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Hierarchy, Systems, and Geography

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ABSTRACT – The concept of hierarchy in geographical studies has been applied primarily to identifications of structure and not process. This limited application is partly due to the omission of the concept in attempts at applying systems theory in geographic studies. Hierarchy as an organizing and integrating concept is an essential element in systems investigations. Several philosophical dichotomies that have hampered holistic geographical research efforts are reviewed, and the concept of hierarchy in process investigations is placed within the wider realm of systems theory. Extension of the integrating nature of geography into authentic interdisciplinary studies is encouraged.

Fred Lukermann pointed out (1965a) a basic conceptual void in geographical studies of particular urban places:

> In the twentieth century literature, two characteristics of an urban system are cited in article after article: the nodal character of its locational pattern and the hierarchical structure of its distribution as measured by size or function. Unfortunately, very few of the articles define either word but take the terms as given. The concept of hierarchy is the least defined of the two and the most troublesome, especially in a locational context.

It would appear, particularly in the case of hierarchy, that little has been done to alleviate the problem since this statement.

At the same time the concept continues to be used within the discipline, in one form or another, and in a somewhat limited and restrictive sense. A danger apparent in this practice is that virtually no unanimity of definition is present, with the likely consequence that key points in well developed works might possibly not be understood in the intended context. Another and potentially more damaging outcome is that the concept itself, lacking clear definition, is not being used to its greatest potential. This paper reviews the use of the concept of hierarchy not only in geography but also in other disciplines. In addition, hierarchy will be placed conceptually within the wider confines of systems theory wherein a major analytical thrust in geographical studies remains potentially high.

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The concept of hierarchy

Mesarovic (1972) takes note of a fundamental shift in conceptual thinking brought about by the implementation of systems analysis into social science methodologies:

> In the past, concepts from the physical sciences were prominent; one talked about pressures, forces, energy, etc., in the context of social, political and economic situations. New metaphors from the systems fields involve concepts such as feedback, information flow, game-theoretic relationships, hierarchies, etc. These are opening completely new avenues which can lead to a dramatic improvement of our understanding of the social and economic systems.

It is within the context of systems analysis that hierarchy as an organizing concept is most fully developed. Yet, unanimity is not found in the definition of the term among disciplines using the systems approach. Mario Bunge's definition (1963) and amplification are offered as a starting point:

> Hierarchy: sequences of terms ordered by a one-sided, i.e., asymmetrical dependence relation. A picture of hierarchies is the staircase pyramid.

Further:

> A rank (or hierarchial grade, or grade in a hierarchy) is an element in a discrete linear sequence, such that its status (importance, power, or value) is higher or lower than the neighboring ranks, and such that, unless it is the highest of all, it is dependent in some respects on the higher ranks.

The analogy of the staircase pyramid and the specification of dependence of the lower ranks on the higher suggests that hierarchy, in Bunge's view, is rigidly structured and inflexible in the sense that control and influence is directed exclusively from higher level to lower. There is no indication of functional reciprocity.

Ernest Nagel (1961) is less emphatic but equally restrictive in his view that lower level hierarchical processes cannot explain processes found at higher levels. Again, the asymmetrical nature of hierarchy is evident. The inference being that processes, or properties, at lower levels, although connected hierarchically, could not be investigated inductively for the purpose of deriving the whole. Similarly, von Bertalanffy suggests (1952) that a principle of rank-order and subordination of the parts is found in highly developed hierarchies.

Thus, scholars have viewed the concept of hierarchy as a rather rigidly structured asymmetrical rank-order relationship wherein a one-way operative authority exists, resulting in the subordination of lower level entities. Further articulation on hierarchies from Albert Wilson (1967) suggests that

> throughout nature . . . the large and complex is constructed in a hierarchical modular manner from the small and simple. Direct confrontation of the large and small is avoided, a hierarchical linkage is always interposed.

On the question of applicability, Arthur Koestler is even more encompassing: "wherever there is life, it must be hierarchically organized", Koestler wrote in 1967.

Levels of organization

Contemporary emphasis on systems theory and associated hierarchical organization was recognized and discussed earlier in this century. The literature in biology is especially valuable in noting the development of this line of thinking. Joseph Needham discussed "the existence of organization in the universe, successive forms of order in a scale of complexity and organization" (Needham, 1943). In this statement may be found the essential attributes cited earlier in this paper. Yet, there is not the emphatic injunction of asymmetry representative of some current views. The emphasis is on organization and order within successive levels. Consideration of levels of organization can be traced to the eminent biologist, J.H. Woodger, and in earlier works to scholars preceding him (Woodger, 1967). The term also is used by Koestler in his 1967 work, The Ghost in the Machine:

> In social hierarchies, . . . institutional controls restrain the self-assertive tendencies of . . . groups on all levels, from whole social classes down to the individual.

In this instance we note the use of the term in a context other than biological. Application of systems theory had, by the time of Koestler's writing, extended to virtually all disciplines and areas of investigation (Bertalanffy, 1952).

Microhierarchy, Macrohierarchy, and Organization

Laszlo (1972) suggests a basic duality of hierarchies. He classifies the terrestrial atoms-to-ecologies hierarchy as the micro hierarchy, and the astronomical structurations in the cosmos as the macrohierarchy. He suggests further that the microhierarchy is defined not by the identity of its component system, but by its organization. The key property, then, in the microhierarchy is organization; and the structure is one which includes "co-acting relationships".

The essence of Laszlo's contribution is an emphasis on the organizational character of systems. Within this organization he suggests a co-acting, or reciprocal, relationship as opposed to a strictly asymmetrical uni-directional authority. His definition of microhierarchy follows:

> a complex dynamic level-structure, within which system coacts with system and is imbedded . . . in an ascending sequence of increasingly individuated systems.

A striking similarity may be noted between Laszlo's definition of microhierarchy and Herbert Simon's definition (1969) of hierarchic system:

> a system composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of elementary subsystem.

Again, the emphasis is on organization (interrelated subsystems), hierarchical structuring, and reciprocity of action.

The key, thus far, is the importance of considering the organizational element. To attest to this, Warren Weaver (1948) reminds us that science must learn to deal with increasing degrees of organized complexity. Further, to succeed in achieving holistic conclusions, there must be the ability to deal simultaneously with a "sizable number of factors which are interrelated into an organic whole." The factors (parts) may be easily identified, but the quality of interrelatedness can be appreciated only by paying heed to the organizational character of the whole.

Philosophical dichotomies

The concept of structure mentioned several times in this discussion is a term used frequently in the geographical literature. Similarly, function is another concept in wide general use. A point of intellectual discomfort evolves, however, when the two are considered in any single study. Writers tend to favor one or the other. Rarely have the two been synthesized and considered as elements in communion: as complementary frameworks to reference one and the same processual event or set of events.

The dichotomy is ago-old. The argument over which is of greater significance continues to the present (Gutman, 1964). In geography, the difficulty comes to light more frequently in the problem of integrating form and function. Despite recognition of the obvious relationship between the two, efforts to link them conceptually are not numerous (Cohen and Lewis, 1967). Yet, to deal in a holistic manner with processes through space and time, integration of these two concepts is essential. Bartalanffy's thoughts (1968) on the problem are a beginning:

> Structure (i.e., order of parts) and function (order of processes) may be the very same things: in the physical world matter dissolves into a play of energies, and in the biological world structures are the expression of a flow of processes.

Examples of studies aimed at the integration of form and function are rare in geography. One of note attempts to outline a methodology for uniting form, function, and process (Eichenbaum and Gale, 1971). Unfortunately, all the examples used are drawn from the biological sciences, and applications within the realm of geography are not attempted.

In concert with the on-going structure-function dichotomy is that of atomism and holism. Since the time of the Greeks, thinkers have tended to fall into either the atomist or holist schools (Whyte, 1954). The argument continues with criticism of the holist for failing to consider the workings of the parts, and of the atomist for failing to gain the comprehensive view. This is a familiar strain in the geographical literature of the last three decades, and is at least partly behind the so-called quantitative revolution and the demand for a more scientific approach to geographical analysis. For the holist view we may consider Laszlo (1972):

> The demand for 'seeing things whole' and seeing the world as an interconnected, interdependent field or continuum, is in itself a healthy reaction to the loss of meaning entailed by overcompartmentalized research and piecemeal analysis, bringing in particularized facts but failing in relevance to anything of human concerns.

Laszlo is correct in pointing out the importance of seeking interconnection and interdependence in a processual (contimuum) sense. Yet the atomist would no doubt take issue with the inferences of piecemeal analysis and lack of relevance. A good example of this would seem to be the recent emergence of ecology with its obvious holistic orientation but with an eye to the atomist view as well. In this regard, Potter suggests that the atomistic details of molecular biology must be considered because they are the targets of environmental hazards (Potter, 1971). Thus, two apparently opposing conceptual views of the same phenomena tend, as in the structure-function dichotomy, to deter the development of a thorough systems approach. The paradox is that neither view is wrong as such. Or it may be better stated that both views, if rigidly followed, have a common shortcoming. Koestler (1967) states that both holism and reductionism (atomism) "failed to take into account the hierarchical scaffolding of intermediate structures of subwholes". Whyte (1954) is more elaborative:

> The holists are right in thinking that complex systems are important, for the laws describe how such systems change in course of time. And the atomists are right that discrete structure is important, for that alone distinguishes one system from another. But the holist neglects structure and the atomist the properties of systems.

We may validly infer from Whyte's statement that structure is used in a context which includes both hierarchically ordered levels and subsystem interfacing with levels. Again the emphasis on the organizational nature of systems is a primary consideration.

Process

Such shifts in emphasis away from either extreme and toward the organizational characteristics of the system can be noted in recent studies. John Platt, citing David Bohm, proposes the derivation of a process metaphysics based on the idea that the universe be regarded as a complex hierarchy of flow patterns (Platt, 1970). The theme of flow as stated by Platt was used by Brian Berry (1973a) to suggest the development of a "process metageography" described as:

> that part of geographic speculation dealing with the principles lying behind perceptions of reality, and transcending them, including such concepts as essence, cause and identity.

Baker, as well, suggests (1972) that historical geographers concern themselves with identifying process that existed in the past and not limit their studies to the reconstruction of past landscapes and cross-sectional anlayses.

The importance of process investigations is, of course, not new in geography. Lukermann, (1965a) noting Ratzel, emphasizes that the study of process should be a primary consideration in geography because it provides a key for conceptually studying situational change over time. Yet, it is with the application of process investigations that a great deal of difficulty is encountered. As an example, one can note what appears to be a certain degree of frustration in Blaut's statement about the role of maps:

> The map-thing, the ink-on-paper sign-vehicle, is, of course, relatively unchanging and beguiles us into imaging that the map-meaning, the significance of the map, is something other than process. Further confusion is added by the fact that maps portray simultaneity directly, pictorially, whereas time-depth is represented only (in most cases) by inference (Blaut, 1972).

At best, a map is nothing more than a "state description," an identification for reference (Simon, 1969). Process may be inferred, as Blaut suggests, but the map remains a static presentation. Yet, maps display information from which process may be in part determined.

In short, given the state (in this case, maps) one proceeds to determine the process. Maps are analytical tools in the same sense as graphs and charts; they are forms of information that may be used to determine process, and not, perhaps ironically, to illustrate it. In support of this, consider Harris' contention (1965) that

> The spatial structure is not separable from the temporal but either of them is differently disclosed according as the reference frame is (arbitrarily) chosen to effect an artificial section across space-time.

In this sense maps are reference frames to portray an instant of space-time. As such, the temporal dimension of contiguity is, for convenience, disregarded. Therefore, process is not considered directly but must be inferred.

Systems, Hierarchy, and Geography

Thusfar, attention has been directed toward certain essential ramifications implicit in the use of hierarchy as an organizing concept. Hierarchy, as used in geography, has received limited application. Similarly, systems theory is only beginning to take hold as a workable methodological form. Since the real power of hierarchical structure is found within the larger matrix of systems theory, the void is understandable. However, systems theory continues to occupy a prominent place in geographical concept development and methodology. Thus, further refinement of the notion of hierarchy is necessary.

In terms of hierarchy as a concept, reference may be made to development within geography. Berry's studies (1973b) on systems of cities and their hierarchical arrangement according to the number of functions found in each would be representative. Further Haggett's attempts at analyzing the variances from regularity as exhibited in the arrangements of settlements, centers, and industrial activities offers a refinement in applying the concept beyond the isomorphism of restrictive theoretical bonds (Hagget, 1965).

Beyond the urban/functionally oriented studies, Haggett and Chorley (1969) note "hierarchic order" in stream systems and "hierarchic grouping" in a regional taxonomy as a modification of cluster analysis (Hagget and Charley.) Lowe and Moryados review hierarchy in the traditional context and in diffusion, networks, and routes (1975) The use of hierarchy as an organizing concept is also found in the laws of ekistics (Doxiadis, 1968). Examples such as these place primary emphasis on the structural parameter of the idea. That is, hierarchies are expressed as arbitrarily chosen lines of division between functionally homogeneous groups of urban places, stream networks and route segments. Little attention is paid to the organizational interconnectedness of one sybsystem with another, an implicit requirement within the dictum of systems theory. The same criticism is valid for Isard's discussion (1975) of hierarchical structure of urban places and social organization. Emphasis is placed primarily on structure and not on process.

Some geographers have concerned themselves with the apparent shortcomings of a purely structural view of hierarchy. William Bunge (1962) commented on the practice of compartmentalizing urban places within a hierarchy based on function. He advanced the concern of whether a rank-size set of urban places should not in fact be viewed as a continuum rather than hierarchically in arbitrary classification mode. The same concern is sounded later by Carter (1973) in a review of the rank-size continuum/hierarchical grouping debate in the study of cities. Carter's criticism is that the ranking of settlements according to central place function does not provide a tool for the study of urban process (Carter, 1972). Again, if the purpose of hierarchical assignment to sets of urban places based on function is primarily a structural one, or a classificatory or taxonomical one, he is essentially correct because process is not considered. Hierarchy as structure must be, by definition, static description.

Carter (1972) introduces another concern on this topic which suggests a more appropriate opening for processual considerations:

> The very acceptance of the observed fact, derived from empirical investigation, that towns can be ranked into levels in a hierarchy, or indeed have any general relation one to another in a systematic way, immediately poses a developmental question--When did this hierarchical structure emerge? --At what point along the rural-urban transformation continuum does a hierarchical structure appear?

The element introduced here is time. And although the temporal frame is stated specifically in terms of hierarchical emergence, an ancillary consideration, the general validity of this element is implicit in geographical process investigations.

All geographical analyses are temporal. The contention that geography is strictly a spatial discipline fails on the point that such a premise limits analysis to findings of state (static) description. Thus, stern advocates of a strictly spatial view have, by definition, denied process.

Social systems

The greatest difficulty in applying systems theory to geographical problems has been in the human realm. This is due to the greater degree of complexity in human organization and to the considerably lower degree of predictability in a probabilistic sense inherent in human activities. Recognition of these limitations has led social scientists to be somewhat skeptical of systems theory as an appropriate analytical vehicle.

Since the inclusion of systems theory is relatively new in social science methodology, it is not surprising that signal accomplishments are rare. Yet there has been a beginning and the work should continue. In this regard, Bruner's remarks (1969) are pertinent: "We know extraordinarily little about systems that acquire their organization in contrast to those that have much of it built in from the start." Geographical concerns are, of course, within the category of systems that acquire organization. The development of the North American urban complex is an obvious example. The analysis and geographical inputs to an explanation of this complexity is quite a different matter than, for instance, a physiographical systems analysis of the human body. In the latter, a high degree of genetically determined specificity allows little variance within individuals and within the parameters of replicability (Whyte, 1965). In the former, where feedback machanisms produce system openness, outcomes are not predictable to anywhere near the same degree of certainty (Langton, 1972).

The recognition that a lesser degree of predictability is implicit in social analysis should not be considered as a deterrent to study. In commenting on this, Ando points out that many areas of concern to social scientists can be represented by what he calls "approximately" hierarchical systems (Ando, *et al*, 1963). The concession to approximation may be interpreted as an acceptance of the realistically anticipated range of variances from certainty in any system of social organization. Certainty is obviously not the goal of investigation. On the contrary, identification of organizational complexity within the parameters of probability provides the analyst with the most significant information.

Interdisciplinary considerations

Georgraphy has a long-standing tradition of making forays into other disciplines for data needed in investigation. With the introduction of systems theory into geographical undertakings, the inherent interdisciplinary nature of the method occasioned Preston James to remark (1972) that since geography is and has been a holistic discipline, "it comes as no intellectual shock to study systems of interconnected and interdependent parts of diverse origin." Yet, others have rightfully noted that geographers must push the intergrating feature of the discipline even further. Robson, for example, suggests (1973) that the current field of urban studies is distinctly multi-disciplinary rather than interdisciplinary. Thus, we may be witnessing the beginning of an era in which interdisciplinary thrusts will be a requirement and not merely a convenience. With many individual disciplines represented in efforts to address crucial problems facing the world, an interdisciplinary approach taking full advantage of the integrating strength of systems theory is essential. It goes without saying that anything short of maximum participation by geographers would be a serious omission, a point well made by Kirk H. Stone (1976) regarding the absence of geographer on the Limits to Growth study.

Finally, we may take a cue from Langton's statement (1972) that systems theory is, at present, most appropriate primarily for empirically based analysis. As such, the majority of geographers should have no aversion to using the organizing and integrating tenets of this methodology. Simon reminds us (1969) that at the present time

> the popularity of 'systems' is more a response to a pressing need for synthesizing and analyzing complexity than it is to any

large development of a body of knowledge and technique for dealing with complexity.

Synthesizing and analyzing must, of necessity, precede any attempts at dealing successfully with complexity at any scale. Nonetheless, all signs point to the recognized need to come to grips with complexity in meaningful ways. The answers to the questions of urban decay or the future of mankind in the year 2000 will not be forthcoming exclusively from geographers, or any other single discipline for that matter. The expansive and integrating nature of systems theory should not be neglected in our search for suitable analytical frameworks.

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