbal, gestural, and behavioral modalities, it is an order that is in a constant state of fluctuation. We refer to this order as flux which, interestingly enough, is defined in *The Concise Oxford Dictionary* as the "flood of talk" and denotes a "continuous succession of changes" (Fowler & Fowler, 1964, p. 469). Such an order is essentially holographic-like in organization in that each interaction enfolds the operations of the collective as a whole in much the same way that each transaction in a market economy enfolds the activity of the entire market place (Pribram, 1982). As we shall see, this concept of flux (of a wholistic field of social connection through which all interactions are processed) is one of the central concepts of the theory.

Previous analyses of the groups in this study (Bradley, 1987; Bradley & Roberts, 1989a; 1989b; Carlton-Ford, 1993; Zablocki, 1980) have shown that these two patterns of organization form the communicative structure. A similar finding, documenting the importance of both reciprocity and transitivity in communication, was made by Rice (1982) in a study of networking in computer-conferencing systems. As shown for the stable groups (groups surviving at least 24 months beyond measurement of their social structure; see Figure 1),[3] one of these patterns is a dense web of reciprocated relations of positive affect interconnecting virtually all members. This web is organized as a field, a distributed, massively parallel order of symmetrical ties in which individuals are essentially interchangeable. There is an absence of social differentiation so that all individuals are interconnected by an equivalent (*equi-valent*, of equal value) relation which allows unrestricted movement of interactional content throughout the web. This notion of field is consistent with the ideas of social networks theorists who argue that effective communication among individuals is a function of the potential social connectedness in a network: the density of "weak [social] ties" (Granovetter, 1973), the social intra-connection among individuals in structurally equivalent "blocks" (White, et al., 1976), the capacity of "q-connectivity" to generate interaction (Atkin, 1977; Doreian, 1986), or the availability of indirect linkages (provided by third parties) across "structural holes" (Burt, 1992).

The second pattern is a densely interlocking order of power relations which also extends to connect virtually all individuals. This is a hierarchical order, a vector of transitively-ordered relations which defines, for each individual, a position that is spatially and temporally local-

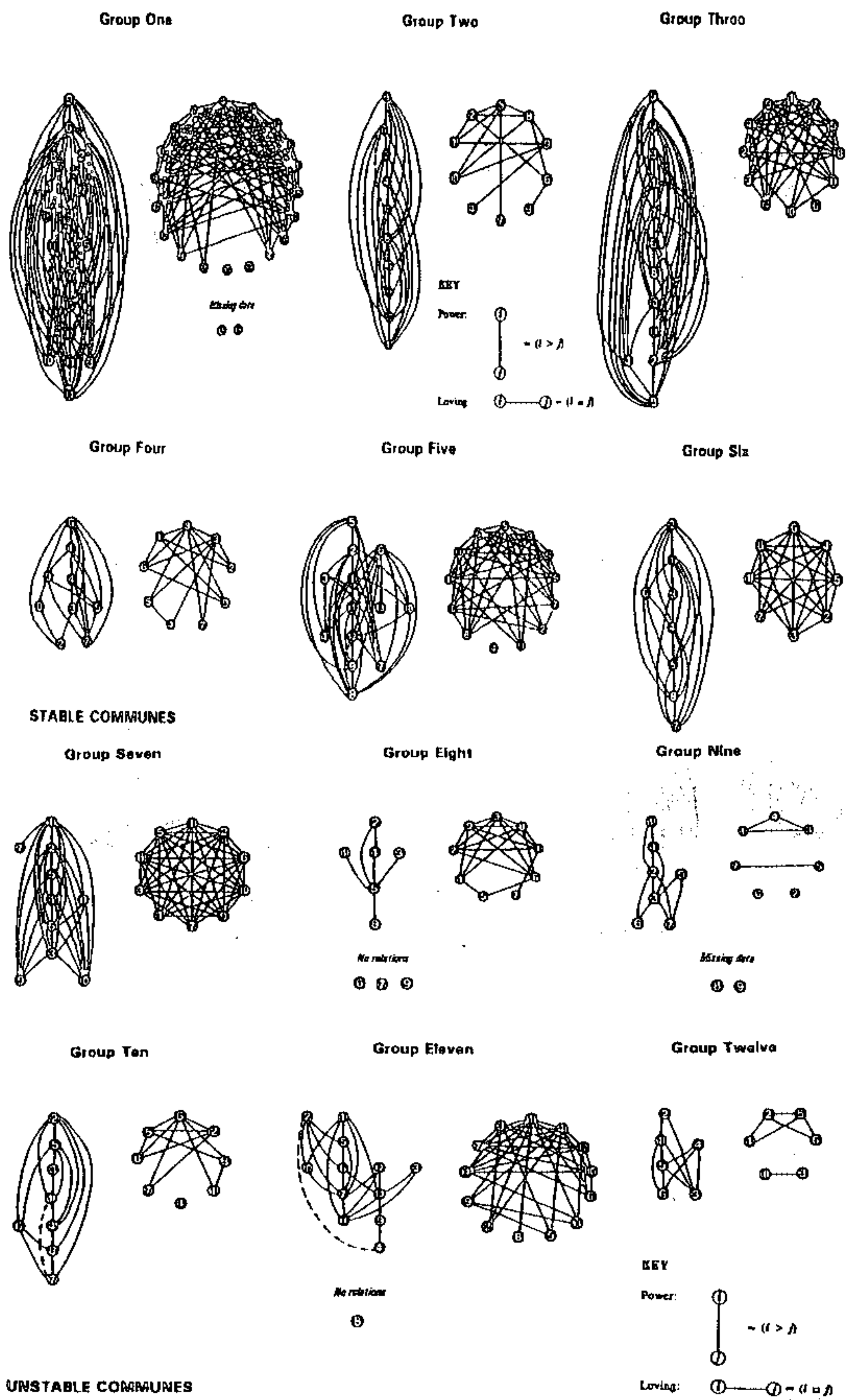

Figure 1. Sociometric Structure of "loving" (Field-Like) and "power" (Hierarchy) Relations in Selected Stable and Unstable Communes.

ized and, therefore, is unique. The relationship between the two orders was found to be strongly associated with group survival (see Bradley, 1987, Chap. 7; Bradley & Roberts, 1989a).

This relationship between relations of positive affect and social control has also been empirically documented in the dyadic systems involved in infant and child development. Thus, in an aptly titled volume, *Affect Regulation and the Origin of the Self*, reviewing the extensive multi-disciplinary research on infant development, Schore (1994) shows that the requisite neurobiological organization for the development of a stable self is prompted by interaction (touching, holding, feeding, and especially mutual eye gazing) along two dimensions in the mother-infant dyad: one involving the stimulation of positive affect and a second entailing modulation and regulation of the infant's affective response. Schore shows how a breakdown in the relationship resulting in a prolonged exposure to heightened negative affect during a critical period (approximately the first year of life) can affect the growth and organization of the infant's developing frontal cortex with enduring pathological consequences for subsequent social behavior (see Schore, 1994, p. 159–167). Hinde (1992) provides evidence attesting to the continued significance of interaction along these two dimensions for the development of the young child. Drawing from a study of aggression among four-year olds in preschools, he reports (on the basis of "three replications") that aggression was found to be lower when "maternal warmth" and "maternal control" in the mother-child relationship were "more or less in balance" (see Hinde, 1992, pp. 1,025–1,026, especially Figure 5).

Following up on these and the earlier findings from the groups in this study that describe *what* the communicative structure was composed of, the aim here is to understand *how*—the processes by which—the interaction between the field and hierarchical orders operates as a communication system. More specifically, two questions are addressed. The first is whether the interaction between the two orders can be best understood as an instance of information processing in which data about the movement of energy (that we describe below as flux) and data about spatial and temporal constraints on each member's behavior (control) are combined to create information about the collective's endogenous organization. The second question is whether insights from non-linear dynamics can illuminate the movements of energy in the interactions among members which compose the field; and whether insights from signal processing can show how the operation of hierarchical constraints on the movement of energy creates information describing the collective's internal structure.

2.2. *Theoretical Framework*

To develop a sociological understanding of how the two patterns of relations (flux and control) operate as a communication system, we begin with the premise that collective organization is, first and foremost, a relationship of collaboration—of individuals working together to achieve a shared end.[4] This is consistent with Searle's (1995) notion of "collective intentionality." Searle argues that "genuine cooperative behavior" is the basis for a nonreductionist order of social life: "The crucial element in collective intentionality is a sense of doing (wanting, believing, etc.) something together, and the individual intentionality that each person has is derived *from* the collective intentionality that they share" (Searle, 1995, pp. 24–25; italics in original).

To collaborate entails work in the form of physical behavior and social interaction, and work requires a supply of energy. We will assume that, as biological organisms, the members of a social collective are the source of this energy, and that they expend this energy as they work and interact in relation to realizing a shared goal. In addition to the availability of a pool of potential energy, collaboration also requires that each individual's expenditure of this energy be coordinated and directed toward the collective objective. Thus collaboration involves two complementary processes. The first is flux, the constant movement of energy throughout the collective as it is activated and expended by the members in physical behavior and social interaction. The second is control, the construction of a system of social constraints which directs the expenditure of energy into collective action. As described below, the interpenetration between flux and control operates as a communication processing network that in-forms the transformation of potential energy into collective work.

The movement of energy (flux) occurs as a distributed, massively parallel process which can be thought of as a field of equi-valent relations interconnecting all members (see Figure 1, above). This field is established by membership in the collective which creates a sociocultural boundary separating members from nonmembers. Membership thus effects a nominal bond of connection by which all members are attuned to one another. As an undifferentiated web of connection extending throughout the collective, this field is the intermediary for all interactions among individuals and, hence, it is the order through which all movement of the collective's energy is processed. The collective operates on this field of relations to activate individuals to action by arousing affective attachments among members. Arousal of affective bonds excites emotions, thereby mobilizing the individual's propensity for action (Pribram & McGuinnes, 1975; 1992; Schore, 1994) and, thus, the potential for expending energy (see Pribram & Bradley, 1998, for documentation of the neurobiological and psycho-social processes involved). Thus, the level of aroused affect is reflective of the degree of the members' activation to action. It is a measure of the amount of potential (biological) energy that has been mobilized and is available for collective (or individual) use.

The second process is control, a system of social constraints that operates to channel the members' energy toward collective ends and prevents the energy's dissipation in other social activity and physical behavior. The controls influence the movement of energy by constraining the spatial and temporal direction of the paths of flux, thereby in-forming (giving shape to) the collaborations among individuals. This control is achieved by the hierarchical order which, as described above, is a vector of transitive relations connecting all individuals. By differentially constraining the paths of inter-action by which individuals expend their energy, the controls render an informed pattern of collective organization.

However, there are limits on the total amount of information generated by flux and control that can be processed efficiently (Bradley & Pribram, 1997a). Amounts that fall outside the limits—amounts that either exceed the collective's processing capacity or amounts that are insufficient to inform energy activation and expenditure—increase the likelihood of collective dysfunction and instability.

Using existing data from an earlier study of 57 social collectives (Bradley, 1987), in the next section we present the results of an analysis we conducted on the relationship

Table 1

Urban Communes Sample: Social Characteristics of Adult Population and Communes

Characteristics of Adult Population (15 years and older; $N = 545$)	
Median age	25 years
Percentage male	54%
Percentage single, never married	72%
Percentage with college diploma	50%
Percentage with white collar or professional occupation	63%
Percentage with FT or PT job	67%
Characteristics of Communes ($N = 57$)	
Mean size (adult members)	9.9
Percentage existed two or more years	42%
Percentage with "many" rules	21%
Percentage assign or rotate chores	51%
Percentage have communal business or jobs	16%
Percentage requiring noviliate or trial membership	33%
Mean percentage members holding formal positions or office	41%[1]
Percentage ideology "important" to group	79%
Percentage without leaders	30%
Ideological Type:	%
Religious	40
Political or counter-cultural	26
Personal growth, household, or family	34
	100%

Notes: 1. $N = 273$, respondents to the "Long Form" interview.

between flux and control, and stability. We begin with a description of these data and our operational procedures.

3. Empirical Procedures

3.1. Method and Data

The data presented in this report were gathered over a decade ago as part of a nation-wide longitudinal field study of sixty urban communes (Zablocki, 1980). A commune was operationally defined as a minimum of three families, or five nonblood-related adults (persons aged 15 years or older) who shared, to some degree, common geographical location, voluntary membership, economic interdependence, and some program of common enterprise—usually spiritual, social-psychological, political, cultural, or some combination of these (Bradley, 1987, p. 14). Stratified on a number of basic social characteristics, and sampled in equal numbers from six Standard Metropolitan Statistical Areas (Atlanta, Boston, Houston, Los Angeles, Minneapolis-Saint Paul, and New York), a variety of formal and informal methods were used to study the communes. While descriptive data from 57 communes[5] are used in this report (see Table 1), for reasons mentioned below, our analysis involved data from 46 communes.

A number of social characteristics make the communes an ideal research site for the study of collective organization. As small, bounded, diverse, social entities (based on voluntary membership) in which members share, to some degree, a common culture and purpose, communes share many organizational features with other small-scale organizations and social groups. Also, they are accessible to study as social wholes; it is possible to establish a boundary for the system, to enumerate all members and investigate the arrangement of social relations that connect them. And while they are not microcosms of larger social entities (Zablocki, 1980, p. 6), they may nonetheless shed light on common underlying structures and processes.

In terms of the sample's social characteristics (Table 1) at the time of the first wave of data collection (the summer of 1974), the communes ranged in size from five to 35 permanent adult members (mean size = ten members) and had been in existence from three months to nine years (mean commune age = three years). A total of 566 adults (fifteen years and older; mean age = 25 years), with slightly more men than women, were residing in the communes; most had never been married. Being a generally well educated population, most reported working at a full-time white collar or professional job.

In terms of social organization, the communes covered a wide spectrum of cultural values and included Christian religious, Eastern religious, personal growth, family, counter-cultural, and political ideologies. Most communes had special requirements for membership and most also had incorporated elements of formal organization into their social structure (e.g., chore rotation, mandatory rules, positions of leadership and office, decision making procedures, group rituals, etc.).

Formal and informal methods were used to collect two panels of data, twelve months apart, during the summers of 1974 and 1975. Data on commune survival status were also gathered for an additional two years. A number of structured interviews and questionnaires were administered to all permanent adult members to gather information on social background, communal involvement, self concept, and attitudes. Data on the organization and activities of each commune were collected by field worker observations and taped interviews during the summer.

A sociometric instrument (Table 2), the primary source of the data presented in this report, was administered to map the structure of social relationships in each commune. Each adult member was asked a number of questions about the content of his or her relationship to each other member, thus providing an exhaustive mapping of the $N(N-1)$ possible dyadic relations in the group (where N = the number of permanent adult members). The instrument was administered under strict field worker supervision to ensure that there was no collusion among members in answering the questions.

Although all except one of the 57 communes cooperated with the administration of the sociometric instrument, the quality of responses in eleven groups was unsatisfactory in that missing data ("no answer," "incomplete," or an "uncodeable" response) were greater than 25% of the total of possible relations in these groups, and contained, therefore, an unacceptable level of potential structural bias (see Bradley, 1987, p. 24, Note 19; p. 98, Note 3). As in the original study, these eleven communes were excluded from the structural analysis. This means that the results from the sociometric analyses presented below are based on relational data collected from 46 communes.

Table 2
Sociometric Instrument

The following set of questions is from "page three" of the "Relationships Questionnaire" (see Bradley, 1980, for the complete instrument) and is the source of most of the relational data Bradley analyzed in his study. Each respondent received a questionnaire with multiple copies of "page three" inserted in it one page for each of the other adult residents. For example, a respondent in a commune of nine adults would receive a questionnaire with eight copies of "page three." Each copy had one of the members' names typed at the top (e.g., "This sheet is about __________"). By completing this questionnaire, each respondent supplied information systematically describing his/her relationship with each of the other members of their commune.

5. This sheet is about ____ .
   a. How long have known the above named person? Years________ Months________
   b. In your own words briefly characterize the changes which have occurred in your unique relationship with this person as a fellow commune member over the last twelve months or, if less, for the time you have known each other.
   ____
   c. How many hours in a typical week do the two of you spend together just by yourselves?
   ____
   d. If you happen to know it, state what kind of work (his/her) father did while the person named above was growing up. ____________________________________
   e. Even the most equal of relationships sometimes has a power element involved. However insignificant it may be in your relationship with this person, which of you do you think holds the greater amount of power in your relationship?
   ____
   f. If this commune did not exist, would you want to have a close relationship with this person?
   ____
   g. For the list of descriptions below, indicate if the following are involved in your relationship with the person named above by checking the appropriate answer. Please answer each of the following:

Work together	Yes ___ No ___ Sometimes ___
Spend free time together	Yes ___ No ___ Sometimes ___
Mind children together	Yes ___ No ___ Sometimes ___
Sleep together	Yes ___ No ___ Sometimes ___
Confide in each other	Yes ___ No ___ Sometimes ___
Loving	Yes ___ No ___ Sometimes ___
Exciting	Yes ___ No ___ Sometimes ___
Awkward	Yes ___ No ___ Sometimes ___
Feel close to each other	Yes ___ No ___ Sometimes ___
Tense	Yes ___ No ___ Sometimes ___
Jealous	Yes ___ No ___ Sometimes ___
Agree on communal policy	Yes ___ No ___ Sometimes ___
Feel estranged from each other	Yes ___ No ___ Sometimes ___
Exploitive	Yes ___ No ___ Sometimes ___
Hateful	Yes ___ No ___ Sometimes ___
Improving	Yes ___ No ___ Sometimes ___
Sexual	Yes ___ No ___ Sometimes ___

   h. Do you feel that the overall relationship between the two of you is more important to you, or do you feel it is more important to the above named person?
   More important to you ____________ More important to him/her ____________
   i. In your relationship with this person, does he/she ever act to you as a father or mother, sister or brother, son or daughter, or none of these?
   ____

3.2. *Operationalization*

Sociometric procedures were used to operationalize the concepts of flux and control. Administered to every adult member in each commune, the sociometric instrument, mentioned above, generated an enumeration of all possible dyadic relations in which the relation between each pair of individuals, *i* and *j*, was measured from both sides of the dyad (namely, from *i* to *j*, and from *j* to *i*). We followed Bradley and Roberts' (1989b) guidelines for sociometric measurement (specifically, the operational logic of their "Model IV"; see pp. 104–107) to construct measures of flux and control from these data.

Flux, the activation of potential energy, was measured by a positively reciprocated response (an answer of "yes") by both individuals[6] to either the "loving," "improving," or "exciting" questions (see Question 5g, Table 2). This operationalization follows from the expected role that mutual bonds of positive affect play in arousing the individual's potential energy—their propensity for action—and, thus, in enhancing the distribution of flux as described above. It follows, too, from the original study in which it was found that other dyadic measures of positive affect had little descriptive or explanatory utility; this result was also true for the measures of negative affect (see Bradley, 1987, p. 83–99).

Two group-level dyadic measures of flux were developed from these responses. The first involved computing the mean proportion of mutual loving, mutual improving, or mutual exciting relations in each commune. For the second measure, only those relations for which both individuals responded with an answer of "yes" to each of the "loving," "improving," and "exciting" questions were used. Then the mean proportion of these relations were computed for each group. The two measures appear to distinguish different intensities of flux. Thus, because all three contents must be mutually agreed as present in the relation between *i* and *j* (i.e., involve mutual loving AND mutual improving AND mutual exciting contents), the second measure characterizes a higher intensity of flux (hereafter referred to as high intensity flux), whereas because only any one of the three contents is required for the first measure, a lower intensity of flux (low intensity flux) is indicated. While most of the analysis was conducted with the measure of low intensity flux, the measure of high intensity flux was used to aid the understanding of energy dynamics in collectives undergoing radical social change.

Control, the operation of constraints on the activation of potential energy, was measured by the "power" question (Question 5e, Table 2).[7] Following the operational procedures used in the original study, all responses that unambiguously indicated the asymmetric ordering of the relationship—i.e., which of the two individuals (the respondent, *i*, or the other individual, *j*) held the "greater amount of power"—were used. Thus, in addition to dyads in which both individuals agree about the order of power (i.e., *i* claims power over *j* and *j* defers to *i*, or vice versa), others were included as well: dyads in which one individual responded with a claim or a deference and the other said the relationship between them was "neutral" or "equal," or gave "no answer" (*i* claims power over *j* and *j* says the relation is neutral/equal, *j* gave no answer, or the converse; or *i* defers power to *j* and *j* says the relation is neutral/equal, *j* gave no answer, or the converse). However, responses that indicated explicit disagreement (i.e., *i* and *j* both claim power, or *i* and *j* both defer power to the other) were excluded. This was done not only because these responses fail to indicate the directionality of the power relation, but also because they have been shown to produce spurious images of network structure (see Bradley, 1987, Figure 9: 4b; Bradley & Roberts, 1989b, p. 121).

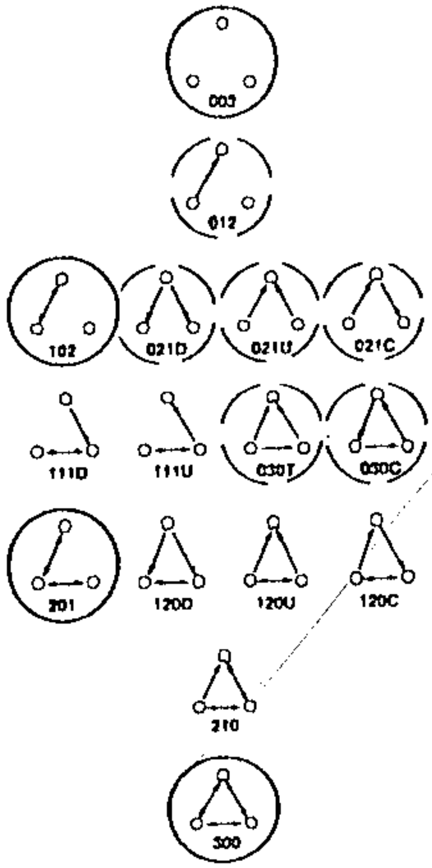

Figure 2. Isomorphic Triad Types Showing Symmetric Triads and Asymmetric Triads. Holland and Leinhardts' sixteen isomorphic triad types: the 16 isomorphism classes for digraphs with $g = 3$ (that is, the triad types). Triad labeling convention; the first digit is the number of mutual dyads; the second digit is the number of asymmetric dyads; the third digit is the number of null dyads; trailing letters further differentiate among the triad types. Four symmetric triad types (unbroken circle) were used in the structural analysis of FLUX relations and seven asymmetric triad types (broken circle) were used in the analysis of CONTROL relations; the "vacuous" 003 triad was used in both analyses. Redrawn from Holland and Leinhardt (1976: 6, Figure 2).

The subsets of relations that met these operational definitions for flux and control were then translated into symmetric and asymmetric sociomatrices, respectively, to encode the disposition of these dyadic relations among all members in each group. A binary coding was used in which, for flux, a value of 1 (one) indicated the presence of a reciprocated relation, and for control, a value of 1 (one) indicated the presence of an ordered relationship (i.e., $i \rightarrow j = 1$, control flows from i to j; $j \rightarrow i = 1$, control flows from j to i); any other condition, for either flux or control, was indicated by a value of 0 (zero). The mean results for the 46 communes on these dyadic definitions of flux and control are provided in the Appendix.

The final step entailed the use of triadic analysis (Holland & Leinhardt, 1976)—a technique for analyzing the structural organization of social networks—as the means to build structural indices of flux and control. This technique first subdivides the sociomatrix into triads, and then, through a census of the 64 different possible triadic configurations, classifies the array of triads for the group into 16 isomorphic triad types (see Figure 2).

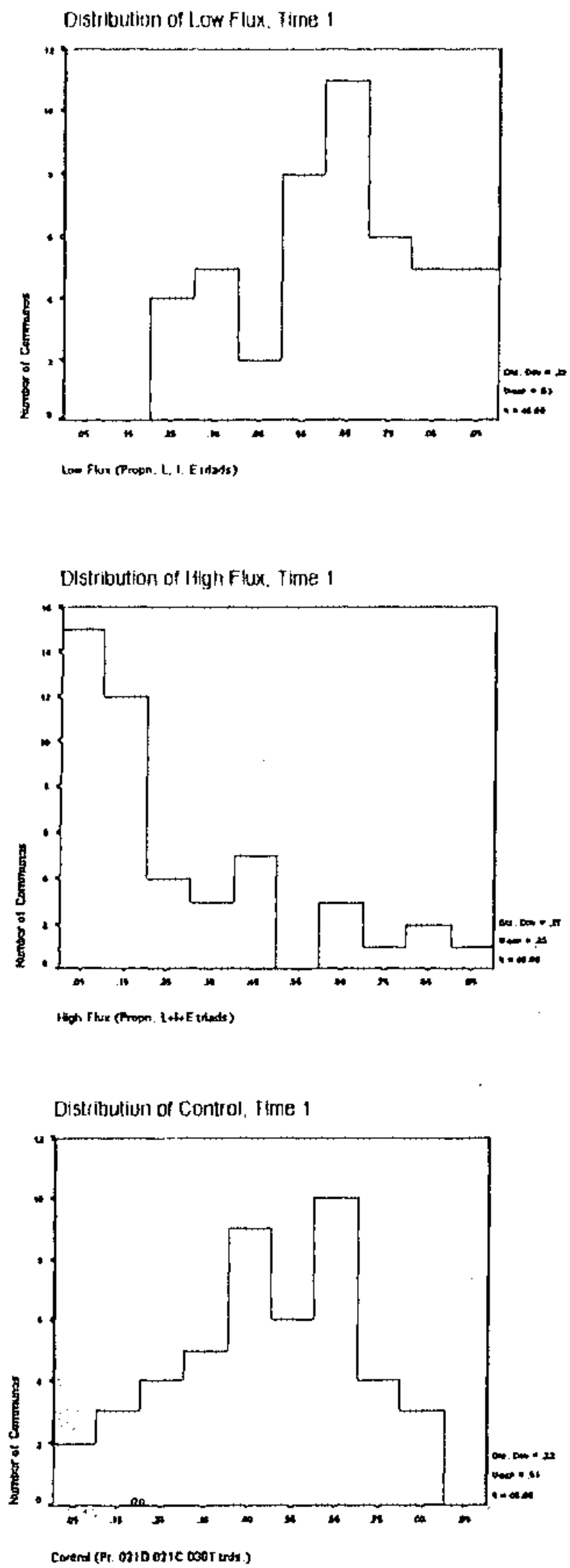

Figure 3. Histograms Showing Frequency of Communes for Low Intensity Flux, High Intensity Flux, and Control at Time 1.

The triad types are distinguished from one another structurally by their composition in terms of three kinds of dyads: Mutual dyads, in which a symmetric relation connects the two individuals; Asymmetric dyads, involving an ordered or directed relation between the two; and Null dyads, in which there is no relation between the two. Hence, each triad type can be uniquely identified and labeled in terms of its dyadic composition. For example, the 012 triad (see Figure 2) has no Mutual relations, one Asymmetric relation, and two Null relations.

Of the sixteen triad types, three are symmetric in form in that they are composed exclusively of positively reciprocated dyads (see Figure 2: the 102, 201, and 300 triad types, enclosed by a solid circle). Aggregated across the "loving," " improving," and "exciting" relations, the mean sum of these three triad types as a proportion of all possible triads in a commune was used as a structural measure of the amount of low intensity flux. For a structural measure of the amount of high intensity flux, the sum of these triads composed of dyads involving all three contents (i.e., where the relation between *i* and *j* involved mutual loving AND mutual improving AND mutual exciting contents) was computed as a proportion of all possible triads in each commune.

The two bar graphs in Figure 3a plot the distribution of the 46 communes on the two measures. The bar graph for low intensity flux shows a positively-skewed distribution (mean sum = .629, standard deviation (SD) = .196) with a dip of the incidence of groups in the .400 to .499 range, while the bar graph for high intensity flux shows a strongly declining negatively-skewed distribution (mean sum = .262, SD = .266) composed of two clusters of communes: the main cluster of 39 groups in the zero to .499 range and a second cluster of seven groups in the .600 to 1.00 range; the two clusters are separated by an absence of communes in the .500 to .599 range.

Seven other triad types (enclosed by a broken circle in Figure 2) are composed exclusively of asymmetric dyads. In constructing our structural measure of control, we selected triadic configurations consistent with our conception of control as a vector of transitively ordered relations connecting all individuals. Operationally, this translates into triadic configurations in which control flows from a single source to link the three individuals involved in a transitive order. This was true for only three of the triad types—the 021C, the 021D, and the 030T—where control flowed from the sociometric "leader," either directly through a single connection from that source (the 021D), or through a path of indirect connections flowing solely from that source (the 021C and the 030T). Of the other four triad types, the 003 was excluded because it is vacuous with no relations of control; the 012 was excluded be cause only two of the three individuals are connected by control; the 021U was excluded because two different paths of control, which lack a common source, flow to a single individual; and the 030C was excluded because control flows in a never-ending intransitive cycle. These triadic differences can be seen in the structural organization of the stable and unstable communes shown in Figure 1, respectively. Accordingly, the incidence of the 021C, the 021D, and the 030T triad types, when summed and expressed as the proportion of all possible triads, was used to measure the amount of control in each commune; the three triad types constituted just over half (.509), on average, of all possible triads in the communes.[8] A bar graph of the result for all communes, showing a bi-modal distribution with two peaks in the .400 – .499 and .600 – .699 intervals (separated by a dip in the .500 – .599 interval), is shown in Figure 3b (mean sum = .510, SD = .218).

The mean results of the triadic census for all communes on low and high intensity flux and on control are provided in the Appendix.

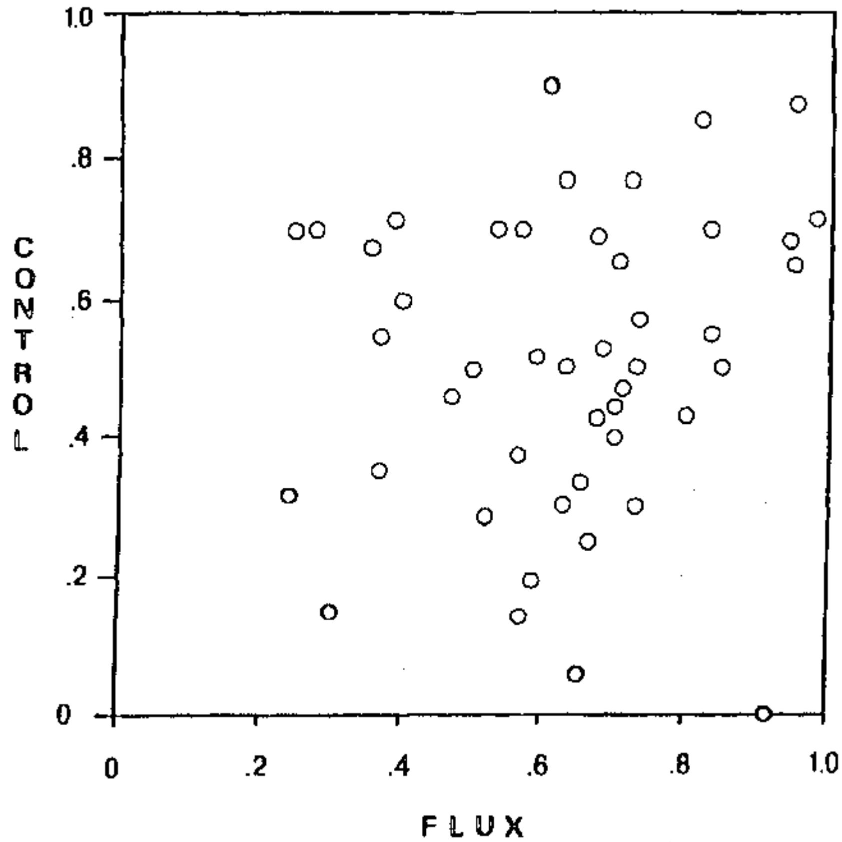

Figure 4. Scatterplot of All Communes ($N = 46$) by Flux and Control at Time 1 (outlying cases shown as hollow dots).

Stability, the degree to which the collective is able to maintain structural integrity and functional viability as a self-sustaining entity, was measured by a commune's survival status at a specific moment in time. Classified into one of two categories, survivor or nonsurvivor, each commune's stability was determined at each of the four successive twelve month intervals that observations were collected; Time 0 is the point in time when a commune was founded and Time 1 is the moment of the first wave of data collection (August, 1974). Starting with Time 1, measurement of each commune's stability (survival status) was made at twelve-month intervals for the succeeding four years, that is, through Time 5. Twenty-two (48%) of the 46 communes survived the 48 month observation period. A pattern of declining instability over time was observed, from 24% by the end of the first twelve months, at Time 2, to 8% by the end of the last twelve months, at Time 5 (see the Appendix).[9]

4. Analysis and Results

The objective of our analysis was to determine the degree to which the expected relationships between our measures of flux, control, and stability, as described above, were observed in the data from the communes study. Among other techniques, a spatial representation of the data was derived since the framework upon which the expectations are based rests on a field-theo-

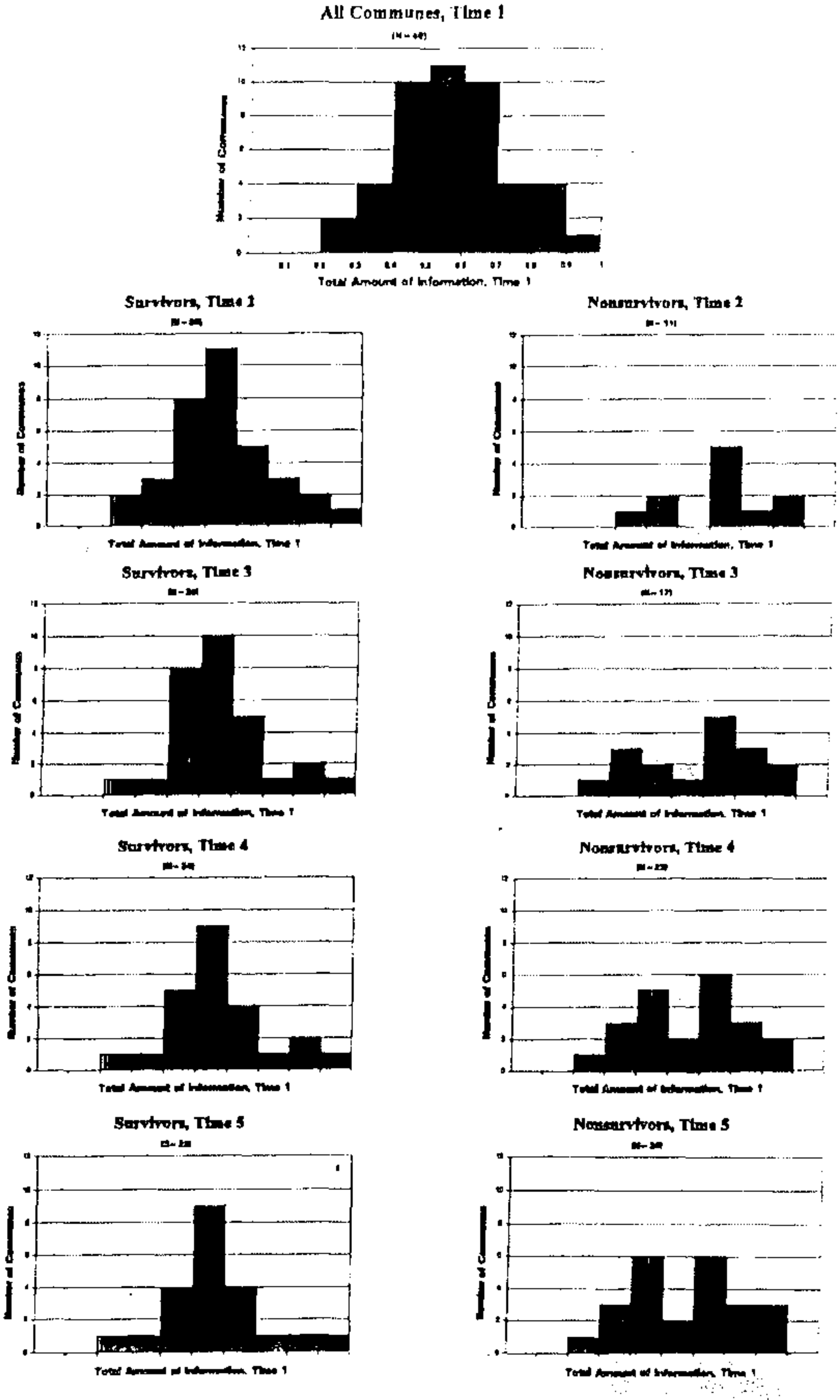

Figure 5. Barcharts Showing Distribution of Communes for Total Amount of Information at Time 1 by Stability at Time 2 Through Time 5.

retic conception of energy. This conceptualization of the collective's potential for action as an endogenous field of energy operates along two dimensions: an unordered dimension of equivalent, symmetrical relations (flux); and an ordered dimension of (transitive) asymmetric relations differentiated by spatio-temporal position (control). We begin with an analysis of the relationship between flux and control; unless otherwise indicated, we use the measure of low intensity flux as just described.

4.1. Relationship Between Low Intensity Flux and Control

Data bearing on the relationship between flux and control are shown in the scatterplot in Figure 4. In accordance with the dimensionality of our concepts of flux and control, the measure of control is the vertical ordinate and that for flux is the horizontal ordinate. It can be seen that the null hypothesis—an equal or random distribution of groups over all locations in the endogenous field—does not hold, and that the low non-significant correlation (Pearson's $r = .12$; pr. > .43) actually masks a non-linear association. Moreover, with the exception of five outlying cases (hollow dots in Figure 4), a triangular distribution is observed with a wide base and an apex in the high flux/high control region (upper-right quadrant). Accordingly, there is an absence (with one exception) of communes in the high flux/low control region (lower-right quadrant), an absence in the low flux/high control region (upper-left quadrant), and (with two exceptions) an absence of communes in the low flux/low control region (lower-left quadrant).

4.2. Relationship of Total Amount of (Low Intensity) Flux and Control to Stability

Data on the amount of information generated by flux and control and its relationship to stability is presented in Figure 5. A measure of the total amount of information generated by these orders in a collective at a given moment in time was computed by combining the measures of flux and control.[10] This was obtained by summing the measure of low intensity flux and the measure of control at Time 1 for each commune, and averaging the product (the mean for all communes = .569; median = .552, and SD = .155). The values for all communes were grouped into .10 intervals and, holding these values on this measure constant at Time 1, the sample was partitioned by survival status and the distribution of survivors and nonsurvivors was plotted on a time series of bar charts at twelve month intervals, that is, from Time 2 through Time 5 (see Figure 5).

Examining the pattern of results in Figure 5, two things stand out. First, the distribution for the total amount of information for all communes at Time 1 approximates a normal distribution with 67% falling within one standard deviation of either side of the mean. Second, this bell-shaped distribution gradually devolves over time into two contrasting patterns that are virtually the inverse of each other by Time 5: a single-peaked distribution for the twenty-two survivors with its mode (9 cases, 41%) in the .500 – .599 interval; a bi-modal distribution for the twenty-four nonsurvivors with its trough (2 cases, 8%) in the .500 – .599 interval and its twin peaks (6 cases, 24%, each) in the two adjacent intervals of .400 – .499 and .600 – .699. This difference in survival rates between the groups in the .500 – .599 interval and the other groups outside this range is statistically significant (chi-square = 6.695, pr. = .010).

Taken together, these two patterns appear to mark the bounds of a region where the probability of stability is maximized, that is in the .500 – .599 interval. So that although, in this

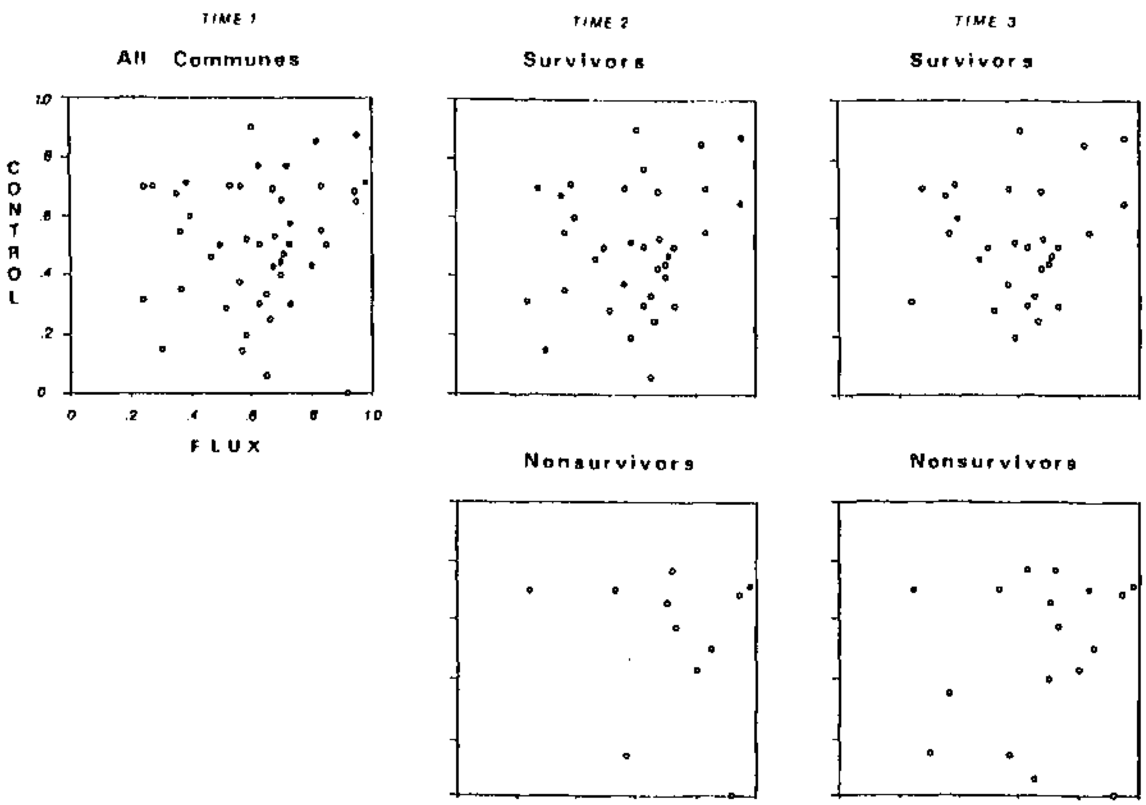

Figure 6. Scatterplots of communes on Flux and Control at Time 1 by Stability at Time 2 and Time 3.

interval, the rate of instability for all communes is lowest (18%, two of eleven groups), it rises sharply in the adjoining intervals: 60%, six of ten groups in each of the .400 – .499 and .600 – .699 intervals; 75%, three of four groups in each of the .300 – .399, .700 – .799, and .800 – 899 intervals. When computed for the communes in the two sets of adjoining intervals at Time 1, the rate of instability by Time 5 for each grouping of communes is 63% (twelve of nineteen groups at .600 and above, and ten of sixteen groups at .499 and below), which is significantly different than the 18% for the eleven communes in the .500 – .599 interval (chi-square = 6.966, pr. = .035). Thus, it would appear that the total amount of information generated by flux and control in the intervals above .599 was excessive in terms of information processing capacity, whereas the amount of information in the intervals below .500 was insufficient to sustain a viable collective.[11]

4.3. Relationship of (Low Intensity) Flux and Control to Stability

Figure 6 presents a time-series of scatterplots showing the relationship between flux and control at Time 1 to stability at Time 2 and at Time 3—in other words, the relationship between the composition (in terms of low intensity flux and control) of the information provided by a collective's communication system at a given point in time and the stability of the collective at two successive moments in the future. The scatterplot on the far left-hand side is for all communes plotted by their values for flux (horizontal ordinate) and control (vertical ordinate) at Time 1, the first point of measurement. Holding the values for each commune on flux and control constant at Time 1, the scatterplots for Time 2 and Time 3 are divided into a plot for survivors (top row of scatterplots in Figure 6) and a plot for nonsurvivors (bottom row). This provides a view of the relationship between the structure of the endogenous order at a given moment in time and collective stability at twelve and at twenty-four months later.[12]

Starting with the baseline pattern at Time 1 for all communes, three patterns become increasingly evident as survival status is plotted at Time 2 and Time 3. First, the probability of instability is highest for groups in the peripheral regions of the field, that is, for groups with the greatest imbalance between flux and control. Second, including the three stable groups in the high-flux/high-control region, survivors tend to form a triangular pattern with most groups clustered together in the mid-region. And third, location in this mid-region at Time 1 is strongly related to survival at Time 3, twenty-four months into the future. What is most striking about the results for the mid-region is that the pattern for survivors is virtually the converse of that for nonsurvivors: there is a complete absence of nonsurvivors in the mid-region where the greatest concentration of survivors is observed.

Looking more closely at the pattern for survivors and nonsurvivors at Time 3 in Figure 6, two bands of stability and two bands of instability, orthogonal to the main axis, are apparent. Immediately below the cluster of the three stable communes in the high-flux/high-control region is an upper-band of instability that separates the former from a set of stable communes in the mid-region. And beneath this stable region is a lower-band of unstable communes. In short, these different bands of communes seem to distinguish functional from dysfunctional combinations of flux and control.

To test the veracity of this interpretation, we divided the full sample of communes into stable and unstable sets such that the probability of survival was maximized for the former while being minimized for the latter. Operationally, this entailed establishing partitions that would mark the upper and lower bounds to the regions where stability would be optimized.[°]

The boundary of the lower-bound to the stable mid-region was established by the four communes (see the scatterplot for nonsurvivors, Time 3, Figure 6) on a line in the lower-band of instability orthogonal to the low flux-low control/high flux-high control axis. A total of six communes were observed in this region of which five (83%) had become nonsurvivors by Time 3; the baseline rate of instability for all communes was 37%, 17 nonsurvivors out of 46 groups.

For a boundary marking the upper bound to the stable mid-region, there were two possibilities. The first is the line (orthogonal to the axis just mentioned) established by the three communes at the bottom of the upper-band of instability; this is not an optimal partition because although the probability of survival is maximized (100%; there are no nonsurvivors) for the fifteen groups in the area defined by this line and the lower bound, the probability of instability is not maximized for the twenty-five groups classified by this line as belonging to an upper-band of instability (nonsurvivors = 12 communes, 48%). The second possibility is the line (orthogonal to the same axis) established by the four nonsurvivors immediately above the three communes. This second line meets our two criteria for an optimal partition. First, between the lower bound and this line marking the upper bound, twenty-five communes were observed, twenty-two (88%) of which survived through Time 3. And second, on this line and above, fifteen communes were observed, nine (60%) of which had become nonsurvivors by Time 3.

These fifteen communes can be partitioned into two sets by a line establishing a boundary for this upper region of instability. This is the line, orthogonal to the main axis, that separates

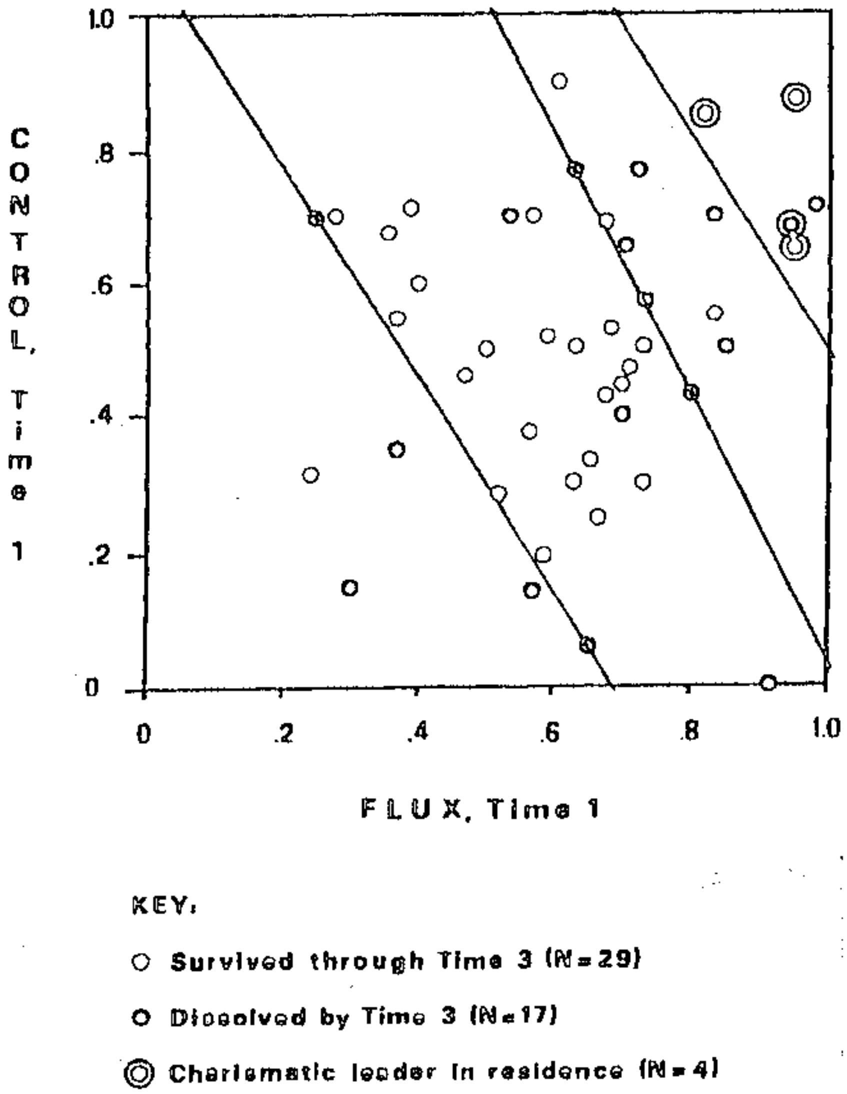

Figure 7. Scatterplot of Communes on Flux and Control at Time 1 by Stability at Time 3, and Showing Transformational Communes (charismatic leader in residence).

the five communes in the high-flux/high-control region from the ten communes between this line and the line marking the upper boundary of the stable mid-region. Above this line, stability is maximized—three (60%) communes survive of the five groups in this region; below this line, instability is maximized—seven (70%) of the ten communes in this unstable region are nonsurvivors by Time 3.

The results of this procedure are shown in the scatterplot for all communes in Figure 7. This scatterplot is identical to the scatterplot at Time 1 in Figure 5 with the following additions: first, the three lines separating the bands of stable and unstable regions, as just established, are indicated; and second, the survival status for each commune is shown at Time 3 (nonsurvivors are shown as hollow dots in Figure 7). It is clearly evident that the three partitions separate two areas of stability (one in the mid-region and one in the apex of the high-flux/high-control region) from two adjoining

Table 3
Comparison of Stability Groupings of Communes on
High Intensity Flux: Analysis of Difference in Means

1. Univariate Statistics

Stability Grouping	*No. Cases*	*High Intensity Flux* Mean	*High Intensity Flux* SD
Stable-Transformational	5	.754	.161
Unstable-Turbulent	10	.340	.233
Stable-Optimal	25	.170	.196
Unstable-Insufficient	6	.109	.094

2. t-Test Results

Stability Grouping Pair	*t-Test*	*DF*	*Pr. - 2 Tailed*
Transformational/Turbulent	4.02	11.23	.002*
Transformational/Optimal	7.11	6.62	.000*
Transformational/Insufficient	7.89	6.20	.000*
Optimal/Turbulent	−2.04	14.43	.060
Optimal/Insufficient	1.11	16.99	.283
Turbulent/Insufficient	2.79	12.87	.016*

Note: *Pr. ≤ .05.

areas characterized by a high probability of collective instability; the differences in the rates of instability, by Time 3, among the communes in the four areas is statistically significant (chi-square = 16.928, pr. = .0007). Moreover, in addition to its extraordinarily high stability over the twenty-four month period from the point of initial measurement, the mid-region also is distinguished by the lack of dispersion of communes along the low control-high flux/high control-low flux axis. Instead, there is a strong tendency for groups to locate between these extremes.

Finally, also shown in Figure 7 are four communes, out of the whole sample, which had a charismatic leader living in residence with the group (circled in Figure 7). Of all communes in the sample, these were the collectives most intent on achieving a radical restructuring of social order (see Bradley, 1987). All four of these transformation-oriented (charismatic) communes, three of which were still in existence by Time 3, are concentrated exclusively above the partition in the apex of the high flux/high control region; the fifth group (a nonsurvivor) is a noncharismatic commune whose members expressed a strong desire for charismatic leadership as the means to facilitate their efforts at social change.

For the purposes of further analysis, the communes were classified into one of the four categories of stability at Time 3 just established, as shown in Figure 7: namely, location in the upper band of stability (N = 5; survivors = 3 communes, 60%); location in the mid-band of instability (N = 10; survivors = 3, 30%); location in the mid-band of stability (N = 25; survivors = 22, 88%); or location in the lower band of instability (N = 6; survivors = 1, 17%). Henceforth, we will refer to these four groupings of the

Table 4a
Optimality Classification of Communes By Selected Social Characteristics: Analysis of Difference in Means

Social Characteristics, Time 1	*Optimality Classification, Time 3*		*t-Test Statistics*		*pr.—2 tailed*
	Optimal	*Non-Optimal*	*t-Test*[1]	*DF*	
(N)	(25)	(21)			
Mean (SD) Group Age, Years	3.36 (1.91)	2.33 (1.20)	2.13	44	.039*
Mean (SD) Group Size, Adults (≥15 yrs. old)	9.20 (4.44)	8.33 (2.22)	0.86[2]	37	.398
Mean (SD) Propn. Adult Pop. Members ≤1973	0.46 (0.29)	0.46 (0.33)	−0.01	44	.995
Mean (SD) Propn. Members Reject $10,000 to Leave	0.58 (0.32)[3]	0.58 (0.32)	0.02	43	.985
Mean (SD) Hours in Group Over Last 3 Days	51.60 (10.18)[4]	48.77 (10.24)	0.90	40	.375

Notes: 1. Pooled-variance *t*-Test.
2. Separate-variance *t*-Test.
3. Excludes 1 missing case.
4. Excludes 2 missing cases.
*Significant at ≤.05 level.

communes as *stable-transformational, unstable-turbulent, stable-optimal,* and *unstable-insufficient*, respectively.

4.4. *Relationship of High Intensity Flux and Control to Stability*

Our second measure of flux, high intensity flux (composed of mutual loving AND mutual improving AND mutual exciting relations), reveals big differences in the amount of potential energy activated (see Table 3). Of particular interest is the enormous difference observed between the stable-transformational category and the other groupings of communes. When compared to the other groupings, the communes in the stable-transformational category generate, on average, more than two times, four times, and almost seven times the amount of high intensity flux, as the groups in the unstable-turbulent, stable-optimal, and unstable-insufficient categories, respectively (mean proportion of high intensity flux = .754 versus .340, .170, and .109, respectively). The results of a *t*-test of the difference in means (Table 3) show that the differences between the stable-transformational grouping and each of the other categories are statistically significant. However, with the exception of the difference between the unstable-turbulent and unstable-insufficient categories, the differences between the other pairs of categories shown in the table are not statistically significant. The results suggest, therefore, that the activation of such enormous amounts of potential energy is associated with radical structural change which, in the case of these communes, is inspired by the presence of a charismatic leader (see Bradley, 1987, pp. 167–193, 264-268). We will return to this relationship between radical change and the activation of high levels of potential energy in a later section.

Table 4b

Optimality Classification of Communes By Selected Social Characteristics: Cross-Tabulation Analysis

Social Characteristics, Time 1	*Optimality Classification, Time 3* *Non-Optimal*	*Optimal*	*Total*
(N, %)	(21, 46%)	(25, 54%)	(46, 100%)
Survival Status, Time 3	%	%	%
Dissolved	67	12	37 (17)
Survived	33	88	63 (29)
	100%	100%	100%
Chi-Square = 14.639, DF = 1, pr. = .0001*			
Affiliated to Larger Organization			
% Not Affiliated	52	48	100% (27)
% Affiliated	37	63	100% (19)
Chi-Square = 1.013, DF = 1, pr. = .314			
Admission Requirements			
% If Room/See Individual	48	52	100% (21)
% Trait Required/Group Ready	43	57	100% (7)
% Trial Membership/ Novitiate/Group Closed	44	56	100% (18)
Chi-Square = 0.065, DF = 2, pr. = .968			
Formal Rules			
% None/Few	44	56	100% (27)
% Some/Many	47	53	100% (19)
Chi-Square = 0.038, DF = 1, pr. = .845			
Extent of Authority			
% None/A little	50	50	100% (24)
% Some/A lot	41	59	100% (22)
Chi-Square = 0.382, DF = 1, pr. = .536			
Organization of Chores			
% Totally Voluntary/Voluntary Choice	57	43	100% (21)
% Rotated/Assigned	38	63	101% (24)[1]
Chi-Square = 1.736, DF = 1, pr. = .188			

(continued)

Table 4b
(Continued)

Ideological Type			
% Religious	50	50	100% (18)
% Political/Counter Cultural	50	50	100% (12)
% Family/Household	36	64	100% (11)
% Personal Growth	40	60	100% (5)
Chi-Square = 0.675, DF = 3, pr. = .879			
Degree of Ideological Consensus			
% A Little/Some	48	52	100% (29)
% A Lot/Unity	41	59	100% (17)
Chi-Square = 0.218, DF = 1, pr. = .641			

Notes: 1. Excludes 1 missing case.
*Significant at ≤.05 level.

4.5. *The Question of Social Correlates*

A matter of considerable sociological importance is the question of social correlates: the degree to which there are distinguishing social conditions associated with location in the region of maximal stability. Data bearing on this question are presented in Tables 4a and 4b.

For this analysis, the twenty-five communes positioned in this mid-region (the groups in the stable-optimal category) at Time 3 were compared on a number of basic social characteristics at Time 1 to the twenty-one groups located outside this region; the two categories are labeled in Tables 4a and 4b as "optimal" and "non-optimal," respectively. As shown in Table 4b, there is a large, statistically significant difference in the rate of survival between these two categories of communes (88% versus 33%, respectively; chi-square = 14.639, pr. = .0001).

Starting with the analysis of the relationship between the interval-level (of measurement) independent variables and our optimality classification (see Table 4a), the results show that the groups in the optimal category had been in existence 1.03 years longer, on average, than the groups in the non-optimal category (3.36 versus 2.33 years, respectively; *t*-test of the difference in means = 2.13, pr. = .039). However, most of this difference is due to three groups in the optimal category which were six or more years old at Time 1. When the three are held aside, the mean group age for the twenty-two groups remaining drops to 2.86 years, leaving a non-statistically significant difference of 0.53 years (*t*-test = −1.38, pr. = .176).

On group size, the slight difference of almost one adult member (0.87), on average, between the optimal and non-optimal categories (mean size = 9.20 and 8.33, respectively) was also not-statistically significant (t-test = 0.86, pr. = .398).

With respect to member behavior, it is clear that on the measures of length of residence, member commitment, and member participation, the two categories of groups are virtually indistinguishable. The two categories have the same mean proportion of members resident in the group for a year or more (0.46; *t*-test = −0.01, pr. = .995), and the same mean proportion of members who say they would not accept an "offer of $10,000 to leave" the commune (0.58

Table 5a

Discriminant Function Analysis of Stability Classification of Communes By Selected Characteristics: Univariate Statistics

Variable	*Stability Groupings* *Unstable-Insufficient* Mean	SD[1]	*Stable-Optimal* Mean	SD	*Unstable-Turbulent* Mean	SD	*Stable-Transformational* Mean	SD	*Total* Mean	SD	Wilks' Lambda[2]	Univariate F-ratio	Pr.[3]
(N)	(6)		(24)[4]		(10)		(5)		(45)				
Admission Requirements	2.00	.89	1.92	.93	1.80	1.03	2.00	1.00	1.91	.92	.994	.077	.972
Affiliated to Larger Organization	.33	.52	.46	.51	.30	.48	.40	.55	.40	.50	.981	.269	.848
Authority	1.33	.52	1.50	.51	1.30	.48	1.80	.45	1.47	.50	.914	1.291	.290
Control	.286	.231	.462	.180	.654	.143	.755	.101	.514	.218	.589	9.552	.000
Low Intensity Flux	.396	.174	.578	.152	.739	.089	.928	.064	.628	.198	.445	17.066	.000
High Intensity Flux	.109	.094	.165	.199	.340	.233	.754	.161	.262	.269	.486	14.454	.000
Formal Rules	1.50	.55	1.42	.50	1.30	.48	1.60	.55	1.42	.50	.969	.443	.724
Group Age	2.67	1.51	3.38	1.95	2.20	1.14	2.20	1.10	2.89	1.71	.898	1.550	.216
Group Size	8.67	2.73	9.08	4.50	8.20	2.30	8.20	1.79	8.73	3.60	.987	.175	.912
Ideological Consensus	1.00	0	1.42	.50	1.30	.48	1.80	.45	1.38	.49	.826	2.886	.047
Prpn. Old Mmbrs.	.41	.35	.47	.30	.37	.34	.70	.22	.47	.31	.912	1.324	.280
Prpn. Reject $10K	.29	.19	.58	.32	.55	.24	.98	.05	.58	.32	.704	5.757	.002

Notes: 1. Standard Deviation.

2. U-statistic.

3. Statistical significance, with 2 and 43 degrees of freedom.

4. Excludes 1 case with a "missing value:" the mean value was assigned to this case for the classification analysis.

Table 5b

Discriminant Function Analysis of Stability Classification of Communes By Selected Characteristics: Stepwise Results and Canonical Analyses

*Summary of Stepwise Analysis**

Variable	*Step*	*Wilks' Lambda*	*Pr.*	*Minimum D-squared*	*Pr.*	*F*	*Equivalent Pr.*
LoFlux[1]	1	.445	.0000	1.378	.0033	9.726	.0033
Control	2	.142	.0000	6.281	.0003	10.213	.0003

Test of Differences Between Pairs of Groupings After Step 2

Stability Grouping Pairs	*F-statistic*	*Significance***
Optimal/Insufficient	20.331	.0000
Optimal/Turbulent	28.245	.0000
Optimal/Transformational	57.818	.0000
Transformational/Turbulent	10.213	.0003
Transformational/Insufficient	91.603	.0000
Insufficient/Turbulent	61.731	.0000

Canonical Discriminant Functions

	Function 1	*Function 2*
Canonical Correlation	.926	.085
Squared Canonical Correlation	.857	.007
Percent of Variance	99.88%	.12%
Eigenvalue	5.988	.007

Unstandardized Canonical Discriminant Function Coefficients

	Function 1	*Function 2*
Control	7.014	3.590
Low Intensity Flux	9.406	−3.402
(Constant)	−9.513	.293

Notes: *Maximum significance of F-statistic to enter = .050; minimum significance of F-statistic to remove = .100.
**With 2 and 40 degrees of freedom.
[1]Low Intensity Flux

and 0.58, respectively; *t*-test = 0.02, pr. = .985). In addition, the small difference in the mean amounts of time (2.83 hours) spent by their members in the commune over the "last three days" is not statistically significant (51.62 hours and 48.77 for the optimal and non-optimal categories, respectively; *t*-test = 0.90, pr. = .375).

Turning to the ordinal and nominal independent variables (see Table 4b), there is some evidence of differences between the two groupings of communes for the measures of formal organization. Thus there is a moderate (26%) difference on whether a commune is part of a larger (usually nation-wide) federation of communes (chi-square = 1.013, pr. = .314); small (3%) to modest (14%) differences in terms of the stringency of different procedures for selecting prospective members (chi-square = 0.065, pr. = .968); a small (6%) difference on the presence of "some or many" group-sanctioned rules in the commune (chi-square = 0.038, pr. = .845), a modest (9%) difference on the degree of authority vested in the group

Table 5c
Discriminant Function Analysis of Stability Classification of Communes By Selected Characteristics: Classification Results

	Predicted Group										
	Unstable-Insufficient		*Stable-Optimal*		*Unstable-Turbulent*		*Stable-Transformational*		*Total*		
Actual Group	*N*	*%*	*N*	*%*	*N*	*%*	*N*	*%*	*N*		*Prior Probability*
Unstable-Insufficient	5	83.3	1	16.7	0	0	0	0	6	100.0%	.13
Stable-Optimal	0	0	25	100.0	0	0	0	0	25	100.0%	.54
Unstable-Turbulent	0	0	0	0	10	100.0	0	0	10	100.0%	.22
Stable-Transformational	0	0	0	0	0	0	5	100.0	5	100.0%	.11
TOTAL	5	n.a.[1]	26	n.a.	10	n.a.	5	n.a.	46	100.0%	1.00

Notes: 1. Not applicable

(chi-square = 0.382, pr. = .536), and modest (14%) to moderate (25%) differences in the degree to which chores are formally organized (chi-square = 1.736, pr. = .188). However, as is evident from the chi-square coefficients, these differences can be accounted for by chance alone.

This pattern of the lack of statistically significant differentiation between the optimal and non-optimal categories continues on the two measures of ideological content. So that although the variation between the optimal and non-optimal groups on "ideological type" ranges from no difference to a moderate (28%) difference (chi-square = 0.675, pr. = .879), and from a small (4%) to modest (18%) difference on the degree of ideological consensus present among a commune's members (chi-square = 0.218, pr. = .641), the differences are due to chance.

In short, what is particularly striking about the overall pattern of these results is that there is no evidence of any statistically significant relationship either between measures of member behavior and location in the optimally stable region, or between measures of the collective's normative and formal organization and location in this region.

4.6. *A Multivariate Model of Stability*

To this point, our analysis has employed largely simple bi-variate statistical techniques which, given the small number of cases available, has been both necessary and appropriate. But because it was possible that deeper more complex multivariate relationships among our variables could have gone undetected (masked or hidden as a latent order) discriminant function analysis was conducted to ensure that this was not the case.

Two features of discriminant analysis made it especially appropriate: first, the procedure aims to construct a multivariate linear (discriminant) function that maximizes the separation between two or more mutually exclusive groupings of data; second, it offers a test of predictive power by comparing the a priori group classifications against those made by the discriminant function/s. As a measure, thus, of statistical optimality, discriminant analysis provides a rigorous means of testing the finding that, in relation to the other sociological factors examined here, our measures of flux and control provide the best means of predicting optimal collective stability.

To perform the discriminant analysis, we used the four-way stability classification of the communes at Time 3, as established above (see pages 47 - 49, and also Figure 7) as the dependent variable: namely, stable-transformational (N = 5), unstable-turbulent (N = 10), stable-optimal (N = 25), and unstable-insufficient (N = 6), respectively. Three discriminant analyses were conducted: one on the variables examined in the previous section ("The Question of Social Correlates"); the second was conducted with the addition of low intensity flux and control; the third was identical to the second with the exception that the measure of high intensity flux was substituted for low intensity flux. Along with our two measures of flux and our measure of control, nine of the twelve (sociological) variables listed in Tables 4a and 4b were used as independent variables for the two stepwise multivariate analyses.[13] The univariate statistics (means, SDs, Wilks' Lambda, and univariate F-ratio) are given in Table 5a.

Maximizing the minimum Mahalanobis distance (min. D-squared, a measure of separation) between the four groupings of communes, was the selection rule used for the stepwise multivariate analysis; the statistical significance of the F-statistic was used as the criterion to enter (pr. ≤.050) and remove (pr. ≥.100) the independent variables.

The first analysis,[14] conducted on the nine sociological variables alone, was not successful. Only one variable, the mean proportion of members "who would reject an offer of $10,000 to leave the commune" (Prpn. Reject $10K), met the selection criteria for the step-wise analysis, and the single, weak canonical discriminant function constructed not only possessed little statistical power,[15] but also was insufficient for the analytic task at hand; a minimum of two discriminant functions are required to discriminate among more than two groupings of data.

Adding low intensity flux and control to the nine variables examined in the first analysis, a second discriminant analysis was conducted. The summary of results from the multivariate stepwise analysis of this procedure is presented in the first section of Table 5b.

As is clearly evident from the results, the only two variables selected in the stepwise procedure were low intensity flux and control; all of the other variables, including the variable selected in the first discriminant analysis (Prpn. Reject $10K), failed the selection criteria. Low intensity flux, the variable with the strongest discriminating power, was entered into the stepwise analysis at the first step (min. D-squared = 1.378, pr. = .0033; Wilks' Lambda = .445, pr. = .0000). At step two, control was entered as the next most powerful discriminating variable (min. D-squared = 6.281, pr. = .0003). Wilks' Lambda has decreased substantially (to .142; pr. =.0000), indicating that only a low association among the four groupings of communes remains. The F-test of the differences between each pair of groupings after Step 2 (which range from F = 10.213, pr. = .0003, to F = 91.603, pr. = .0000) shows that there are differences between each pair which cannot be explained by chance.

The rest of Table 5b provides information on the nature and statistical power of the two canonical discriminant functions formed by low intensity flux and control. [The canonical discriminant functions are statistically independent of each other; each is a linear combination of the variables entered in the stepwise analysis—similar to a multiple regression equation—and should be thought of as a latent variable (not measured directly), a statistical artifact comparable to a factor constructed by factor analysis.] Comparing the statistical information on the

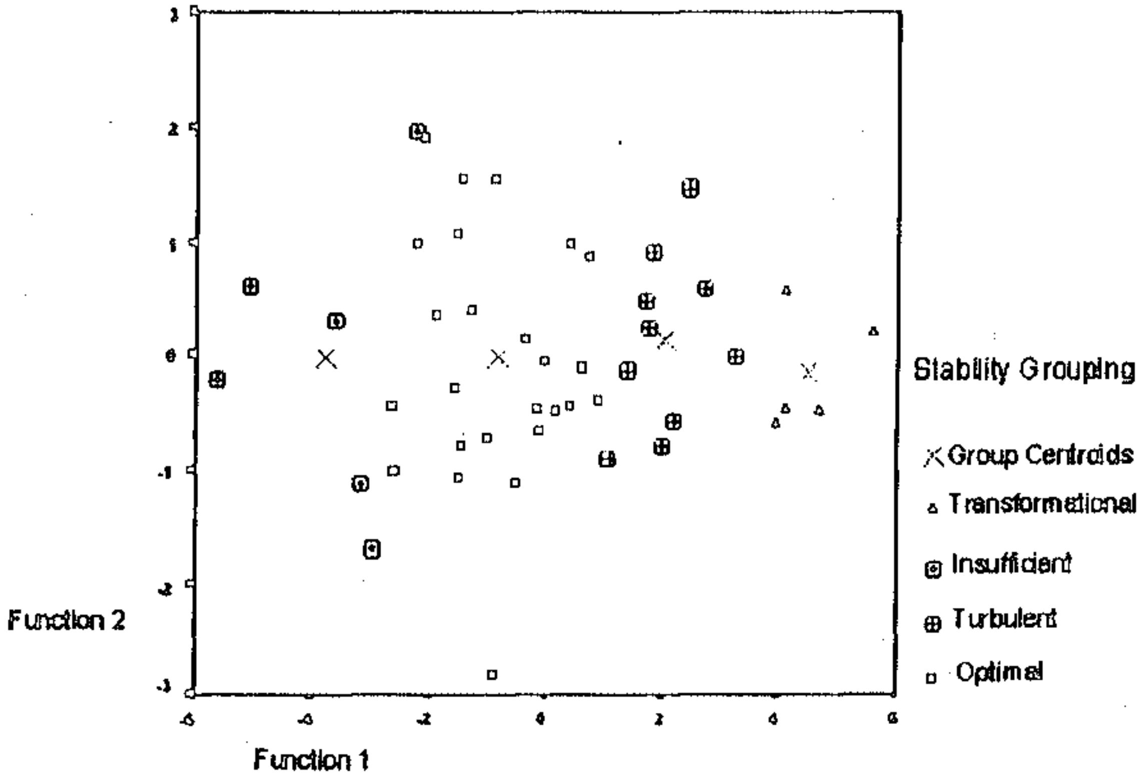

Figure 8. Plot of Stability Groupings of Communes by Canonical Discriminant Functions.

two discriminant functions shows that the first function possesses much greater discriminating power than the second function. The canonical correlations are .926 and .085, respectively, and indicate that the first function possesses most of the discriminating power, approximately 86% compared to 0.70% (squared canonical correlation = .857 and .007, respectively). This is confirmed by the huge difference in the eigenvalues for the two functions, 5.988 versus 0.007.

Table 5b also presents the unstandardized canonical discriminant function coefficients which were used to compute discriminant scores (one for each discriminant function) for each case. The two discriminant scores were then used to classify individual cases into one of the four stability groupings of communes established prior to the discriminant analysis. Comparing the a priori grouping to the posterior classification provides a means of determining the predictive power of the two discriminant functions in correctly assigning cases.

The results in Table 5c show that the two discriminant functions were able to correctly predict the stability grouping for each commune in 45 of 46 cases, an overall success rate of 98%. Thus, five (83%) of the six communes belonging to the unstable-insufficient category were correctly classified, all 25 (100%) of the communes belonging to the stable-optimal category were correctly classified, all 10 (100%) of the communes belonging to the unstable-turbulent category were correctly classified, and all 5 (100%) of the communes in the stable-transformational category were correctly classified. Moreover, these prediction rates are substantially higher than the prior probabilities of commune membership in these groupings (0.13, 0.54, 0.22, and 0.11, respectively; see Table 5c). A plot of the communes on the two discriminant functions (see Figure 8) shows that the two discriminant functions reproduce virtually the same pattern and clusterings of the four groupings of communes, as was observed in the scatterplot of their (raw) values on low intensity flux and control (see Figure 7, above).

The third discriminant function analysis entailed a replication of the second analysis, but using the measure of high intensity flux in the place of low intensity flux; space constraints permit only a narrative presentation of the results. Repeating the stepwise multivariate discriminant analysis (conducted as just described above) on the nine sociological variables plus high intensity flux and control, produced almost the same results but with one difference: this was the selection of the variable Prpn. Reject $10K (the mean proportion of members who say they would not accept an "offer of $10,000 to leave" the commune) along with high intensity flux and control in the stepwise procedure; all of the other variables failed the selection criteria. Control had the strongest discriminating power and was entered first (min. D-squared = 0.334, pr. = .2976; Wilks' Lambda = .589, pr. = .0001); high intensity flux entered second (min. D-squared = 2.125, pr. = .0118; Wilks' Lambda = .196; pr. =.0000); and Prpn. Reject $10K entered at the third step (min. D-squared = 3.734, pr. = .0025; Wilks' Lambda = .160; pr. =.0000). The reduction in Wilks' Lambda suggests that a good portion of the association observed among the four groupings of communes had been removed, and the F-test of the differences between each pair of groupings after Step 3 (which ranged from F = 5.682, pr. = .0025, to F = 43.844, pr. = .0000) indicates that differences between each of the pairs of groupings were statistically significant. Finally, three canonical discriminant functions were constructed (canonical correlations = .900, .317, and .257; eigenvalues = 4.237, 0.112, and 0.071, respectively) which correctly classified 41 (89%) of the 46 communes into their four a priori groupings. However, only for the stable-transformational grouping (N = 5) were all communes correctly classified.[16] The selection of Prpn. Reject $10K (a measure of commitment) in the presence of high intensity flux is notable, for it suggests that regulation of the enormous potential energy activated during radical change requires strong individual commitment buttressed by a system of hierarchical controls.

4.7. *Validation Studies*

To check the primary results, two validation studies were conducted: one to verify that the results were not an artifact of the operational procedures used to measure control; the second to check the reliability of the results from the discriminant analysis. Again, space constraints permit only a narrative presentation of the results.

For the first study, we conducted a further discriminant analysis in which we substituted the values for the seven individual asymmetric triads types of power relations in each commune for our measure of control. Adding these variables to low intensity flux and the other nine variables used above meant that a total of 17 variables were submitted to the stepwise analysis. Four variables were selected for inclusion: one was low intensity flux and two were triad types from our measure of control (the 021D and the 030T); the fourth variable was the 003 (vacuous) triad type. While all of the other variables failed the selection criteria, the 021C triad type (the third triad in our measure of control) only just missed the significance level of the F-test to enter with a pr. of .067; the criterion for entry was pr. ≤.050.

The four variables selected achieved a reduction in Wilks' Lambda from .445 (pr. = .0000) at Step 1 to .130 (pr. = .0063) at Step 4, indicating that most of the association observed among the four groupings of communes had been removed. Also, the F-test of the differences between each pair of groupings after Step 4 (which ranged from

$F = 4.225$, pr. = .0063, to $F = 37.3879$, pr. = .0000) suggests that the differences between each pair were statistically significant. Finally, the three canonical discriminant functions constructed[17] were able to correctly classify 44 (96%) of the 46 communes into their four a priori groupings. Based on the individual asymmetric triad types, these results are broadly comparable to those we obtained above, and suggest that our findings do not appear to be an artifact of the construction of our measure of control.

For the second validation study, a split-sample analysis was performed. This was done by randomly dividing the 46 communes into two samples of 23 cases each, replicating the stepwise multivariate discriminant analysis (conducted as described above) on the nine sociological variables plus low intensity flux and control, and using the discriminant functions constructed on the first-half sample to predict the classification of cases in the second half-sample into the four a priori stability groupings of communes.

As before, the only variables selected in the stepwise analysis of the first-half sample were low intensity flux and control; all of the other variables failed the selection criteria. Also, low intensity flux had the strongest discriminating power and was entered at the first step (min. D-squared = 0.882, pr. = .1242; Wilks' Lambda = .405, pr. = .0005); control entered at the second step (min. D-squared = 6.012, pr. = .0303; Wilks' Lambda = .097; pr. = .0000). The reduction in Wilks' Lambda suggests that most of the association observed among the four groupings of communes had been removed, and the F-test of the differences between each pair of groupings after Step 2 (which ranged from $F = 4.271$, pr. = .0303, to $F = 48.0633$, pr. = .0000) indicates that the differences between each pair were statistically significant. Finally, the two canonical discriminant functions constructed (canonical correlations = .940 and .419; eigenvalues = 7.522 and 0.212, respectively) were able to correctly classify 19 (83%) of the 23 cases in the second-half sample into their four a priori groupings.[18] In short, as a statistical means for testing the veracity of our findings on an independent sample of collectives, these results offer strong corroboration.

Overall then, the results of the discriminant function analysis confirms our conclusion based on more simple statistical procedures: namely, that flux and control are predictive of collective stability.

4.8. Summary of Findings

There are a number of findings established by the results of these analyses. The first is our finding of a strong, direct relationship between the measures of flux and control, at a given point in time, and group survival twenty-four months in the future. There are three aspects of this first finding that are of significance. First, when plotted as a field with low intensity flux on the horizontal ordinate and control on the vertical ordinate, the distribution of communes forms a triangular pattern with a wide base involving many combinations of low values of flux and control, and narrowing progressively to an apex of high values involving virtually a one-to-one correspondence between flux and control. Second, the distribution of communes in this field form alternating bands of unstable and stable groups (that we have labeled as *insufficient-unstable, optimal-stable, turbulent-unstable,* and *transformation-stable*, respectively), suggesting that there are dysfunctional and functional combinations of flux and control. These two aspects of the evidence suggest that the relationship between flux and control is nonlinear. The third matter of significance is that the results of the multivariate discriminant function analysis show that flux and control are strongly predictive of stability; this was true for both measures of flux (namely, low intensity flux and also high intensity flux).

The second finding is that there are big differences between the four stability groupings of communes on the measure of high intensity flux: the *stable-transformational* category ranged from two-times the mean value of the *unstable-turbulent* category to seven-times the mean value for the *unstable-insufficient* category. The presence of the extraordinary amount of high intensity flux was associated with a resident charismatic leader in these groups. This suggests that enormous levels of potential energy are activated in collectives undergoing radical structural change.

A third finding is that there appear to be limits (a lower amount and an upper amount) on the total amount of information generated by flux and control that can be processed by a stable collective. Groups observed outside the limits experienced much higher rates of instability than those that operated within the limits.

The fourth finding is that, with the exception noted below, there is little evidence that the other measures of socio-cultural organization (including ideological orientation, normative regulation, formal organization, structural characteristics, and member characteristics) are associated with stability. This was clear from the results of the bi-variate analysis which found no (statistically significant) relationship between the nine sociological variables investigated and commune location in the region of optimal stability. Moreover, the discriminant function analysis with low intensity flux showed that none of these variables played even an indirect role in predicting a commune's stability grouping. However, the inclusion of both "Prpn. Reject $10K" and control in the discriminant function with high intensity flux suggests that stability requires strong member commitment and a system of hierarchical controls when enormous levels of potential energy are activated, as occurs under the condition of charismatically-inspired radical change.

Although it is possible that some of our measures of socio-cultural organization may not have captured the salient or causally active aspects of such factors, it is most unlikely that all of the measures missed the mark. Either way, this is a question that is best settled by further research.

Finally, the results from the two cross-validation studies provide corroborating evidence for the veracity of these findings. The first study, in checking the validity of our use of three (of seven) asymmetric triad types as a measure of control, found little evidence of a measurement artifact contaminating our results with this operational procedure; it should also be noted that the selection of the three triad types was not arbitrary, but guided by theoretical considerations. The second study, a split-sample reliability study checking the predictive power of flux and control on a random sample of communes, corroborated our original results and confirmed their generalizability.

Overall then, it is reasonable to accept the evidence and conclude that the interaction between the two relational orders of flux and control has direct consequences for the collective's stability. This is consistent with the theoretical expectation based on earlier work that we articulated at the outset: namely, that the interaction between a distributed order of energy activation (flux) and a hierarchical system of social constraints (control) operates to in-form collective function.

5. Part 2: Theory of Communication

In the second part of this work, we aim to show how the interpenetration between flux and control operates as an information processing system to inform the collaboration among members and produce stable, effective collective action. Thus, it is toward an understanding of these dynamics and their implications for collective organization that the following discussion is directed. To this end, we build on the empirical results presented above and draw on the concepts of energy and information from the natural sciences.

5.1. Assumptions

We begin by limiting our task in four ways. First, our interest is restricted to collectives that have an explicit boundary distinguishing members from non-members; our account does not include partially bounded structures such as cliques or open-ended entities such as social networks.[19] Second, we give little direct consideration to the influence that normative elements, such as cultural values, norms, and roles, may have on the organization and behavior of social collectives, and on the conduct of their members. Third, that apart from their potential energy, their biological capacity for physical behavior and social activity, we ignore effects the characteristics (e.g., gender, age, personality etc.) of the collective's members, as individuals, may have on system behavior. The fourth restriction is to limit our focus to the collective's endogenous operations. Here we make the simplifying assumption that, to be exogenously effective, the collective must be stable. Our interest lies in exploring the efficiency of the endogenous processes by which stability is generated, of developing an understanding of which patterns of endogenous organization are optimal for the collective's stability (Coleman, 1990, p.42). We will leave for a later discussion the question of the collective's effectiveness in its environment.

We also have an ontological imperative: namely, that rather than appealing to metaphysical mechanisms of communication (e.g., Bohm, 1980; Durkheim, 1965; Jung, 1969; Laszlo, 1995; Sheldrake, 1981), we aim to develop an account which has its basis in the processes of interaction empirically documented.[20]

5.2. Energy and Least Action

In virtually all social science, energy as the means for action, and the element that makes social organization possible, is not explicitly identified. Instead, it remains as an ontological given, apparently thought to be of little direct importance for understanding social organization (see Turner's, 1986, review of the major sociological theories). In those rare instances when the term "energy" is used by social scientists, it is used as a metaphor (e.g., Collins', 1990, notion of "emotional energy") instead of as a scientific concept.[21]

Ontologically, a rigorous concept of energy, or its equivalent (e.g., Rosenstein, 1997), is fundamental to an understanding of collective organization. Energy is the means—the fuel—for maintaining order in the face of challenge (novelty) or changing an order in the face of inertia. As individual biological organisms, a collective's members possess the potential for work, measured as energy. To exist as an entity, a social collective must mobilize and appropriate the members' potential energy for work—their biological capacity for physical behavior and activity—and direct it toward collective ends. As noted above, energy is also the medium for information processing, the medium for encoding and relaying communications as signals back and forth among the elements of a system.

In the physical and biological sciences, energy is a measure of an amount of (physical) work that can be accomplished (McFarland, 1971). Two types of energy can be distinguished: kinetic and potential. When work is actually being done in maintaining order or in producing change, it is defined as kinetic energy; the measure is directly proportional to the amount of kinesis, that is, to the amount of physical activity required to maintain order or to produce change. Potential energy is inferred from an estimate of the amount of possible work that a situation provides. It is an inference based on similarity to conditions which have previously been observed to transform potential energy into actual work.

In most physical and biological systems, there is a tendency to minimize work in order to conserve energy. This is known as the least action principle,[22] or the system's Hamiltonian unction. In its general formulation, the principle holds that a system is at equilibrium under conditions which maintain potential energy at a minimum (Considine, 1976, p. 1,454). This means that any departure from equilibrium—any disequiliberating change in the system's structure—creates potential energy. In order to return to equilibrium, the system must expend the potential energy by performing work to use it up. A least action path (one that is optimal for the system) is determined by piece-wise subtraction of potential by kinetic energy. Thus, potential energy is reduced through a series of successive fluctuations between potential and kinesis until its minimum level is reached.

Such changes in levels of potential energy have been studied in the natural sciences and have resulted in dynamic systems models—so-called "chaos theory" (Morrison, 1991; Nicolis & Prigogine, 1977; Strogatz, 1994). These models have enjoyed wide success in accounting for the behavior of far-from-thermodynamic-equilibrium systems in the natural sciences (e.g., Kauffman, 1993; Prigogine & Stengers, 1984), and have sparked a growing interest in psychology (Abraham & Gilgen, 1995; Barton, 1994; Pribram, 1991; Robertson & Combs, 1995), economics (Brock, 1986; Arthur, 1989), and sociology (Bradley, 1987; Dendrinos & Sonis, 1990; Morgan, 1986).

In applying these concepts, we assume that the members of the social collective are biologically capable of work, and that this capability is measurable as potential energy. When activated by the collective, the members' potential energy becomes engaged in social interaction. To realize collective action entails work; work is measured as kinetic energy. The tendency to energy conservation leads the collective to strive towards an efficient use of energy. This requires effort to explore alternative paths towards order, patterns of actualization that allow collective work to proceed efficiently, that is, with the least amount of dissipation (Pribram & McGuinness, 1975). For instance, Henry Ford experimented with different ways of joining together the energy of his factory workers to find the maximally efficient structure of *co-laboration* for manufacturing cars (Lacey, 1986). To do this, he implemented a set of social constraints, based on his invention of the production line and its associated techniques of mass production, that directed and thus optimized the action paths among the collective of workers. Thus, he produced automobiles at minimum cost which, in turn, proved effective in the market place.

5.3. Flux and Control

Within this framework, two processes can be identified which act to generate descriptions of the collective's internal organization and thus inform collaborative interactions among members. The first is flux, the constant transformation of energy throughout the collective. The second is control, the construction of a system of social constraints which efficiently directs the transformation of potential energy into collective action. As described below, the system of controls determines a communication processing network that in-forms the patterns by which the potential energy is actualized as collective work.

The transformation of potential energy to kinetic energy, flux, occurs in the field which, as already noted, is established by membership in the collective and forms a distributed, massively parallel social web of equi-valent relations connecting all individuals to everyone else. The field operates to unify and activate affective attachments among individuals, arousing each member's emotions and thus their potential energy, their propensity for action. As an undifferentiated network of connections extending throughout the collective, the field is the order through which all transformation of the collective's energy is processed. The energy transforms continuously throughout the field as the collective adjusts and readjusts continuously to internal and external changes.

In the absence of other factors, initial conditions such as negative feelings like fear, hatred, or jealousy, will block the efficient conversion of potential to kinetic energy; in non-linear dynamics such systems are characterized by negative Liapunov exponents leading to stasis, ossification (complete thermodynamic equilibrium) or to regular fluctuations described by relaxation oscillators (Abraham, 1991). On the other hand, as elaborated below, initial conditions such as mutual admiration, awe, or love create a kind of harmonic resonance (due to a positive Liapunov exponent) in the relations among members which will enhance the conversion of potential to kinetic energy, a phenomenon Zablocki (1971; 1980) observed in his studies of communes and called the "cathexis effect." The danger here, if this enhanced kinetic energy is unconstrained, is that undue dissipation of energy will ensue: in the language of non-linear dynamics, chaos will result (for examples, see Zablocki, 1980, Figure 4-5, pp. 165).

The second process is control, a system of social constraints that operates on the transformation of potential energy to prevent undue dissipation of kinetic energy. The system of controls influences the conversion of potential to kinetic energy by constraining the spatial and temporal direction of the paths of flux thereby in-forming, literally, giving shape to,[23] the collaboration among individuals. This operation is achieved by the hierarchical order which, as described above, is a densely interlocking stratified system of asymmetrical relations connecting all individuals. By differentially constraining the paths in space and in time by which individuals expend their energy, the controls render an informed pattern of collective organization. For example, to maintain social and, hence, physical stability while running white water rapids, the crew of a river raft must know, at each moment, the pattern of their interactions and how these are coordinated as co-laborations with respect to the raft's location in the river. In addition, the crew must also determine which of several alternative paths of action affords them the greatest likelihood of a safe trajectory down the river. As described below, the coupling of the movement of energy mediating the endogenous interactions (flux) with a system of hierarchical constraints (control) creates a communicative structure that informs collaboration and results in a stable, effective collective.

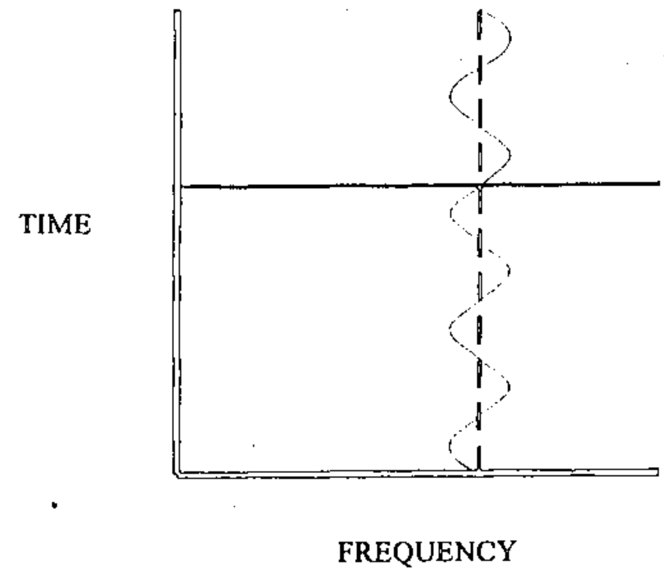

Figure 9. Limits of Concurrent Measurement of Time and Frequency of a Signal (Adapted from Gabor, 1946, Fig. 1.3).

5.4. *Information and Communication*

Surprisingly, given the rich, dense flow of verbal and nonverbal signals that comprise human interaction, information is rarely used as a rigorous concept in social research; in three recent influential works (Burt, 1992; Coleman, 1990; White, 1992) it is employed as an undefined term. Irrespectively of whether the term is explicitly defined (e.g., Rogers & Kincaid, 1981, pp. 48–51) or not, its use in social science corresponds to Claude Shannon's (1949) concept of information, that is as a reduction of uncertainty through choice among alternatives. In this conception the smallest unit of information is the BIT, the BInary digiT, nowadays corresponding to the smallest standard unit of information in computational information systems. Shannon's concept applies to computation-based communication systems. In these systems, each unit of information in a sequence contributes to resolution of the signal's message by reducing the probability of alternative meanings. For instance, in computer hardware, each pulse represents the "on" state of a binary code (no pulse = "off") so that the pulse, as the smallest unit of information, is a BIT.

However, it is clearly apparent that our primary empirical finding, that information in social collectives appears to be produced by the interaction between a distributed order of energy activation and expenditure (flux) and a system of hierarchical constraints (control), is neither describable nor explicable within the terms of Shannon's concept of a reduction in uncertainty. Accordingly, to show how the interaction between flux and control acts as a communication system, we draw on Nobel Laureate Denis Gabor's concept of information (Gabor, 1946). Although virtually unknown in the social and psychological sciences, Gabor's concept is radically different than, though related to, the more commonly used measure of information developed by Claude Shannon (1949).[24] While Shannon dealt with a reduction in uncertainty, Gabor designates the minimum uncertainty beyond which a message cannot be compressed. In what follows, we briefly describe the conceptual and mathematical basis of

Gabor's concept and then go on to show its application to information processing in social collectives.

In his classic article, "Theory of Communication," Gabor (1946) defines a unit of information as the minimum uncertainty with which a signal can be encoded as a pattern of energy oscillations across a waveband of frequencies, as in the encoding and transmission of vocal utterances for telephonic communication. Gabor determined that there exists a restriction to the efficient processing and communication of a set of telephone signals. The restriction is due to the limit of precision that can be achieved in concurrent measurements of the signal's spectral components (frequency, amplitude, and phase) and its (space) time epoch. This restriction is illustrated in Figure 9 in which time and frequency are treated as orthogonal coordinates. Although the energy frequency of a signal, represented by a dashed vertical line, is exactly defined, its duration in time is totally undefined. Conversely, a sudden surge or change in the signal (a unit impulse function) shown as the solid horizontal line, is sharply defined in time, but its energy is distributed evenly throughout the whole frequency spectrum. Since, at the limit, accurate measurement of the signal can be made only in time or in frequency, it cannot be simultaneously made in both beyond this point (Gabor, 1946, pp. 431–432).

Gabor was able to show, mathematically, that this limit could be given formal expression by Heisenberg's uncertainty principle.[25] In its rigorous form the uncertainty relation is given as $Dt\ Df \geq ½$ (where D = delta), which states that time (t) and frequency (f) cannot be simultaneously defined in exact terms, but only with a latitude of greater than or equal to one-half in the product of the uncertainties. Since certainty can be obtained only by minimizing uncertainty on both ordinates, the minimum measurement of the signal in time and frequency is Dt Df = ½, which defines an elementary unit of information (Gabor, 1946, pp. 431-437).

Gabor called his unit a *logon*, or a quantum of information, and showed that the signal that occupies this minimum area "is the modulation product of a harmonic oscillation (of energy) of any frequency with a pulse in the form of a probability function" (Gabor, 1946, p. 435; our addition). Mathematically, this unit is a sinusoid variably constrained by space-time coordinates, essentially a space-time constrained hologram (see Bradley, 1998a or 1998b).[26] This elementary unit of information both minimizes uncertainty and provides the maximally efficient compression of communication—the minimum space or time of transmission occupied by the signal which still maintains fidelity in telecommunication. In essence, Gabor's concept is that of information as the product of interaction along two distinct dimensions: 1) an energy dimension measured (in physics) in terms of frequency times Plank's constant, and 2) a space-time constraint (either Gaussian or rectangular).

The Gabor elementary function, as it is often referred to, has been found to characterize perceptual processing in the neural connection web, that is the interaction between horizontal dentritic networks and vertical axonal transmission pathways, for several sensory systems in the cerebral cortex (see Pribram, 1991, Lectures 1-5, for a review of the evidence).[27] There is also sociological evidence, from the work on speech convergence and accommodation, of an energic system of nonverbal information transmission operative in human social interaction (see the review by Giles & Coupland, 1991, and especially the studies by Gregory and his associates: Gregory, 1983; Gregory, 1990; Gregory & Hoyt, 1982; Gregory, Webster, & Huang, 1993). For instance, in a recent study of 25 dyadic interviews between a talk show host and his guests, Gregory and Webster (1996) found evidence of a low frequency (beneath 0.5 kHz) nonverbal signal in the energy spectra of vocal communication that appears to carry

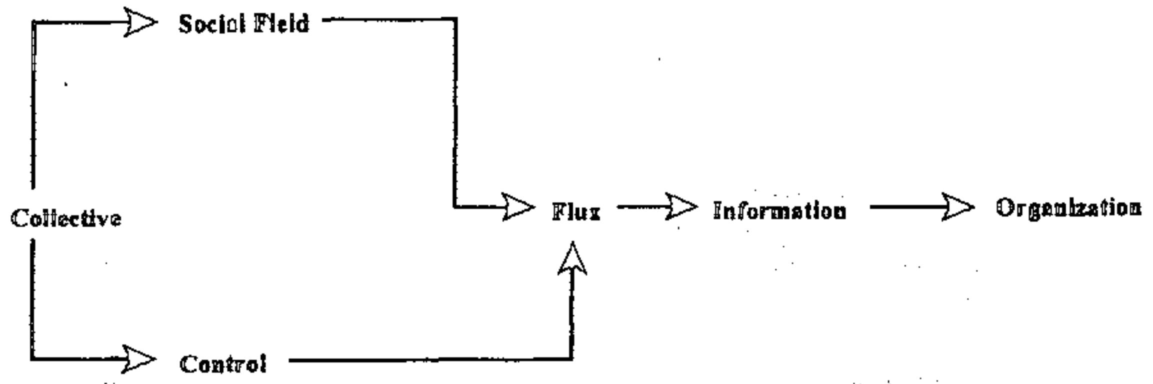

Figure 10. Logic of Theoretical Model.

encoded information about the relative social status of the individuals involved.[28] Such an energic nonverbal communication system may be better understood within the terms of Gabor's concept than Shannon's.

Evidence with direct bearing to the present work are two findings from Bradley's (1987) study of 57 social collectives. The first finding is that of a non-localized order of relations of positive affect in which information about the collective's global organization appears to be enfolded and distributed to all individuals; the second is that this holographic-like order was found to be coupled to a system of power relations (see Bradley, 1987, Chaps. 8 and 9; Bradley & Roberts, 1989a; 1989b). This coupling of a distributed order of affective energy to a constraint system of power relations is not describable as an information processing system within the terms of Shannon's concept; however, it is readily understood as such with Gabor's concept.

We should now be in position to apply Gabor's concept—of information as the product of the interaction between an order of energy oscillation and a system of spatio-temporal constraints—and show how the interaction between flux (a field of energy movement) and control (a system of hierarchical constraints) operates as a communication system in the collaboration among members to inform the expenditure of energy and produce collective order. The symmetric bonds of the distribution of energy indicate that individuals are essentially interchangeable so that there is a more-or-less equivalent patterning of flux throughout this field. By contrast, because individuals are asymmetrically connected in the hierarchical order, the system of controls operates differentially on the collective's members, both with respect to their energy expenditure at a particular location in space as well as with respect to its actualization in particular moments of time.

Drawing on Gabor, it is expected, therefore, that the operation of hierarchical controls on the distribution of flux (Figure 10) generates information as a moment-by-moment, quantized description of the collective organization in terms of both structure (spatial-temporal position) and flux (distribution of energy). By providing a succession of descriptions within space-time and spectral coordinates, units of information are constructed and communicated throughout the collective. Thus the information exchange that characterizes the endogenous order, as it continuously evolves in an on-going series of interactions, can be described as quantized. Because, by virtue of its spectral nature, each Gabor unit, each quantum of information anticipates the unit that succeeds it, each "contains information" about the future potential order of the collective (Bradley, 1997; Gabor, 1946, p. 437).

However, whenever there is an imbalance between the amount of distribution of flux and the amount of control, quantization breaks down, resulting in a lowering of information transmission. The reduction in information transmission impairs the efficient operation of the collective which, in turn, increases the likelihood of instability. This impairment is due to what Ashby (1956) characterizes as the necessity for "requisite variety" in cybernetic (information and control) systems.

5.5. An Example

Musical notation is an example of a Gabor-like energic communication system that operates to inform the collaborative interactions of a musical (social) collective such as an orchestra, a band, or a choir. An individual "note" can be viewed as a direct analogue of a logon. It is composed of data "plotted" in a (written) musical score on the same two orthogonally-related dimensions as a logon: one dimension is frequency, the major determinant of pitch, varying oscillations of sound waves (energy vibrations) produced by the operation of a musical instrument; the second dimension is time, how long the note is to be played. The second dimension is signified, in part, by the tempo (e.g., allegro or largo) at which the piece is to be played, and in part by the notation of the duration of each note (an eighth or a sixteenth, etc.). The pattern of energy expenditure by which the music is actualized is prescribed on a musical score as a moment-by-moment sequence of operations on the musical instrument, for each musician, specified both in frequency and in time. Moreover, the score for all musicians contains a spatial component as well: it also specifies which subset of musicians, in relation to the whole orchestra, is to play at each moment. Thus a composer's written musical score represents a description of how the potential energy of a collective of musicians is translated into expenditures of energy, differentiated for each individual on the dimensions of frequency and time-space, to actualize a given composition as "music."[29]

This example of musical collectives suggests that there are limits to normative regulation of this kind of information processing. At one extreme is the written musical score—the composer's moment-by-moment prescription for each action by every musician on the two dimensions of frequency and time-space, a formalized embodiment of the ultimate level of normative regulation. Sociologically, this is equivalent to formal (social) organization, like a bureaucracy. At the other extreme, it is clear that certain minimum normative specifications on the two dimensions are also necessary for communication within more informal social collectives, such as jazz bands. At minimum, the jazz band must specify (normatively define) the "key" (the progression of harmonic frequencies to be used) and specify the "time signature"(the number of beats per measure of time) in order to improvise effectively in their construction of "music." As Barrett (1998, p. 20) notes, such "minimal constraints," or what jazz artist Herbie Hancock calls "controlled freedom" (Berliner, 1994, p. 341), create a stable collaborative order of constantly evolving interaction.

The example indicates, as noted, that the way that this kind of information processing allows individuals to "anticipate" future collective order is derived from the harmonic order implied in the oscillation of energy at different frequencies (Bradley, 1997). By defining the progression of musical frequencies that can be played by any member at any given moment, the key defines the set of optional structures within which our jazz band's behavior must be organized to produce coherent order, or "music."

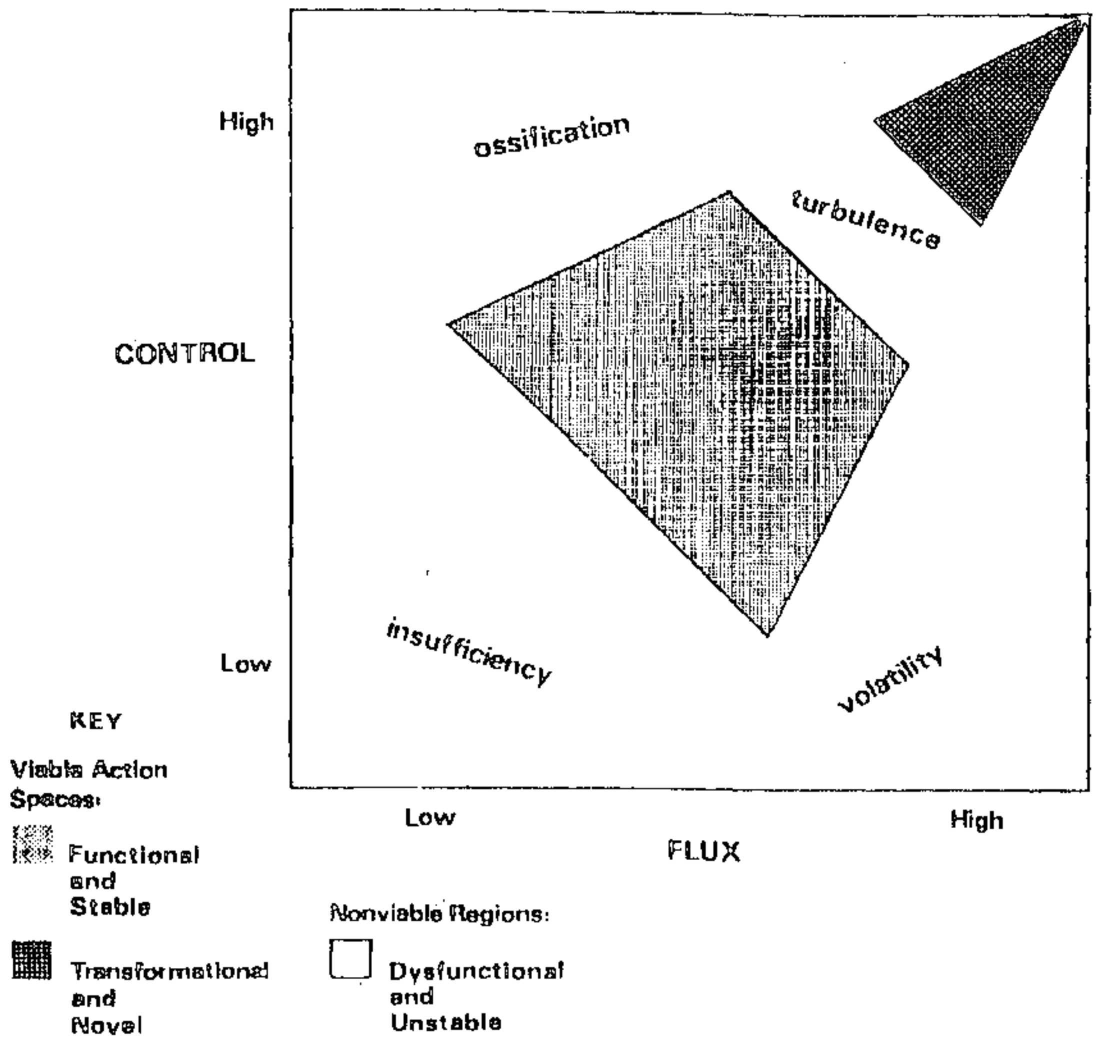

Figure 11. Model of Endogenous Communicative Structure and Action States of Collective Organization.

> When (jazz) musicians abandon the melody as a model for invention ... they depend on the progression's salient features as signposts for the improvisation's "progress." Moreover, the syntactic implications of harmonic structures assist artists in their endeavor. Once they cultivate a "feeling for form, the form will guide you; it will almost play itself" [Berliner, 1994, p. 173; our addition].

Thus, future action for the individual musician is informed by the implied subset of combinations of (musical) frequencies that are harmonious, consistent when combined with those produced by the other musicians, and which will when actualized, therefore, create coherent sequences of (musical) interaction. It is our expectation that such "anticipated order" is characteristic of such energic communication in all social collectives. And while our concern has been confined to human social collectives, it is likely this may extend to communication involving the moment-by-moment anticipations of order in rapidly moving animal collectives like shoals of fish and flocks of birds (Bradley, 1997).

6. Communication to Action

Drawing on the empirical results and the theory of communication presented above, a theoretical model is constructed that shows how distinctive states of collective order are produced by the collective's communicative structure. This was done by linking different levels of the communicative structure's operation to a phase space of potentials for collective action (see Figure 11).

6.1. Theoretical Model of Endogenous Communication

In the terms of the model, the communicative structure is formed by the interpenetration of networks of endogenous relations organized along two dimensions in which the values allocated in each dimension define points within a social field (Bradley and Roberts, 1989a). The values ascribed to the horizontal dimension represent flux, the amount of activation of potential energy in a social collective. The values ascribed to the vertical dimension represent the amount of control (the degree to which individuals are interconnected by a transitively ordered network of relations) exercised at that location.

The coordinates representing the dimensions bound a phase space within which each value represents an amount of information in Gabor's terms that characterizes the communicative structure and informs the collective's energy expenditure. Thus each unit of information, a different configuration of flux and control, is associated with a corresponding potential for collaboration among members and, hence, stability in their collective action.

6.2. States of Order

Two regions of action can be distinguished within the phase space (Figure 11). One of these is a stable region of collective organization associated with efficient patterns of communication; it is comprised of two subregions (functional and transformational) that are separated by an area of turbulence and instability. The second is an unstable region in which the minimum values for efficient communication are not met so that various forms of collective dysfunction result. The regions are separated from each other, marked, in the terms of non-linear dynamics, by a phase transition from psycho-social instabilities to (far-from-thermodynamic-equilibrium) psycho-social stabilities in collective organization (Prigogine & Stengers, 1984). The region of stable collective order represents, therefore, a qualitative change in psycho-social organization.

6.2.1. Instability and Dysfunction

In the unstable region, the patterns of potential energy and control are either unable to establish or unable to sustain viable forms of collective organization. Values of low potential and low control (the area labeled as insufficiency in Figure 11) fail because, in addition to a certain minimum of kinetic energy, stability also requires at least a minimum of direction be given to that energy. This direction comes from the interpenetration of flux and control which informs the paths by which kinetic energy is expended in social organization. Viable organization (patterns of effective collaboration) thus requires, at minimum, a linkage to each individual on these two relations. Without this, a new collective could not be created or founded, and an existing organization would devolve into a loose aggregation of disjointed cliques and isolated individuals unable to communicate and, consequently, work together as a functional, socially autonomous entity. Two other combinations are also expected to produce instability. Coordinate values representing high control and low potential energy (labeled ossification in Figure 11) delineate a rigid organization in which insufficient flux is available for social communication. The lack of communication means that the paths to organization are fixed, not adequately informed by the ontological reality of current circumstances, and are therefore unable to adapt as the situation changes.

At the other extreme, combinations of high potential energy and low control (labeled volatility in Figure 11) delineate a turbulent situation in which little of the enormous flux is guided by hierarchic controls. Communication is inadequate as insufficient information about the ever-changing situation is distributed.

6.2.2. *Stability, Innovation, and Transformation*

The region of dysfunction surrounds the region of stable organization which is centered along a main diagonal of the phase space, and which, as noted, embodies a qualitative change in psycho-social organization. The phase transition from dysfunctional to viable collective forms (which includes the area of turbulence between the two stable subregions) is described by fluctuations in potential and control which end in a point where the patterns of energy activation and expenditure no longer dissipate into the environment (no longer average out to equal the energy levels of the surrounding context) but coalesce, under the normative constraint of a membership boundary, to crystallize as an emergent collective order. To defy the tendency toward entropy (disorder) and sustain a viable, stable order requires minimizing the fluctuations by linking the activation of potential to the control operations so that the energy expenditure of all members is informed in relation to the collective's action. Thus, in terms of the data presented in Figure 1, viable organization requires a certain minimum of flux and a certain minimum of control: a network of reciprocal equivalent connections linking every individual to at least one other person; this order must be coupled to a transitive network of asymmetric relations linking the energy expenditure of each individual to that of at least one other person.[30]

The lower and upper boundaries of this stable region define the values representing efficient information processing. This region is consistent with the evidence from studies of the interactional dynamics of infant and child development (Schore, 1994; Hinde, 1992, respectively; see above page 34), and it also is consistent with the thermo-dynamically inspired connectionist models of neural networks (e.g., Hinton & Sejnowski, 1986; Hopfield, 1982).

In such models, efficient pattern matching is found to occur in a region between total randomness and total organization: in our terms, between rapid flux and rigid control. The relation of flux to control narrows from many degrees of freedom at the low end of the space, to an almost one-to-one correspondence at the high end. There is a progressive narrowing of optional structures for stable collective organization based on the increasingly close articulation between flux and control. Thus, the shape of the space of stable collective function is triangular.

Figure 11 also shows that this space can be subdivided into distinct types of collective order: functional and transformational. The transition from one subregion to another is not gradual but involves a qualitative change; distinct types of communication can be defined. In between the subregions is a phase transition characterized by turbulence and instability. Each subregion is composed of different combinations of flux and control so that a collective can only have one of these patterns of communication at any given time. Furthermore, there is considerable difference in organizational effectiveness and vulnerability to collective dysfunction between the patterns constituting the subregions.

At the low end of the functional subregion, the range of combinations of flux and control is great and there are thus many different viable patterns of communication possible. As a result of this loose articulation between flux and control, communication tends to be effortless but minimally efficient. The pattern of communication here fits best with routine organization, that is, collective function involving simple activities or the repetition of an invariant structure of operations in an environment marked with little change.

At the high end of the functional subregion, there is a close articulation between flux and control so that the patterns of information processing tend to be optimal—maximally efficient—and give rise to highly dynamic yet stable patterns of organization. The densely knit, closely coupled horizontal and hierarchical networks of flux and control operate to produce fast, continuous information processing. Because all information is distributed continuously to all points throughout the collective, aspects of these data can be processed (combined and reviewed) by any member(s) in many different ways. Thus, in this market-like order of communication, a member at any location can be the point of origin for a different or a new pattern of social organization. This is the communicative structure of innovative organization, a highly flexible, adaptive structure of almost constantly changing patterns of energy expenditure responding to a rapidly evolving social context (Roberts & Bradley, 1991; Roberts & King, 1996).

Beyond this, at the apex of the viable region, is a small subregion (labeled transformational in Figure 11), separated from the functional subregion by a turbulent gap, defined by an almost one-to-one relationship between flux and control. To assure stability here a tight coupling between the two must be maintained, a not-so-easy task: the greater the flux, the more control must be exercised and vice versa, taking much effort (Bradley, 1987). Often, when such an effortful course is in operation, a sudden organizational spasm occurs. The spasm has two possible outcomes. One is a structural transformation in the pattern of information processing, resulting in total reorganization to create a novel, qualitatively different collective. The other is structural devolution—implosion—the complete breakdown and collapse of the collective as a viable organization (Bradley & Roberts, 1989a; Roberts & Bradley, 1988; Zablocki, 1971).

7. Conclusion

Prigogine (Nicolis & Prigogine, 1977; Prigogine & Stengers, 1984; Prigogine, 1997) has shown that the persistence of stability in far-from-thermodynamic-equilibrium systems such as biological collectives is exogenously dependent upon an unbroken supply of energy from the collective's environment; this, of course, is also true of a functioning social collective. However, because we have focussed here on the organization of the energy that has become endogenously available, our model concerns the social collective's internal structure.

This internal structure is conceived to be based on the biological potential of the individuals composing the collective to engage in physical work, measured as energy. When activated by the collective, this energy is made available for social interaction as a field of potential energy. We have labeled this dimension of the endogenous order "flux." In the other dimension, individuals are connected hierarchically. We have labeled this dimension "control" because it appears to direct and regulate the activation of the collective's energy. Controls over the activation and distribution of flux result in social communication by way of quantized (logonlike) units of information which become distributed throughout the collective. Each unit of information enfolds a holographic-like description of the collective's endogenous organization. Thus the interpenetration between the two orders operates as a communication system that informs the moment-by-moment expenditure of energy to create stable patterns of collective organization.[31]

Different states of collective order are produced by different levels of the communicative structure's operation. Functional (and thus stable) organization requires a certain minimum of energy and also that a minimum of direction be given to the expenditure of that energy: that all members are interconnected by at least one bond of flux and one relation of control. If these minimum values for communication are not met, dysfunction results and nonviable or unstable states of order are created.

Beyond the threshold of these minima, the range of low values for stable organization narrows progressively from many different loosely coupled combinations of flux and control to close coupling between high values of flux and control. When communication is minimally efficient, the former fits best with the simple or repetitive activities of routine organization. On the other hand, when the amount and speed of information processing is maximally efficient, the pattern of communication corresponds to the constantly changing pattern of energy expenditure that characterizes innovative organization.

There is a discontinuity in the values defining functional organization, giving rise to a pattern of extremely high values that create the potential for structural transformation. When energy expenditure is maximized thus, stability is problematic and requires an equivalent level of control: a tight, one-to-one coupling between flux and control.

The efficiency of the internal dynamics, and its relationship to the collective's action, was found to display an optimal (energy conserving) combination of flux and control which is associated with stable collective action. Our empirical results thus show that for the group to survive as an effective working unit, an efficient communicative structure was required. Only those configurations that produce a path of least action, one which entailed the smallest amount of turbulence, resulted in a stable, efficient collective.

We began with a simplifying assumption that stability can be identified with survival. Unless the collective remains a stable, durable social entity, there is little to enquire about. Thus in order to understand how stability is accomplished, we have restricted our concern to the structure and internal dynamics of the collective, and have left aside, for the moment, its behavioral effectiveness as a system operating on its environment. We are now investigating the possibility that less stable collectives, such as charismatic organizations, are more effective under certain limited conditions—say, for achieving radical transformation (Roberts & Bradley, 1988)—than hyperstable organizations like bureaucracies.

Appendix
Summary Statistics for the Measures of Flux, Control, and Stability ($N = 46$ communes)

	Mean Dyadic Density[1]	*Triadic Structure (Mean Proportions)* *Symmetric Triad Types* 003	102	201	300	Total
Flux						
Loving (L)	.44	.260	.341	.208	.192	1.001
Improving (I)	.46	.232	.348	.224	.196	1.000
Exciting (E)	.17	.622	.285	.067	.027	1.001
Low Intensity Flux:						
Mean (L, I, or E)	.36	.371	.325	.166	.138	1.000
High Intensity Flux:						
Mean (L AND I AND E)	.11	.738	.201	.046	.015	1.000

		Asymmetric Triad Types 003	012	021D	021U	021C	030T	030C	Total
Control									
Power	.30	.097	.261	.137	.113	.129	.243	.020	1.000

Stability
Survival status, Time 1 - Time 5 (12 month intervals)

	T1 *1974* N	%	*T2* *1975* N	%	*T3* *1976* N	%	*T4* *1977* N	%	*T5* *1978* N	%	*Total* N	%
Survived	46	100	35	76	29	83	24	83	22	92	22	48
Disintegrated	0	0	11	24	6	17	5	17	2	8	24	52
Total	46	100	46	100	35	100	29	100	24	100	46	100

Note: [1]Number of relations of a selected dyad type/all possible relations. For the three indicators of flux (*loving, improving*, and *exciting*) the numerator was the number of relations formed as a dyad of positively reciprocated relations (i.e., both *i* and *j* answered "yes"); for the indicator of control (*power*) the numerator was the number of dyads for which an asymmetric ordering was evident in the relationship between I and J (i.e., either *i* had greater power in the relationship than *j*, or *j* had greater power than *i*).

Notes

1. Carley's (1991) work is no exception in that it is based upon computer simulations of the distribution of "information" by "individuals" in artificial small social "groups."

2. There is much empirical evidence that these two dimensions of order are the basis for stable organization at the neurobiological, neuropsychological, psychological, and the sociological levels of behavior (see Pribram & Bradley, 1998).

3. The sociograms in Figure 1 were constructed from sociometric enumeration of all possible pair-wise relations (dyads) in which each adult member was asked a set of standardized questions about his/her relationship with each other member. See Bradley (1987) or Bradley & Roberts (1989b) for further details.

4. As discussed elsewhere (Roberts and Bradley, 1991), the word "collaboration" is derived from the French verb *collaborer* and means "working" *laborer* "together" *col* to achieve a common objective or outcome. This conception is similar to Piaget's (1965/95) concept of cooperation, "a system of (reciprocal) operations carried out in common" (p. 153).

5. Three communes from the original sample were not included as membership in these groups was not completely voluntary (for more detail on the methods of the original study, see Bradley, 1987, and Zablocki, 1980).

6. The restriction of the measure to include only mutual responses (i.e., both *i* and *j* answer "yes") conforms to Bradley and Roberts' (1989b) imperatives for sound sociometric measurement. In an empirically-based analysis of the operational procedures routinely employed by networks researchers, they have shown that the inclusion of nonreciprocated responses (where *i* says "yes" and *j* says "no" or "no answer", or vice versa), when measuring the presence of a relation, introduces measurement error and results in spurious images of network structure (Bradley & Roberts, 1989b, especially pp. 119–122).

7. The wording of the "power" question ("Even the most equal of relationships sometimes has a power element involved. However insignificant it may be in your relationship...") was deliberately designed to encourage a response from respondents after extensive field testing with other forms of wording failed to illicit the hierarchical ordering consistently observed among members in the communes used for pilot testing the study's instruments.

8. Validation for this measure of control is offered below when the results of a discriminant analysis using all seven triad types are presented.

9. Although the communes ranged in group age from three months to nine years at Time 1, there is little evidence that "period effects" (differences in group age at the time data collection commenced) explain the variability in survival status. Dividing the sample into "young" (two or less years; $N = 23$) and "old" (more than two years; $N = 23$) categories of group age at Time 1, and cross-tabulating these classifications by survival status grouped in three categories (dissolved by Time 2 or Time 3: $N = 17$; dissolved in Time 4 or Time 5: $N = 7$; survived beyond Time 5: $N = 22$) shows non-existent (0%) to modest (12%) non-statistically significant differences between the "young" and "old" categories of communes (chi-square coefficient with two degrees of freedom = 1.260, pr. = .533).

10. Theoretically, this is consistent with Gabor's (1946) concept of information (introduced in Part 2 below), which states that although different dimensionalities are involved—unordered and ordered, respectively—the two ordinates of are of equal importance: neither has more weight than the other in contributing to efficiency of communication; the data on both ordinates must meet the same minimum amount as mathematically defined by his formalism for a logon, a quantum of information. At the operational level, also, the two measures of flux and control were empirically equivalent in that the number of potential links among group members ($N(N\text{-}1)$) for both measures was identical, and the observed mean dyadic density of links among members was comparable (.36 and .30, respectively; see the Appendix).

11. Because they are based on an index that is an average (the mean of the sum of low intensity flux and control in each commune), it is possible that these results may simply reflect the relative weights of low intensity flux and control in our measure of total information. To check this we computed a difference score for each commune by subtracting the value for control from the value for flux (a positive value = more flux, a negative value = more control; mean difference score = .119, S.D. = .275, range was .917 to −.450). The communes were then divided into two sets: one set of 14 (30%) communes with more control, and a second set of 31 (67%) communes with more flux (means = −.202 and .268, respectively; *t*-test of difference in means = −8.56, pr. = .000, DF = 42), and partitioned by survival status at Time 2 through Time 5 (one case with a difference score of zero (equal amounts of flux and control) was excluded from this analysis). The results show that while the probability of survival is virtually the same at Time 2 (11 (79%) survivors of 14 communes with more control, and 23 (74%) survivors of 31 communes with more flux (chi-square = .100, pr. = .751)), the difference in the probability of survival increases notably by Time 5 (13 (42%) survivors are observed for the groups with more flux compared to 9 (64%) survivors for those with more control (chi-square = 1.928, pr. = .165)). However, none of the differences in the survival rates between these two groupings of communes was statistically significant.

12. This time-series of scatter plots on stability was run out across the full forty-eight months (i.e., Time 1 through Time 5) for which observations were collected on the communes. The results for the first twenty-four months (i.e., through Time 3 as shown in Figure 6) suggest this is a reasonable period over which to aggregate survival status to accumulate enough nonsurviving cases (non-

survivors at Time 3 = 17 cases) for the analysis; the scatter plots for Time 4 and Time 5 (not displayed) show evidence of a deterioration in the "predictive power" of the information provided by flux and control at Time 1 for stability beyond twenty-four months.

13. Two of the variables not included (the mean number of hours adult members had "spent in the commune over the last three days," and the "organization of chores") had "missing cases," and were excluded from the analyses reported in Tables 4a and 4b to keep the case counts as high as possible, particularly in the "transformational" and "insufficient" categories. While not presented here, the results from separate discriminant analyses, run with each of the two variables excluded by itself, are comparable to the results reported here. Some categories within the third variable, "ideological type," have too few cases to be treated as dummy variables and, therefore, could not be included in the analysis.

14. The results are summarized in narrative form here due to space constraints.

15. The canonical correlation, a multivariate measure of the association between the discriminant scores and the groupings of communes, was .544; the squared canonical correlation was .296, indicating that only 30% of the variance was explained.

16. The breakdown of cases correctly classified in the other categories is: eight (80%) of ten cases in the unstable-turbulent grouping, twenty-four (96%) of twenty-five cases in the stable- optimal grouping, and four (67%) of the six cases in the unstable-insufficient grouping.

17. The canonical correlations for each were .916, .433, and .090, and the eigenvalues were 5.186, 0.231, and 0.008, respectively.

18. The breakdown of cases correctly classified in each category is: all three (100%) cases belonging to the stable-transformational grouping, three (75%) of four cases in the unstable-turbulent grouping, thirteen (93%) of fourteen cases in the stable-optimal grouping, and none (0%) of the two cases in the unstable-insufficient grouping.

19. It is important to note that all members of the collective are included; this follows from our concept of communication, the interaction among networks of relations connecting all individuals in a collective. As mentioned, it is the same notion that underlies the connectionist models of "neural networks." This is a different approach than that employed by most social networks researchers and system dynamics modelers in which the criterion of "mutual relevance" (Laumann et al., 1982) is used to include only those actors who are (contextually) relevant to each other in the system.

20. See Bradley (1998a; 1998b) for an elaboration of this point in regard to Laszlo's theory of quantum vacuum interaction (Laszlo, 1995).

21. It is interesting to note that in the performing arts, by contrast, "energy" has a usage more consistent with its meaning in the physical sciences: the performer is viewed as translating his or her energy into bodily movements which, when also defined in terms of space and time, permit precise descriptions of dance and stage movements (see Laban, 1967; Hutchinson, 1970).

22. The least action principle was enunciated with regard to a measure of efficiency that came from building steam engines. The aim was to convert the action of steam into useful work by minimizing its dissipation into friction and other useless generators of heat. Much experimentation with different engines was required to achieve this objective; it took effort to develop an efficient steam engine. Effort, in this sense, is directly related to internally attaining efficiency; whereas effectiveness deals with the total amount of work necessary to accomplish an external goal, irrespective of how much effort is expended (see Pribram & McGuinness, 1975; Pribram, 1991, Lecture 10).

23. This conception is similar to Bohm and Hileys' notion of "active information" (see Bohm & Hiley, 1993, pp. 35–42, 59–71).

24. See Cherry (1966) for an excellent review of these ideas, and Kaiser (1994) for a readable introduction to the physics of signal processing.

25. Heisenberg had developed his mathematical formulation of uncertainty to define the discrete units of energy, *quanta*, emitted by subatomic radiation.

26. This unit differs from Shannon's unit of information, the binary digit, which is the Boolean choice between alternatives.

27. For example, in a series of recent studies on the barrel cortex of the rat (involving the stimulation of the rat's whiskers in terms of the spectral and spatial components of neural response activity), Pribram and his collaborators (King et al., 1994; Santa Maria et al., 1995) have shown that the response activity of receptive fields could be described in terms of spatially and temporally constrained manifolds, and that each of these manifolds could be derived from Gabor-like functions.

28. Conducting a spectral (fast Fourier transform) analysis of the low (energy) frequency band of vocal spectra of speech samples from the interviews, Gregory and Webster (1996) found voice convergence between interview partners, and also that lower status partners accommodated their voice patterns to higher status partners via the low frequency nonverbal signal.

29. A similar dimensionality also is used in the performing arts. Starting from the premise that "there are three elements in all (human) movement—space, time, and energy" (Sabatine, 1995: 127; our addition), a systematic symbolic language, *Labanotation*, was developed by Rudolf Laban (1967; see Hutchinson, 1970) for recording the minute combinations of energy, space, and time that comprise all of the movements in a dance.

30. While derived from different theoretical principles, this proposition is consistent with the connectionist arguments of some social networks theorists (see Granovetter, 1973; Atkin, 1977; Doreian, 1986; Burt, 1992). It is also consistent with Von Neumann's "automata" for cybernetic systems.

31. Elsewhere (Pribram & Bradley, 1998), we have documented empirically-based correspondences between these field-like and hierarchical dimensions of order and the generation of stable organization across the personal, interpersonal, and collective levels of human experience.

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