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ORGANIZED SOCIAL COMPLEXITY AS AN ANALYTICAL PROBLEM:

AN INTRODUCTION AND EXPLICATION

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One of the most striking aspects of modern political and social development has been the capacity of men to construct social systems encompassing more and more groups in an expanding society. Our lives are bounded by agencies, organizations, combines, coalitions, associations, and networks of hundreds of connected groups and persons. In part this has been a natural outgrowth of economic and technological differentiation translated into organizational and social terms. In part, however, it has been an intentional linking of group to group, organization to organization, nation to nation in efforts to gather specialized and similar resources for some purpose or other. One of the outcomes of such a natural and intentional increase of connected groups is a rapid increase in the number of people and agencies that affect the experiences of persons in day-to-day happenings. Another result is the tightening of organizational dependencies affecting social and political movements and dynamics. And still another consequence has been an increase in the number of surprises we experience. These surprises we often account for on the basis of "it's a complex situation," implying that it is unaccountable. If this statement is not enough to reduce our "psychological puzzlement," we may turn to conceptions of the world which purport to explain what we have experienced or give some insight to it. When we do, the theories available weave a network of notions describing phenomena which are social, complex and organized. In this paper we shall gather these together and explore organized social complexity as a candidate for an important variable in the development of organization, social and political theory.

I. The Concept of Organized Social Complexity

While the term "complexity" appears in many areas of the social sciences, perhaps most often in the study of complex organization, very little has been done to develop this concept so that the phenomenon intuitively collected under the term may be related to other aspects of social, political or organizational life. In this section we shall begin such an explication.

In an important article, "The Architecture of Complexity," Herbert Simon avoids a formal definition of complexity, suggesting only that complex systems are ones "made up of a large number of parts that interact in a nonsimple way" (p. 63). Perhaps more foolhardily we shall attempt to advance past this by dealing with a particular kind of complexity, i.e., organized social complexity. In emphasizing organized complexity we are following the distinction made by Weaver between unorganized and organized complexity. The former describes elements, parts, or variables affecting the behavior or outcomes of systemic operations, but not systematically related to each other. These aggregates of randomly interacting elements, such as gas molecules under pressure, consumer behavior, and voters in general elections, are fruitfully described with statistical techniques. Despite the fact that each of the variables displays unknown behavior, the system as a whole has certain orderly properties which can be discovered through probability analysis.

Systems of organized complexity, on the other hand, are those in which there are at least a moderate number of variables or parts related to each other in organic or interdependent ways. Such systems, for example, as the internal dynamics of living organisms, self-conscious social organizations, and chemical molecular reactions, are not readily described through probability techniques and pose challenging conceptual and methodological problems (Weaver, pp. 537-539).

Our concern will be further limited to <u>social</u> systems possessing the characteristics of organized complexity. Members of such systems will be defined as those persons (or groups) engaged in relatively self-conscious interaction with each other and recognizing their common relatedness to one another within the system. For our purposes, the self-conscious characteristic is crucial; it is central to the requirement that interaction between elements be interdependent and systematic. Without the self-conscious requirement aggregate behavior in social groups could just as well be unorganized.

Within these limitations, the degree of complexity of organized social systems is a function of the <u>number</u> of system components (C_i); the relative differentiation or variety of these components (D_j); and the degree of interdependence among these components (I_k). Then, by definition, the greater C_i, D_j and I_k, the greater the complexity of the organized system.

A <u>component</u> of an organized social system is defined as a person or group occupying a position within the system having these characteristics: (1) sufficient mutual agreement or consensus about the position so that the occupying person or group is the object of expectations and action from other members, and (2) the person or group recognizes the legitimacy of the others' expectations and responds to them positively, at least to the degree required to maintain membership and avoid expulsion from the system (cf. T. Caplow, pp. 1-3).

Differentiation of components is defined as the number of different social roles or positions within the system. This is based on the degree of mutual exclusiveness of the activities distributed among the roles in an organization (Gross, et al.; Katz and Kahn). These differences are based, in turn, on those activities expected of a role occupant by other members of the system. Developing operational indicators of differentiation can become quite difficult. Without necessarily accepting them as definitive, formal job descriptions could be used and/or instruments to determine high norm consensus.

The most difficult element of our definition is the interdependence of components. It is by far the most important and the least developed. Interdependence among persons or groups assumes varying degrees of reciprocal relationships between them. Interdependence means an exchange relationship of at least one resource, between at least two persons. Interdependent relationships can vary between any two members (a,b) exchanging resource r_1 from:

1) Member A dominant over member B, i.e., B depends on A for some desired resource $(a \rightarrow b)_{r_1}$.

2) A and B are equally dependent upon one another for a mutually desired resource $(a \leftrightarrows b)_{r_1}$.

3) B dominant over A $(a \leftarrow b)_{r_1}$.

In our basic illustration only one resource was involved; however, in many situations several resources may be exchanged with all three dependence relationships obtaining between two persons. For example:

$$(a \rightarrow b)_{r_1}, \quad (a \rightleftarrows b)_{r_2}, \quad (a \leftarrow b)_{r_3},$$

when r_1 is promotion, r_2 is mutual protection and r_3 is expertise. On the operational level, determining the degree of interdependence requires that the persons in question perceive or recognize their relatedness. In behavioral terms, a person will not behave in dependent or dominant ways with regard to another unless he recognizes this relationship. Parenthetically, independency of two parties, from this view, implies a non-relationship, i.e., no connection between A and B.

In order to clarify this notion, let us consider three examples of different degrees of interdependence for systems composed of a number of components. Still dealing with only one resource, we can describe the most simple system as a "tree" or simple hierarchy. In general, a hierarchy is defined as "a system that is composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of elementary subsystem" (Simon, p. 64). Formally, "[a] collection of sets forms a tree [or simple hierarchy], if and only if, for any two sets belonging to the same collection either one is wholly contained in the other, or else they are wholly disjointed" (Alexander, p. 60). Figure I illustrated this form of dependence for one resource.

Figure I

A Tree of Dependence

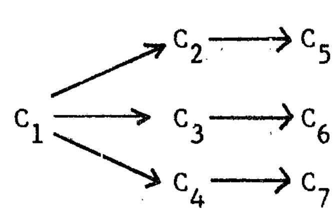


Figure II represents a matrix of complete reciprocal interdependence between members for obtaining one resource. The behavior of every member with respect to this resource is reciprocally related and dependent upon every other member, and forms the matrix $(c_{ij})_{r_1}$.

Figure II

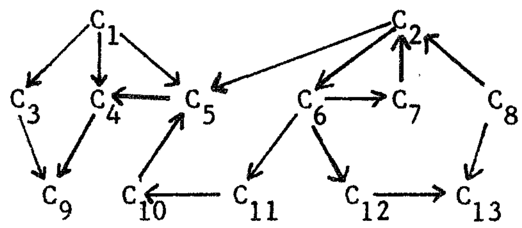
A Matrix of Dependence

	C_1	C_2	C_3 . . .	C_n
C_1	1:1	1:2	1:3. . .	1:n
C_2	2:1	2:2	2:3. . .	2:n
C_3	3:1	3:2	3:3. . .	3:n
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
C_n	n:1	n:2	n:3. . .	n:n

Finally, intermediate between these two extremes are those incomplete matrices, termed "semi-lattice" in set theoretic language. These are systems of relationships between members that are characterized by overlapping relationships where some members are dependent upon several other members and no member is in complete control of the resource (Figure III). Formally, "[a] collection of sets form a semi-lattice, if and only if, when two overlapping sets belong to the same collection, then the set of elements common to both belong to the collection" (Alexander, p. 60; cf. Freedall).

Figure III

A Semilattice of Dependence



Intuitively, in terms of one's own experience, the world is not overly populated by either trees or matrices of dependence. Very seldom are relationships as simple as the illustration of a simple hierarchy, but at the same time our personal patterns of dependence upon others and they on us are rarely, if ever, so dominantly interdependent as the matrix. We shall return to some of the reasons why this latter condition is not likely; first, however, a few more notes on the relationships between the elements of our definition of organized complexity.

II. Social Complexity as an Independent Variable

If organized social complexity is to be used as an independent variable, or antecedent conditions from which we may expect certain things to follow, there are several aspects which require notice. First a warning--comparisons between the complexity of different social organizations at the same point in time, or of the same social organization over time, are not straightforward or easily accomplished matters. MacFarlane, in discussing complexity similarly defined, asserts that the three dimensions of complexity are not additive, and therefore comparisons are likely to be methodologically rather tricky. Including the degree of change in his definition, he states, "if one system has fewer components but greater interdependence and variability [i.e., changes in degrees of differentiation over time] than another, it would be difficult or impossible to determine which system is more complex, unless the system with fewer variables is identical to a subsystem of the second system" (p. 17). What is asserted is that if we are to order and compare systems on the basis of complexity, we must demonstrate that "one system exhibits a greater magnitude than the other on all three dimensions of complexity" (p. 18). This view seems overly impressed with the difficulties of examining the effects of increases in one of the variable elements, holding the others constant, but it is a necessary warning that operationalizing organized complexity is no trivial matter. Having issued the warning, let us go on to consider more detailed aspects of social complexity as an independent variable.

Perhaps the most fruitful way to begin is by considering what is minimumly required to have a system which is organized and complex, that is, is there a way of hitting on a basic unit of complexity. Following from our definition, the notions of differentiation and interdependence are the basis for such a determination. At least two different types of positions are implied by the definition, for the condition of interdependence cannot be met without them. Furthermore, at least two resources are also implied--say, physical effort (r_1) contributed to moving a large rock and someone says "heave" (r_2). At minimum, then, two persons (C_j), are differentiated into two roles (D_k), exchanging two resources (r_n) in interdependent ways (I_k). In formula form, then, complexity $X = (C_i, D_j, I_k)_{r_n}$, when i is 2, j is 2, k is 2, and n is 2.

If any of the elements of the relationship falls below two, the system cannot be said to be organized and/or complex. Note here that the limit of differentiation is (C_i).

Starting at this minimum level, we can now ask what are the consequences for system behavior as the number of components increases, holding constant D_j and I_k. For example, what are the effects of increases in

C for communication patterns if D and I are held constant? It seems clear that operational and conceptual questions regarding the number of components and differentiation can be worked out (Starbuck). There has also been some work in relating size, differentiation and interdependence (generally termed integration) resulting in the general notion that increases in size put strong pressures on the system to increase internal differentiation and interdependence as requirements for coordination increase (Pugh, Lawrence and Lorsch). It is quite probable that as size increases, and D_j **and** I_k are held constant, that the system will begin to take on unorganized characteristics and ultimately dissolve.

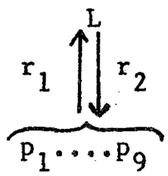
If organizations, say, are ordered in terms of their size, differentiation and internal interdependence, we can begin the task of examining the consequences of increases in one or the other of our definitional elements. Holding variable aspects of organized social systems constant, what are the consequences for other behaviors within the systems or between systems as they deal with their external environment? This can be asked about different organizations at a single point in time, or for a single organization over time.

It appears that, in general, as size and differentiation increase, there is a subsequent increase in the amount of interdependence as well. But what does this mean operationally? If we think of the amount of interdependence (I_k) as the degree to which persons share dependencies (interact, make decision allocations) for resources distributed among each other, then some measure of overall dependence may be constructed. The limiting case would be an organization requiring only two types of resources, that is, the organization of, say, ten persons occupying at least two types of positions exchanging, for example, physical labor (r_1) and coordinative skill (r_2). Nine of them pulling ropes attached to a granite boulder with the tenth coordinating their action. Thus, the pullers are dependent upon the leader for direction, and the leader on the others for their collective effort. In a sense, this is close to Thompson's "pooled interdependence," in which the pullers are dependent upon the leader but not directly dependent upon each other (p. 54).

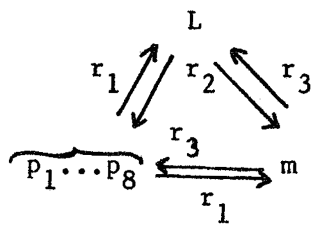
Given this situation, how would interdependence increase? As more resources (valued objects, skills, etc.) are included in the exchanges between persons in the organization, more kinds of dependencies are established (Tannenbaum, et al.). This accounts for an expansion of the basis of dependence and possible control. If, for example, the block of granite is to be cut into a particular shape, then one puller must take on the job of stonemason contributing stone-cutting skill as a resource (r_3). This increases differentiation by one and increases the resource dependencies for the leader. He must now coordinate not only the pulling, but the time and place of stone cutting. The total amount of complexity has increased as D_j increases, and as the sum of dependencies increases.

Figure IV

T_1; $X = (C_{10}, D_2, I_2)_{r_{1,2}}$



T_3; $X = (C_{10}, D_3, I_6)_{r_{1,2,3}}$



Using this reasoning, it is possible to describe various levels of complexity. Still with our example, if the stonemason was required to tell the pullers what rocks to haul before they could get to work, this increases their dependence on him and the total complexity of the relationship by one. It does not, however, increase the total number of resources exchanged in the system. Figure IV illustrates the first and last series of relationships and includes a symbolic summary of overall complexity.

It is possible to imagine doing this kind of elementary designation of C_i, D_j, and I_k for various subgroups within larger organizations, thus developing a way of ordering complex systems in a rough way. If we attempted to do such a detailed level of descriptive analysis for groups as they became larger, more differentiated, and included more types of resources, it would be clear that keeping track of relationships, flows of resources and so on quickly becomes very difficult to manage. Here lies the root of the limitations to the complexity social forms are likely to take.

III. Limitations of Complexity

While organized social systems theoretically can take a matrix dependence configuration, this only rarely happens, and then only with very small systems. As the size of the organization increases, the relatively inelastic limit of individual information processing capacity prevents nearly complete interdependence. In discussing this limitation Miller (p. 82) demonstrates that

> If the human observer is a reasonable kind of communication system, then when we increase the amount of input information the transmitted information will increase at first and will eventually level off at some asymptotic value. This asymptotic value we take to be the channel capacity of the observer: it represents the greatest amount of information that he can give us about the stimulus on the basis of an absolute judgment. The channel capacity is the upper limit on the extent to which the observer can match his responses to the stimuli we give him.

A further limitation is a relatively narrow span of immediate memory; combined with the limitation of absolute judgment, this reduces the amount of information a person can absorb and understand at a given time.

This becomes a nearly absolute limit to the number of persons and/or amounts of information any member of an organization can deal with. If we think of organizational members as having a finite number of open connections available for receiving information or connecting with others, when they all become engaged no more can be made without overloading the person or dropping out previously made relationships.

One of the consequences of increasing complexity is to raise the number of people and/or types of interaction one has within the organization. At some point, individual channel capacities are saturated and no additional relationships are likely to take place. When this happens a system which has exhibited complete interdependence can no longer maintain this as its size increases. There are simply too many other people to take into account. Overload occurs and to relieve this situation delegation begins.

There are ways of temporarily overcoming information saturation, i.e., by regrouping and reorganizing information inputs into summary units or "chunks" of information. "Since the memory span is a fixed number of chunks, we can increase the number of bits of information that it contains simply by building larger and larger chunks, each chunk containing more information than before" (Miller, p. 93). This recoding, however, is itself limited by the ability of the recoder to develop new codes which have a rough correspondence to reality. The larger and more swiftly changing the social system, the more difficult this is to accomplish.

Finally, the development of highly interdependent organization systems is limited by the degree to which members are aware of their interdependence. Members must be aware of their relatedness or they are not likely to act in interdependent ways. As the number of potential interdependent actors increases, this awareness relatively declines. Thus the related limitations of information processing capacity and perceptual awareness make quite unlikely the development of very highly interdependent systems. Rather, as systems become larger they seem to be composed of relatively stable subsystems which among other things attempt to adapt to problems of information absorption, recoding and transmission. The remaining part of this chapter will be a discussion of some properties of such general situations.

IV. Some Properties of Organized Complexity

Simon argues that complexity takes the form of hierarchy, i.e., a complex system composed of interrelated subsystems that, in turn, include their own subsystems, and so on (p. 64). Successive partitioning can be done until the most elementary subsystem is reached. As a whole, then, a complex system can be analyzed as a successive series of sets, subsets and sub-subsets arranged in hierarchical order in the form of trees or semilattice.

Following from the limitations of complexity discussed above, we would not expect the distribution of interdependence to be equally high throughout the organization, i.e., in near matrix form. Rather there will be clusters of interaction and interdependence <u>within</u> subsystems, with varying degrees of connectedness <u>between</u> them.

> [W]e can distinguish between the interactions <u>among</u> subsystems on the one hand, and the interactions <u>within</u> subsystems--i.e., among the parts of those subsystems--on the other. The interactions at the different levels may be, and often will be, of different orders of magnitude. In a formal organization there will generally be more interaction, on the average, between two employees who are members of the same department than between two employees from different departments. In organic substances, intermolecular forces will generally be weaker than molecular forces, and molecular forces than nuclear forces. (Simon, p. 69.)

Types of partitioning or decomposability can be distinguished on the basis of whether a system is completely or nearly decomposable.

Completely decomposable complex systems are made up of several independent subsystems each one of which can be analyzed separately without reference to any of the others. For example, a completely decomposable group would be one in which every member had no other role outside of the group or if those other roles had no effect whatsoever on a member's behavior within the group (Fisher and Ando, pp. 108-109). In a sense this is the other extreme from complete interdependence, seldom occurs in fact, and is close to the condition of unorganized complexity. Put another way, if any single member of the organization fails to contribute his share of resources very little effects are noticeable.

No system of organized complexity is completely decomposable, nearly by definition. Again Simon advances a useful notion of "nearly decomposable systems, in which the interactions [or interdependencies] among subsystems are weak, but not negligible" (p. 69). That is, while the interaction within subsystems may be quite high and complexity extreme, the interdependencies between subsystems are few and relatively weak. In systems or organizations of this sort should failure or loss of a connection occur between subsystems, the organization might dissolve into relatively cohesive and independent subsystems. We see examples of nearly decomposable organizations in large conglomerate corporations, and portions of the Federal bureaucracy.

Two interesting propositions are associated with this form of complex system and, though derived from economics and physics, can be fruitful in understanding the behavior of large moderately complex bureaucracies. They are that in nearly decomposable systems:

1. "[T]he short run behavior of each component subsystem is

approximately independent of the short-run behavior of every other component subsystem.

2. In the long run, the behavior of any one component sybsystem is dependent in only an aggregate way on the behavior of the other component subsystems."

This is possible due to the limited connections between component subsystems and is probably characteristic of most moderately complex organizations. However, if interdependence between component subsystems increases, i.e., the less decomposable the system becomes, these propositions will require modification.

In a sense, the more tightly complex an organization, the closer it moves toward becoming a disaggregative system. That is, a system in which the components are so tightly interdependent that should one component fail the whole system either dissolves or becomes inoperative. Perhaps the best example of this is the design of some man-machine weapons system in which the failure of one or several computers would bring the whole thing to a halt. This type of singular interdependence or dependence upon single components for increasingly critical resource contributions prompts "fragile" systems to develop. For fragile systems, changes in conditions, availability of outside support and so forth which interrupt the flow of external or internal resources become critical for the continued operation of the organization, at least in its steady state. Less fragile or more adaptive organizations exhibit the property of internal redundancy (Landau).

Redundancy of an organized system is essentially the degree to which various components carry on similar functions or activities. For example, public organizations are partially redundant if several subunits each carry on purchasing activities for the whole organization. In terms of our definition of organized complexity, the more differentiated the organization, the less redundant; that is, the fewer units or persons carry on the same activity. Put another way, holding the size of the organization constant, decreasing its differentiation of roles, increases its redundancy and decreases overall complexity. One of the features of redundancy in complex organizations is that it is associated with error correction and failure compensation. It still is a theoretical and empirical question whether functional and dysfunctional redundancy can be distinguished and examined.

Summary and Further Questions

The concept of organized social complexity has been defined in terms of numbers of components, and the differentiation and interdependence of these components. Various arrangements of interdependence can be described as simple hierarchies or "trees," semilattice, or matrices of dependence. Apparently semilattice structures are more common than either trees or matrices and the crucial limit on complex development is the capacity of individuals to process information, thus limiting the number and kinds of interaction they can engage in. An initial attempt was made to provide an operational basis for treating organized social complexity as an independent variable. This was based fundamentally on conceptions of position and role, with exchanges of resources between interdependent positions. Finally, several properties of complex systems were discussed dealing with the relative influence of subsystems among each other in systems of varied decomposability. The more complex a system, the less its decomposability and the more directly the short-run behavior of subsystems is influenced by other subsystems in the organization.

We began this essay suggesting that the world about us seems to be becoming more connected, interwoven and interdependent. We suddenly discover that this or that group of organizations have become dependent upon each other in curious and surprising ways. Part of this feeling is due, we argued, to the objective increase of organized social complexity. Public and private organizations have grown much larger, they have become more internally specialized, and there are many more specialized types of large organizations. Finally, there are closer bonds of interdependence among and within the major institutions of our time. Of course, the extent to which this is true is an empirical question. It is a question that has been rarely asked and the answers for which there are almost no data whatsoever. Yet if it is true that the texture of live and social institutions has become increasingly complex and can be assumed to continue in this direction, the implications for social theory, political science, the techniques of inquiry and perhaps most important, public affairs, are enormous.

The exploration of the potential impact of social complexity upon political studies and public affairs can be bounded by a set of questions which provide a kind of agenda for research. One such question has to do with the adequacy of present perspectives explicitly intended to increase man's control over social and political phenomena. Perspectives such as planning, systems analysis and policy studies require examination asking the question: to what degree, if at all, does each of these "methodologies" comprehend and/or anticipate possible increasing social complexity?

Another question is fundamentally methodological and empirical. Can conceptual framework be constructed using social complexity as a point of departure such that empirical situations and social organization can be described in these terms? This is clearly necessary for any sort of empirical test of this phenomenon. Methodologically, what consequences for techniques of data organization and analysis follow from attempts to conceptualize the social world in terms of interdependence and connectedness? Contemporary methodologies tend to assume relatively disconnected aggregates of persons, voters, etc.; what effect does the development of complex models of assumedly complex reality have for our methodological adequacy?

Finally, and perhaps most critically, the phenomenon of increasing social complexity may have crucial theoretical and epistemological consequences for political and social science. It is generally true that the concepts and symbols we presently use to order and relate our experiences have come to us in the language of the past. As we use these symbols to describe and understand our present and future, they are very suitable if the conditions upon which they have been based and refined are roughly similar to the present. However, our theories of social, political and organizational life have been based on situations much simpler than the present. It is quite possible that as social reality becomes more complex, increasing portions of experience fall outside the symbolic screens come to us from the simpler past and are only dimly visible at best. Theories of political and organizational structure and behavior can profitably be examined for evidence that they take increasing complexity into account. And, ultimately, this phenomenon poses a central challenge to the limits of knowing. Is there some sort of actual limit to what is knowable about complex situations as they become increasingly so? What can be known in a world of increasing complexity?

Together these questions put a partial boundary around the tasks implicit in the assertion by Alexander's reflection on the difficulty of conceptualizing complexity. "In a single mental act you can . . . visualize a tree. You cannot bring the semilattice structure into a visualized form for a single mental act" (p. 60). Have we only developed political and social theories of simple systems? How appropriate are they for a society of extraordinary complexity? What intellectual and research demands are implied in the quest for organizational, political and social theories of complex systems?

Author's Note:

This essay, in slightly modified form, is the introductory chapter for a collection of papers on Social Complexity: Challenge to Politics and Policy which cover many of the questions just listed.

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