PROCEEDINGS

of the 1972 Meeting

of the IGU Commission

on Quantitative Geography

Edited by Maurice Yeates

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Foreword

Between August 9 and 17, 1972, the 22nd International Geographical Congress convened in Montreal in conjunction with the biennial meeting of the International Geographical Union. Over 2,200 persons attended the conference which embraced all aspects of geography. The IGU Commission on Quantitative Geography held two paper sessions during the period of the conference, and these sessions were extremely well attended by representatives from many delegations. This volume contains lengthy versions of papers presented at the two sessions, and as such it is to be regarded as a collection of articles relating to the development and application of quantitative methods in spatial analysis.

The papers have been arranged for publication in a sequence that appears to reflect the general interests of most geographers concerned with the use of mathematical models. The first, by Wilkie, is methodologically oriented, though his argument is couched in terms of a specific example. He neatly summarizes the work of the past few decades and indicates possible paths for future development. This is followed by a series of articles concerned with the development of spatial probability models. Hsu and Mason deal specifically with the boundary problem as it relates to the nearest-neighbor technique based upon the Poisson model. The work of Wellar and LaCava on the gamma probability density function is interesting in that it not only describes the derivation of the parameters of the model, but also indicates how the model may be used in specific spatial situations. The last article in this group, by Getis, focuses upon Polya models. This paper is notable, not only because of the clear presentation, but also because Getis includes a discussion of process as it relates to the interpretation of spatial probability models that appear to describe various distributions.

The article by Meyer contributes to our understanding of the structure of geographic interdependencies and uses two-stage least squares procedures applied to an urban residential location model to describe and assess the technique. This urban application theme is continued by Casetti who develops a model for urban population densities that maximizes a locational welfare function. Haynes and Rube use a different approach to incorporate social differences and physical deterioration into urban population density models, though it is to be noted that the derived utility function does not imply a specific density distribution.

The last two articles offer a change of pace as they are concerned with the application of mathematical programming models to spatial behavior. Normative

models of this type are extremely attractive in specific geographical situations where behavior can be regarded as rational within the evaluative and perceptual limits of the subject. Menchik discusses the nature of these limits within the framework of the Transportation Problem and develops an entertaining interpretation of "psychic transport costs" with respect to space preferences. At a more practical level, Mahadev and Rao use the model to examine the degree of optimality in the distribution of service facilities in Mysore, India.

The reader may care to fit these articles into the developmental model of Human Geography presented in Figure 3 of Wilkie's article. It is suggested that, taken together, they represent an increase in our level of understanding as well as scholarship over the quantitatively oriented contributions of a decade ago. It is recognized, of course, that this latter comment is based upon a qualitative assessment which depends upon the perception of the individual reader!

MAURICE YEATES,

Kingston
December, 1972

The Process Method versus The Hypothesis Method:

A Nonlinear Example of Peasant Spatial Perception and Behavoir

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How valid are multivariate statistical techniques of analysis based on linear assumptions? Is it possible that such techniques can at times misdirect the analysis in such a way that they may hide some relationships that exist in the real world? Many of those who work with quantitative data would agree that at times such techniques of analysis do cover up vital relationships between variables that exist only at certain levels within the data. Many others, however, seem to ignore this fact and thus fail to see countertendencies within various levels of data (e.g., subculture groups) that are canceled out when lumped together in aggregate linear statistical analyses. Therefore, it is the purpose of this article *(a)* to examine briefly the trend against exclusive use of linear analyses; *(b)* to point out that what this writer has called the Process Method is more effective than the Hypothesis Method for isolating the occurrence of nonlinear relationships in changing and evolving communities; *(c)* to demonstrate why spatial studies of the processes of change are necessary and that they are part of a behavioral period in geography that is already underway; and *(d)* to develop several lower-level techniques for examining and illustrating nonlinear relationships in a case study.

Illustrations throughout the article focus on the relationships among the following variables collected for each peasant family in the village of Aldea San Francisco, Entre Ríos, Argentina: *(a)* social-class position; *(b)* spatial perception of distances between and populations in communities within the region; *(c)* frequency of regional movement, and *(d)* sources of communication entering each household (local versus cosmopolitan media inputs). As will be shown below

in analysis of data on peasant spatial perception and behavior collected in the study area, linear analyses of research materials often failed to show the complexity of opposing processes at work in the community. In contrast, many nonlinear analyses yielded greater insights into different spatial perceptions, structures, and decision-making behavior of various population subgroups in the village.

One reason behind this occurrence is that different forms of human behavior arise out of different combinations of forces influencing decision-making within subculture groups, even within an apparently homogeneous lower-class peasant community. Two variables may correlate and have significance within one subgroup and have no significance among other subgroups. Further, it is the particular combination of interaction among many variables (some high, some medium, and some low) that produces a given form of behavior, not just the factors that have high correlation. Most studies which use linear forms of statistical analysis, however, do not isolate these different subgroups, but lump them together. Not only are the subgroups hidden within the aggregate totals, but the results often become misleading-not for those relationships that are linear at a given level, but for the nonlinear relationships that are judged to be insignificant and are discarded.

In all probability, the main problem between the use of linear and nonlinear techniques relates to the scale at which the data are analyzed. The close examination of a nonlinear relationship of aggregated data at the national or regional level often leads to the discovery of a subgroup where linearity actually exists between these same variables, but only within that particular subgroup. Thus it appears that the analysis should move through a series of steps beginning at the aggregate data level and slowly working down to smaller and smaller subgroups. At each step, nonlinear patterns can tell the researcher almost as much as the linear patterns, except that beyond a certain point the pursuit of nonlinearity will not prove to be useful. Somehow this problem of data scale is ignored, perhaps because of the view that higher-level laws of human behavior that cut across all groups are more desirable. Is it not more logical, however, for social and behavioral scientists to isolate first the laws of human behavior within the various levels of a given culture? The similarities and differences between subgroups can then lead us to higher and more encompassing behavioral laws as they are compared cross-culturally, but this cannot be done adequately if important intermediate steps are left out of the analysis by discarding behavioral laws for individual subgroups before they are even discovered.

It was the use of nonlinear techniques which helped this author give meaning to social class in Aldea San Francisco. For example, aggregate linear analyses showed that the variable, social class, did not correlate significantly with aspects of migration or with more dynamic forms of spatial perception and behavior. Once the social-class subgroups were isolated, however, it became obvious

Figure 1

A Typology of Peasant Types of Orientation and Behavior by Social Class*

Aldea San Francisco, Entre Ríos, Argentina

SOCIAL CLASSES	PERSONAL ORIENTATION	COMMUNITY ORIENTATION	SPATIAL AND ENVIRONMENTAL ORIENTATION AND BEHAVIOR	OUT-MIGRATION ORIENTATION AND BEHAVIOR
UPPER CLASS	EXTERNALLY DIRECTED (to peer group expectations and custom)	INWARD LOOKING (into the community)	-poor spatial perception -medium trust of the environment -greater regional movement -regional market preference split between larger and smaller regional centers	-least dynamic migrant group -move shorter distances -move to smaller communities -low percent of active migrants (based on greater authoritarian dictates- -family, social pressure, church, etc. --thus, more passive than other classes)
MIDDLE CLASS 2 types	INTERNALLY DIRECTED (to one's own resources)	OUTWARD LOOKING (from the community)	-good spatial perception -trust of the environment -greater regional movement -regional markt preference for the larger center	-most dynamic migrant group -move longer distances -move in larger communities -high percent of active migrants (most often planned and thought out along the lines of controlling one's life and environment --thus, greater psychological, social and spatial influence)
	EXTERNALLY AND TRADITION DIRECTED	INWARD LOOKING	-resemble either upper- or lower-class patterns	-resemble either upper- or lower-class patterns
LOWER CLASS	**TRADITION DIRECTED** (to custom & community expectations)	INWARD LOOKING (into the community) -but often based on fear and the unknown	-poor spatial perception -mistrust of the environment -lesser regional movement -regional market preference for the smaller center	2 types MEN--appear to be more dynamic, but probably due to chain migration -move longer distances -move to larger communities -last to leave rural area, but high percent active migrants WOMEN--less than men in each category & similar to the upper class (both based on greater economic need, but also strongly influenced by an authoritarian structure)

*This is a generalized typology that ignores the diversity of sub-groups within each social class, although it does represent the composite statement of the internal behavioral processes at each level in the community.

Richard W. Wilkie, 1970

through a combination of linear and nonlinear analyses that a group in the middle class stood out as having more accurate spatial perception and more dynamic behavior in most of the measured relationships than either the upper- or lower class groups.[1]

Figure 1 (Wilkie, 1972A, p. 103) helps to illustrate that, for the upper-class peasant, the decision to migrate is often based on dictates imposed by peer groups, family, or life styles encouraged by the Church, while the moves involve shorter distances and smaller new communities and are much more passively dependent upon others than are the moves by migrants in the middle and lower classes. For one sizable group of middle-class peasants, who are often more "internally directed" by psychological, social, and spatial influences, the decision to move is generally planned to control one's own life and to select carefully the physical and social environment in which one lives. A second smaller group of middle-class peasants also behaves much like the upper- and lower-class peasants. Lower-class peasants tend to be tom between their traditional authoritarian ties to the community and a greater economic need that works to force them out of the community. The lower-class moves, especially those of the lower-class females, are not well planned, do not involve many options, and are more chain-like than the moves of the middle class.

Although it appears to be a contradiction, both externally directed peasants (usually upper class) and traditionally directed peasants (usually lower class) look into the community. That is, they look away from themselves and into the community for answers, usually to peers or tradition. Internally directed peasants (usually middle class) turn inward to their own standards and core values for guidance of their behavior; consequently they look outward from the values and traditions of the community. Thus, for very different reasons, the externally directed and traditionally directed peasants hold Aldea San Francisco together as a community. In their eyes the internally directed peasants represent a disruptive force within the community because they do not adhere to custom and peer expectations. This often creates a push from within the community against peasants who are internally directed personally, and national- and world-oriented in general. This group. however, is also more receptive to pull forces from the cities than either of the other groups, and their moves tend to demonstrate a greater degree of planning and dynamic behavior than the other two subgroups. Thus, in spite of the fact that the variable social class did not surface from the aggregate linear analyses as significant, through nonlinear analysis it did turn out to be

[1] It should be noted that the use of the terms upper, middle, and lower class relate specifically to social stratification within the peasant community of Aldea San Francisco. Even though each of the three peasant groups personally identify with national upper-, middle- or lower-class norms, these peasants would be ranked by outside observers for the most part as lower class in the national socioeconomic structure. The significance of each of these subgroups within a lower-class peasant community would be lost without making this distinction.

extremely important, as vastly different migration processes were at work in each social-class group based on its own set of priorities, desires, dreams, and fears. One of the most interesting aspects of this analysis is that such great internal variation exists between population subgroups in what was thought to be a relatively homogeneous community that is lower class at the national level.

The Hypothesis and Process Approaches to the Laws of Human Behavior

Nonlinear relationships within the data are often ignored because most young scholars are trained to use the Hypothesis Method, which is considered the scientific approach. Other scientific approaches exist, however, and in gathering data for a study of migration in Argentina the standard Hypothesis Method was avoided because it usually permits testing only a few variables. Rather, a method was designed to generate enough data about human affairs in a peasant community to examine many complex and interrelated factors. Since the purpose of this approach was to measure a universe of variables involved in the various processes of change in Aldea San Francisco, the method was called the Process Method by the present author (Wilkie, 1968). Regarding the Process Method, this author states elsewhere (Wilkie, 1972A, p. 80):

> Such an approach stands in contrast to the so-called "scientific method" in which a limited hypothesis is set forth to test the relationship of a few variables which, *a priori*, are thought to be important. Studies of the processes of change demand an open-ended approach because seldom do only two or three variables relate independently from a maze of man's interactions, perceptions, and attitudes. In short. we are interested, for example, not only in finding out if A is related to B as might be hypothetically presumed, but, more importantly, how variables, A. B, C, D, E, F, G, H, etc., are interrelated to each other (A, B, and C may not be important m themselves but only when they combine with F).

Cattell (1966, p. 12) in contrasting the multidimensional and bivariate approaches supports this view. He has stated that the psychologist who pursues the multivariate approach

> may actually be proceeding more wisely than his far more exact bivariate experimentalist brethren. The important point is that he is attempting to bring into a single experimental field of reference *all* the variables necessary to detect and define the concepts that need to be employed for scientific understanding and without which it may not be possible to arrive at any lawful relationship. By contrast the bivariate experimentalist often starts out with such a meaningless fragment of the totality that it is impossible to encompass any lawful relation or construe the conceptual sentence. There is no particular reason *why* one should expect to find a simple and clean lawful relationship between any two of the two thousand variables that could be measured in a given situation. The lawful relation is more likely to exist between two or more abstracted *concepts*, each of which could be an underlying factor representable and measurable *only* by perception of a weighted combination of many variables.

Having suggested the existence of different approaches to discerning lawful relationships, let us explore the reasons why the Hypothesis Method tends to focus primarily on linear analysis, while the Process Method includes both linear and nonlinear forms of analysis.

The very nature of the Hypothesis Method[2] has led scholars to examine only the linear relationships between variables. Digman (1966, p. 460) states that:

> Typically, in an analysis of variance, an investigator is examining the plausibility of a hypothesis of *some* kind of relationship versus none. In this sort of analysis, the question of non-linearity is irrelevant, particularly where the experimental variables are not ordered, i.e., where they consist of qualitative categories.... In the case of a two-way or more complex design, interaction should always be of interest to the researcher. Unfortunately, the discovery of significant interaction is all too frequently regarded as an annoyance, which implies that investigators, looking for simple answers to questions, are disappointed to find complex ones.

The result of this method, all too often, is that many scholars examine only the linear relationships within the data, thus avoiding the problem of what to do about nonlinear patterns. Digman (1966, pp. 459, 475) states, however, that "linear methods are usually regarded as useful in the determination of first approximations of relationships ... [yet] investigations in the field of multivariate psychology have been characterized by an almost complete dependency on linearity and additivity." Gould's argument (1970, p. 441) that "most of us seem to be stuck in a linear rut" is consistent with the view of other observers (Baken, 1954; Camilleri, 1962; Lindquist, 1953; Lubin, 1961; Morrison and Henkel, 1969; Plackett, 1960; Rozeboom, 1960; and Sidman, 1952) who also raise the issue. For example, Morrison and Henkel (1969, p. 136) state that this approach often leads "to an emphasis on prediction on 'variance explained' in an acuarial sense rather than to concern with developing explanatory concepts and theories."

Gould (1970, pp. 440 -41) carries this argument against the exclusive use of linear analysis one step further by pointing out that many of the classical parametric statistical methods developed during the nineteenth and early twentieth centuries were founded on random distributions and used for "plausible descriptions of contemporary physical data and experiments, [which] are frequently quite meaningless as descriptions of social and behavioral data." In the study of human behavior the significant relationships may only be seen by consistency within whole patterns of interrelated variables which, if considered in isolated components, might not pass the sacred criteria of 95 percent confidence. The implications of a research perspective which subordinates logical significance to statistical significance are noted by Lubin (1961, pp. 815, 817): "Scientific inference is not identical with statistical inference. Tests of significance are certainly part of scientific methodology, but they are neither necessary nor sufficient for scientific induction.... [Thus the] most important questions arising out of a statistical finding of significant interaction are non-statistical ones of cause and control."

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[2] It has been suggested that it is unfair to set the Hypothesis Method up in the straw-man position, but that is not the purpose of this discussion. Since hypotheses can be useful in almost any research design, criticism is directed at the overstatement and overapplication by most (but not all) researchers who tend to claim that it is the only scientific approach.

Debates in the social sciences about the role of statistical significance tests in assessing substantive significance have increased considerably since the late 1950s. In sociology, for example, Taylor and Frideres (1972, p. 464) mention agreement "that substantive significance is not statistical significance, and that it is a mistake to confuse the two." Morrison and Henkel (1969, p. 139) state this case strongly:

> Alas, statistical inference is not scientific inference. To have the latter we will have to have much more than the façade that claims of significance provide. But how is scientific inference possible if significance tests are of little help? This question leads us beyond the scope of this paper, but we have offered some hints: replication over diverse samples as well as internally, the use of abstract concepts, and the incorporation of such concepts in deductive theories with the conditions of their validity specified. There are, of course, no computational formulas for scientific inference: the questions are much more difficult and the answers much less definite than those of statistical inference. In the absence of such computations ... [we] will have to use [our] brains. We agree ... that science will not suffer.

Not only is the researcher overly concerned with linear models, but as Cattell (1966, p. 13) points out, the hypothesis-testing researcher seldom makes major scientific breakthroughs in theory:

> Research need not begin with the hypothesis at all, and in its true life setting, a finished hypothesis is rarely the real germinal point of research action. It can begin with noticing a curious and intriguing regularity.... A statistical count of fruitful researches of any really frankly written history of science will show that the real turning point in major scientific theoretical advances, in a quite substantial and noteworthy proportion of cases, has been the noticing of just such intriguing regularities or irregularities as those in observed phenomena or tables of data gathered for some other primary purpose or out of sheer curiosity.

It should be noted again, however, that hypotheses in themselves are not to blame; rather, the method of using them is often abused. Instead of pursuing a "sacred ritual" where the entire analysis revolves around the central hypothesis, the Process Method lets hypotheses evolve out of the data that have been collected, as the nature of the relationships begin to take shape during the analysis.[3] Thus, the Process Method does not exclude the testing of hypotheses, but they are not central to the analysis. When the researcher is trying to discover cause and effect networks of relationships, which are different for each subculture group, the testing of hypotheses for every two-way relationship is often superfluous. This does not mean that a researcher should enter into a study without pursuing well defined goals, but it is important that he not let those predetermined goals limit spontaneous creativity. The researcher who uses the Process Method is in a much freer position to allow the results of the relationships within the data to shape both the kinds of process hypotheses to be posed and the theoretical laws of human behavior which will result.

Contrary to popular belief, it is not much more difficult to study a small group in great depth than it is to study a large group with only a few variables and a

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[3] Cattell (1966, pp. 15 17) refers to the creation of hypotheses from the data as the "inductive hypothetical deductive spiral."

hypothesis. except that one has to be more broadly trained. Nor is the selection of variables in the Process Method random, since great care must be taken in the construction of the universe of questions to be asked. Quantitative precision in the collection and handling of the variables is demanded on the same level as those who would test only several variables around a central hypothesis.

In short, it is not logical to confine ourselves only to the analysis of linear relationships and to rely for the determination of significance only on statistical tests, yet the standard Hypothesis Method leads researchers to do just that. It becomes too easy to forget or to overlook the fact, for example, that within the processes of change one force often works to counter another force, thus resulting in nonlinear relationships in the behavior of population subgroups. Studies which attempt to interpret these nonlinear relationships as well as the more obvious linear relationships are essential if our research is to reflect reality rather than to develop an artificial view of reality.

Linear Models and the Overemphasis on Studies of Structure

Part of the problem of dependence on linear techniques is an overemphasis on structural studies as opposed to studies of the processes of change. Change and the processes which bring about change are constant and part of reality. Some processes of change are rapid, others slow; but the constant flux makes change more normal than nonchange. Thus, change may be defined as the primary reality, and studies of the processes of change considered fundamental to any theory about human social existence and interaction.[4] In contrast, structure is a more formal concept-an abstraction made from reality for one moment in time, often as an idealized model of what the system is under perfect conditions.

Structural analysis is useful as a conceptual tool for understanding complexities, but since structures evolve constantly, those structures which are analyzed at one moment in time do not offer views of reality. but rather momentary truths. Most truths fade fast on rapidly moving research frontiers. The average life of a truth in the physical sciences is considered to be about ten years. Are we to assume that a truth in the social and behavioral sciences should last longer than a truth in the more precise sciences. or are we to recognize that with constant change we must constantly redefine new structures (the new truths)? This is not to say that all laws or truths are to be discarded at regular intervals. Rather, we must learn to think in terms of defining processes of change on an equal basis with our efforts in defining structures. Too many researchers, however, stop with

[4] Bergmann (1957, 1962) argues that process knowledge is the ideal in the sense of being the ultimate goal of all science, and to possess process knowledge is to know (1) the conditions of closure ft)r the study of controlled boundary conditions, (2) a complete set of relevant variables, and (3) the process laws.

structure, and base theory on these findings in a rather deterministic manner. This form of determinism leads many researchers in each discipline to look for causes only in the structure of their own core specialty.

Nonlinear Models and Complicated Truths

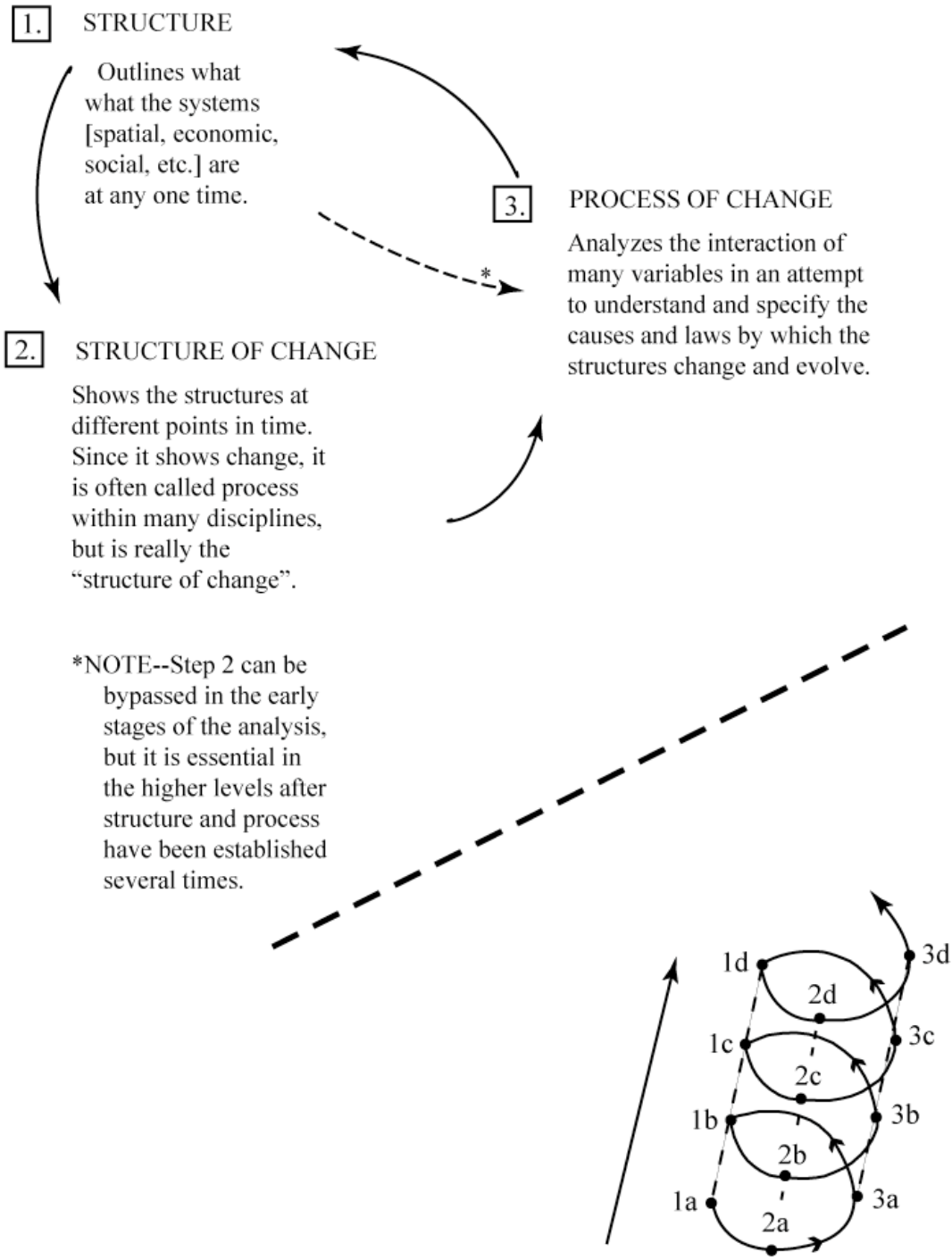
Because of such problems, it seems more reasonable to base theory on a changing multidimensional system that attempts to explain the change dimension in a given discipline (e.g., spatial change) rather than to base it on the more static system which centers on only the structural components in that one discipline (e.g., spatial structure). Much of the widespread dissatisfaction with existing theories in the social sciences may reflect this preoccupation with structural patterns and a neglect of small-scale generating processes which invariably involve the interaction of structural components of several disciplines. If analysis of changing and evolving systems gives a more valid understanding of reality, theories should be based on forces that bring about change and the processes of change.[5] Thus. the study of process is a more unifying concept for the social and behavioral sciences and humanities than studies of structure; studies of process encourage scholars in various disciplines not only to make their work more relevant to others but also to search those other disciplines for important variables of explanation fm use within their own component of concentration.

To infer that structural studies have not outlined change over time would be somewhat misleading. Many social scientists have studied what they call process, or change over time, but in most cases these studies have represented a second gage in structural analysis (see Figure 2), or perhaps an intermediate step between structure and process. These historical base-line studies only tell us in what way the systems have changed from one moment in time to another; generally they do am tell us how the change occurred.

Figure 2 illustrates how these three approaches or stages fit together to create a kind of spiral staircase of ongoing understanding within a given disciplinary component. Each of the three approaches represents a supporting column for the study of change, just as each of the three represents a step on the staircase. Step I (structure) outlines what the systems are at any one time. Step 2 (structure of change) is built on the first step, and shows comparatively how the structures have changed from one time period to the next. Step 3 (process of change) is built on the first two stages, and analyzes the interaction of many variables in an attempt to understand and specify the causes (and laws) by which the structures

[5] For example, we cannot understand spatial change only by studying spatial structure and organization; rather we must examine how spatial structure and organization interact with psychological core values as well as with social, economic, political, temporal, philosophical, ecological. and other structural systems to give us greater insights into an evolving spatial order.

Figure 2
Simple Structure and Process Interaction Diagram
showing research approaches in the study of human behavior



change and evolve. Finally, knowledge of the laws that determine the processes of change then allows us to reset the definitions of the structures at a more sophisticated and higher level. This entire analytical progression is ongoing, each step built on the others.

All three steps are of equal value and dependent upon the other two steps to reach a higher level of understanding. Step 2 (structure of change) can be bypassed initially in many studies, but eventually it is a vital step in the analysis as it yields insights into the forces of change themselves.[6] The processes of change, however, cannot be understood without first establishing what the structures are that are changing, nor can we understand the laws behind the structural systems without studying the processes and forces that are shaping and changing them. Although the traditional Hypothesis Method could be used to explore Steps 2 and 3, it usually focuses on Step 1 -outlining structure, while the Process Method tends to focus on Step 3 --outlining the process of change.

Structure and Process Trends in Human Geography

Perhaps it is too early to suggest that the trends in human geography in the twentieth century that are outlined in Figure 3 will accurately predict the 1970s and 1980s. If the need for understanding processes of change shown in Figure 2 can be taken to predict short-term direction, spatial processes and behavioral geography in general will continue to expand. This does not mean that the behavioral approach will or should be the exclusive emphasis in geography. On the contrary, a diversity of approaches should be encouraged as necessary for the total development of the field as outlined in Figure 2. In fact, while it does not show up clearly in Figure 3, all three approaches discussed here--cultural historical, structural, and behavioral are interdependent. All three methods need to be strengthened so geography can move into the structure-process period (D in Figure 3) where each is recognized as being of equal value and each builds on the other two (spiral in Figure 2). Until that time, the three approaches will most likely be concerned with maintaining their own independence and traditions while maintaining an air of superiority.

The placement of the cultural-historical approach on a lower level of understanding is not an evaluation of that school of geography in a qualitative sense.

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[6] Not only is Step 2 (structure of change) essential in understanding how structures and processes within various disciplinary components change over time, but the structure of change provides longitudinal studies of keys to another level of understanding. While Step 3 (process of change) specifies how interrelated factors lead to change, it is not supposed that these dynamics remain constant. Therefore, once the processes of change have been initially established in Step 3, longitudinal studies of changing structures and processes themselves will provide laws governing these forces. Additionally, philosophers of science will move beyond explaining the structures, structures of change, and processes of change in various disciplinary components (e.g., social, political, spatial, etc.) and will want to explain the laws behind the structures, structures of change, and processes of change themselves. Consequently all three steps are of equal value in the ongoing understanding process of human behavior.

The point being made is not that one approach is more important or reaches a more meaningful level of understanding than the others, but that each provides a base of support which opens up new insights and possibilities for the other methods. Without the base of strength that the analytical-descriptive period of geography provided, the structural period could not have evolved as rapidly as it did. Additionally, the behavioral period is building from the already established bases of the other two approaches, especially the more recent structural (spatial organization) period. As the interaction between geographers in each of these major trends gains momentum, it will become clearer that the ultimate strength of each depends on strength in all three. Ideally, geography should reach a period of more harmonious equality (spiral in Figure 2) in the structure-process period (D in Figure 3).

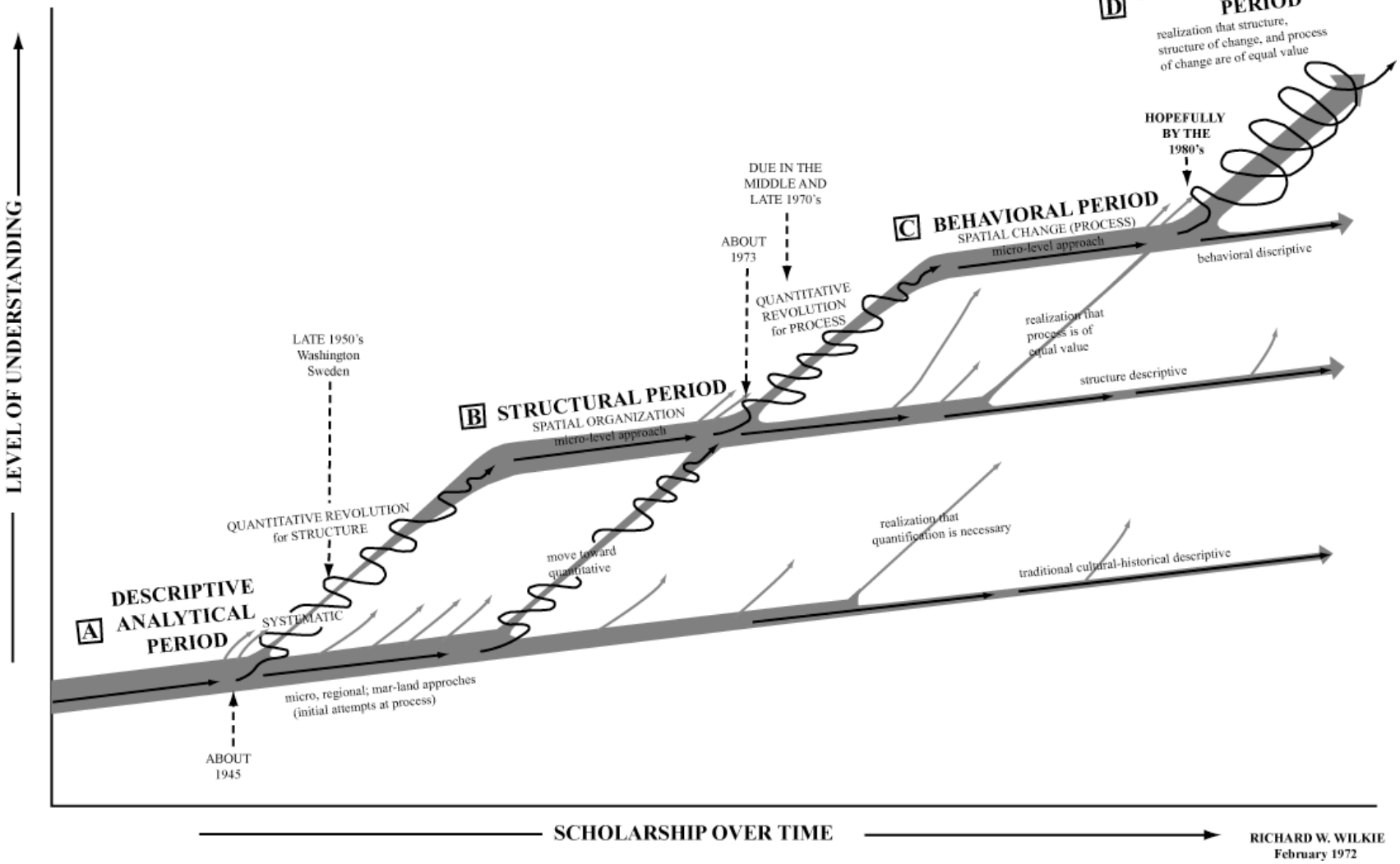
This means that a high priority should be given to the development of the behavioral process approach to geography. Until it is more fully developed, it will remain as a major roadblock holding up the ultimate advancement of all of geography. To make this needed breakthrough in behavioral geography, however, there must be a second quantitative revolution, this time to develop techniques of analysis for process. With certain exceptions, the quantitative techniques used and developed for understanding the more static structures will not accomplish what is needed in order to understand dynamically changing relationships. This paper does not have a solution to this dilemma, but it does provide several lower level techniques that may help other researchers who are seeking insights into the complexity of diverse forms of subgroup spatial behavior.

Isolating Levels and Subgroups within the Data

Isolating the unit of analysis for a study of the processes of change has always proved to be difficult. The different behavioral processes operating within subgroups of society only come to light when the data are divided into levels with natural breaks between. One of the least complicated methods for discovering these natural levels is through the analysis of both data arrays and bivariate scatter diagrams. This approach requires close visual examination of the data frequencies and diagrams, as well as close personal familiarity with the data from the interviews through to the analysis. Instead of forcing divergent groups into a continuum, the researcher is able to distinguish, for example, between groups which show great growth and change and those which reflect relatively static positions. As Rosenberg (1971, p. 56) notes: “One of the major errors psychology continues to make is that it treats the human organism as a *closed system*, a mechanical model of fixed inputs and predictable responses. I would like to suggest that the human being is an open system, capable of change and endless growth. We should abandon the mechanical model for what might be called the process model.”

One technique- mathematical distortion-has ignored these differences, yet it

Figure 3
Structure and Process in Human Geography in the Twentieth Century



RICHARD W. WILKIE
February 1972

is commonly used by researchers for ease of analysis. This distortion, which allows linear analyses of the data. does not allow the researcher to isolate readily the various subgroups which exist or to permit easy identification and interpretation of the particular levels in variables at a later stage in the analysis. If we are ever going to meet the needs and provide meaningful options for the various subgroups in society (even subgroups within subgroups), it is important to know that they exist, where they exist, and what their needs and aspirations are. This can never be accomplished if they are lumped together in ways that often cancel each other out of having any statistical significance.

It is true that ultimately most meaningful relationships are linear within any behavioral subgroup if they are to be significant. But the question is: How does one isolate the behavioral subgroups before one tests for linearity or nonlinearity to discover significance? This author found that close analysis of data arrays and scatter diagrams for nonlinear patterns in the aggregate totals helped to isolate the existence of these subgroups. To have depended exclusively on linear tests for significance at the aggregate level would have been grossly misleading for those variables which were linear only within one behavioral subgroup. Therefore, the analysis should move through a series of steps beginning at the aggregate data level and slowly working down to smaller and smaller subgroups. At each step one can determine what pattern exists- linear or nonlinear. If nonlinear, it can tell the researcher almost as much as the linear pattern. It should be stressed, however, that a number of variables are needed in order to give consistency between nonlinear patterns.

The lack of detailed data for isolating levels and dissatisfaction with the techniques of analysis has led many researchers who are working on structural studies to feel a sense of incompleteness in their work. Such a feeling of frustration has been well described in a self-revealing novel by an economic historian, Williams (1960, pp. 9-10):

> It is a problem of measurement, of the means of measurement, he had come to tell himself. But the reality which this phrase offered to interpret was, he could see, more disturbing. He was working on population movements into the Welsh mining valleys in the middle of the nineteenth century. But I have moved myself, he objected, and what is it really that I must measure? The techniques I have learned have the solidity and precision of ice-cubes, while a given temperature is maintained. But it is a temperature I can't really maintain; the door of the box keeps flying open. It's hardly a population movement from Glynmawr to London, but it's a change of substance, as it must have been for them when they left their villages. And the ways of measuring this are not only outside my discipline, they are somewhere else altogether, that I can feel but not handle, touch but not grasp. To the nearest hundred, or to any usable percentage, [a move like my own) is indifferent, but is not only a relevant [move]: without it, the change can't be measured at all.

This quote underscores the basic differences between research projects which are bound up in limited studies of structure and studies of process which examine the forces that together create an action pattern of human behavior.

In order to illustrate the Process Method developed here, the following section discusses the interrelationships of four variables which have been selected from a comprehensive analysis of interaction and change in an Argentine peasant community presently being developed by the author.

Illustration of Nonlinear Analyses in the Process Method

The argument developed here to support the use of nonlinear forms of analyses involves (*a*) showing a need for the use of nonlinear techniques; (*b*) developing a way to examine and illustrate nonlinear relationships; and (*c*) analyzing the relationships among four variables: social-class position, accuracy of regional spatial perception, total regional movement during one year, and primary source of communication information for each peasant household group.

These four variables were selected from 136 variables collected on all 290 inhabitants (58 household groups) of Aldea San Francisco, Entre Ríos, Argentina. In an intensive study of this community, between 300 and 600 items of data were collected for each family. These items were grouped into 136 composite variables that cut across the major components within the community, including demographic, economic, psychological, social, spatial, political, historical, and ecological components (Wilkie, 1968).

The Nature of a Nonlinear Relationship: Social Class and Regional Spatial Perception

When data on social class[7] in Aldea San Francisco are tested against regional spatial perception (distance between and populations of communities within the region), most researchers probably would decide that no relationship exists because the correlation coefficient of 0.06 is neutral. A scatter diagram of the same data. however, reveals in Figure 4 that a pattern exists which helps us to understand how social class in Aldea San Francisco is related to many forms of spatial and social behavior. In the first stage of analyzing the diagram, there is little the researcher can do beyond noting that more accurate regional perception builds to a peak in the middle class and then drops sharply within the upper class.

Analysis of my field research notes, however, facilitates preparation of a modified diagram (Figure 5) which corrects two regional perception cases that seem to be out of position. One case of low regional perception, circled **X** in Figure 4, is an elderly widow who spent most of her life in the upper class and was forced to sell off land possessions in order to obtain funds after the death of her husband.

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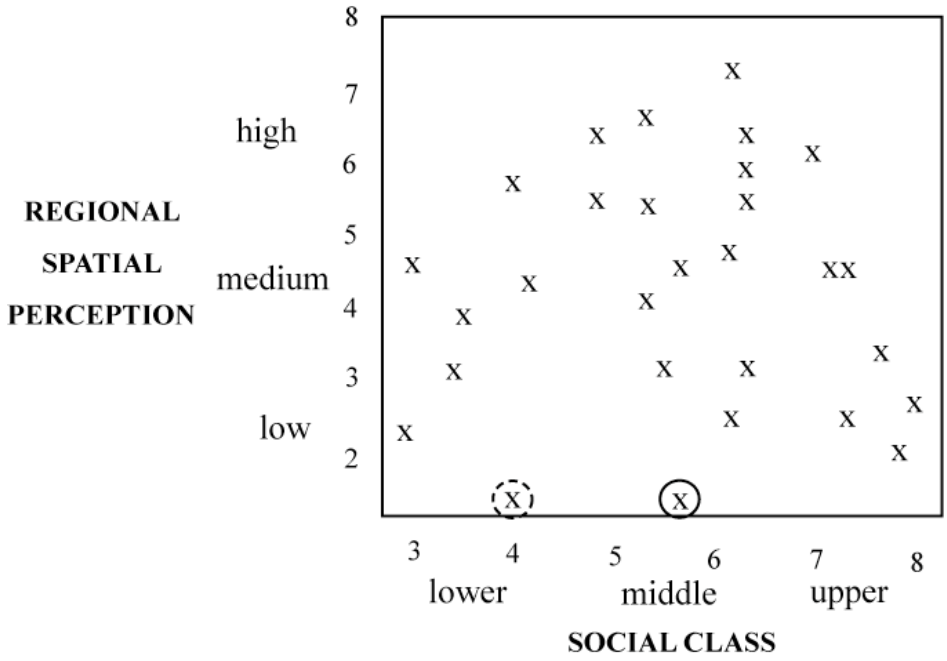
[7] Social -class groups were determined by scaling the average score (0 to 9) given by each head of household for every other family in town on the “good life.” Since each respondent had to define the -best possible life" as well as the "worst possible life," the scores reflected definitions set by the respondents rather than the researcher. These good-life rankings proved to be highly correlated with conditional measures of social class (Wilkie, 1968 and 1972A). These rankings had a correlation of 0.88 with economic stratification and 0.76 with respondents' scores of interpersonal confidence with every other family.

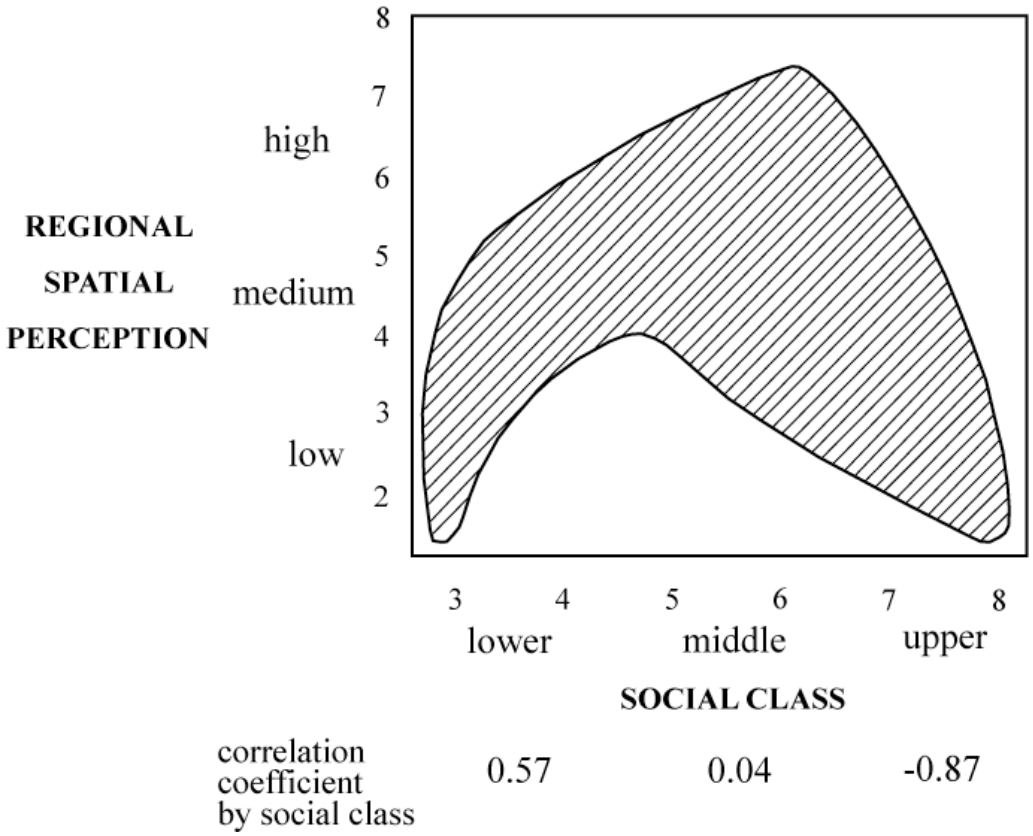
Figure 4
Scatter Diagram: Social Class and Regional Social Perception
(correlation 0.06; n = 31 families & 155 inhabitants)



For this reason she is now ranked in the middle class although her spatial perception remains consistent with the upper class. The second case, **X** in broken circle in Figure 4, represents a peasant who is one of the poorest in the community, yet is honest, well liked, and ranked higher in social-class status than his economic position warrants. If these two cases are changed and placed in corrected positions according to economic rank, the curvilinear pattern, as seen in Figure 5, is even more obvious. For the rest of the analysis, however, these two cases will remain where they are in Figure 4, as the other peasants perceive them.

A next step in the nonlinear analysis of the variables social class and regional spatial perception is to investigate the nature of the relationship within the various natural levels of the data. This can be accomplished in a number of ways. First, one may run a separate correlation analysis of these variables for each social class. By social-class level. the correlation coefficients are 0.57, 0.04, and - 0.87 for lower, middle, and upper classes, respectively. This tells us a great deal more than does the correlation coefficient of 0.06 for the three groups combined. The significant rise in the linear correlation among the lower class, the nonexistence of any relationship among the middle class, and the strong negative linear relationship among the upper class helps to show the curvilinear nature of the relationship.

Figure 5
Nonlinearity Between Social Class and Regional Spatial Perception



Another way of viewing this relationship is by using a cross-tabulation matrix presenting the total number of individuals failing into each of the possible combinations. Figure 6 illustrates a three-by-three matrix case. Both Digman and Lubin suggest that this technique helps to uncover more sophisticated levels of interaction in the data by making the patterns within the data visually apparent. Lubin (1961. p. 815) expresses the point of view (in a medical context) that it is "far more important to determine the form of the equation relating the treatment effect to the block effect than to make accurate statistical inferences about the variance of the difference between two means." Thus, he is saying that treatment of the patient varies on the variables examined by where the patient falls in the matrix. There are nine different medical approaches to a person with a given illness rather than only two-yes or no-based on linear statistical significance of the variance from the means.

Digman (1966. pp. 460-61) uses a visual representation of such data in graph form, as illustrated in Figure 7, where the height of each bar is equal to the number

Figure 6
Possible Combinations in a Two-way Matrix of Three Levels Each

VARIABLE B	A1 LOW	A2 MEDIUM	A3 HIGH
B3 HIGH	low-A HIGH-B	MEDium-A HIGH-B	HIGH-A HIGH-B
B2 MEDIUM	low-A MEDium-B	MEDium-A MEDium-B	HIGH-A MEDium-B
B1 LOW	low-A low-B	MEDium-A low-B	HIGH-A low-B

VARIABLE A

Figure 7
Interaction in a Two-way Analysis of Variance: Social Class and Regional Spatial Perception

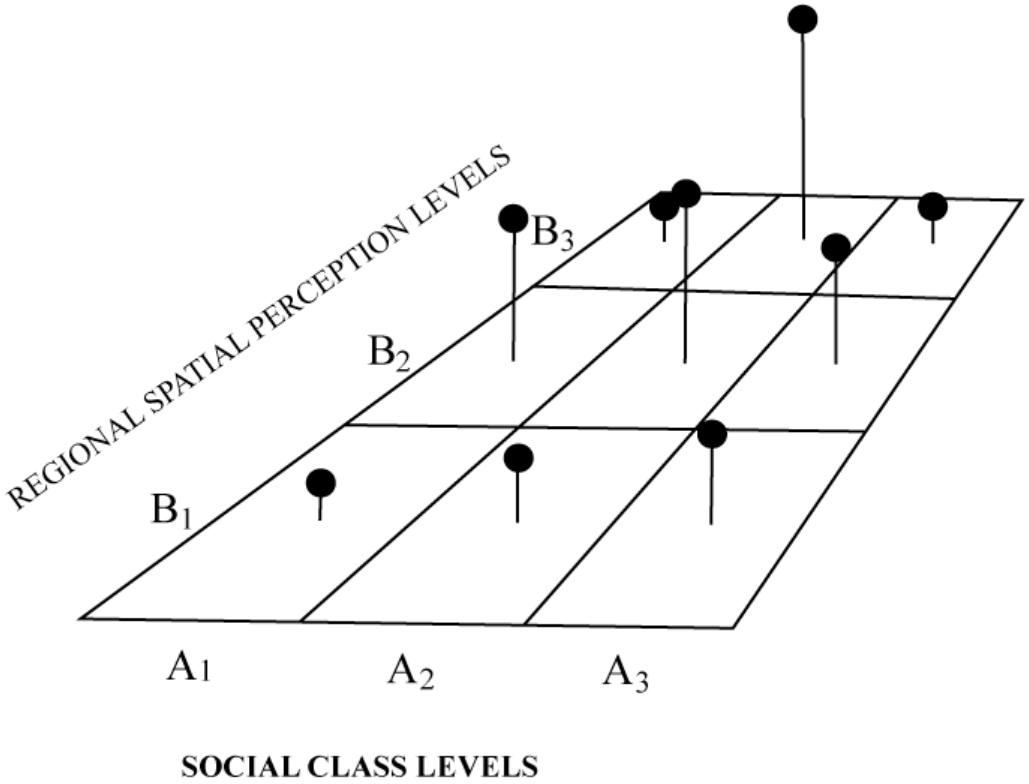
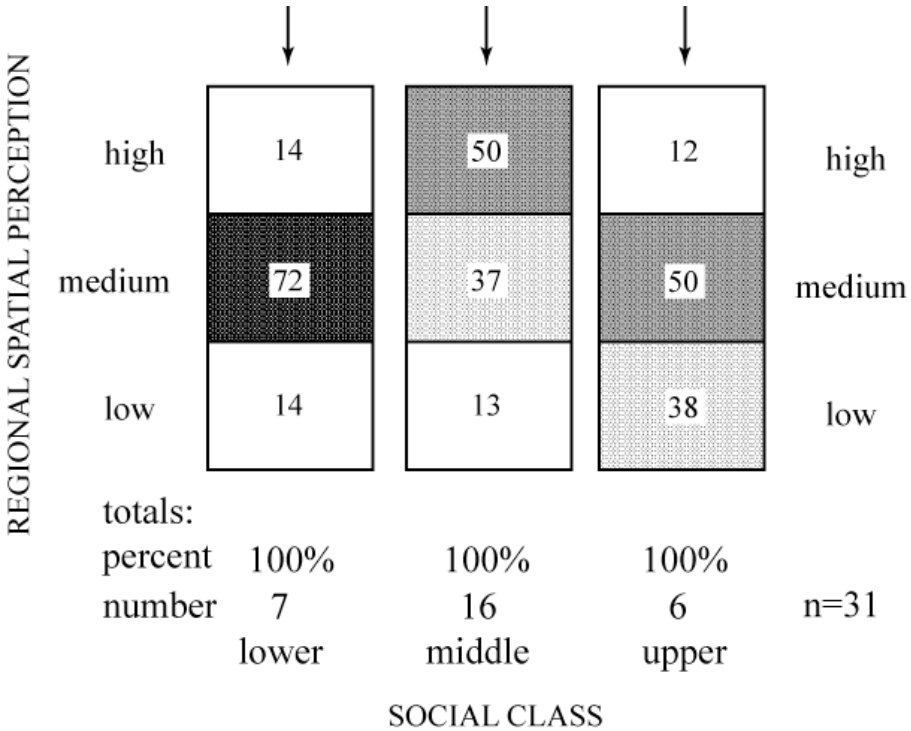


Figure 8
Peasant Regional Spatial Perception by Social Class Level

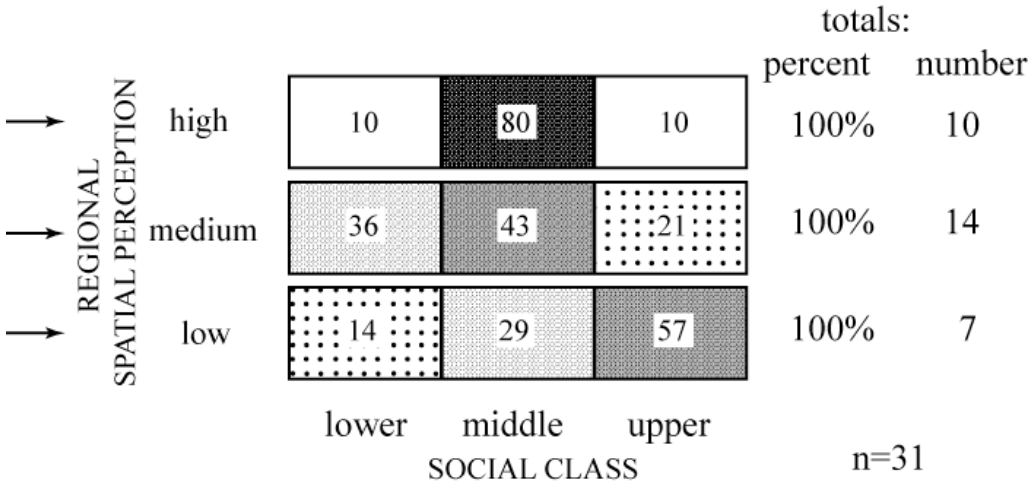


of cases in each of the nine units. This visual presentation, however, lacks the precise percentages that fall into each box of the matrix, even though the researcher can see that linear relationships exist in row B_1 and column A_2, and curvilinear relationships exist in rows B_2 and B_3 and columns A_1 and A_3.

Figure 8 illustrates that another way to view the matrix is to show the percentages in each social class that fall into the categories of high, medium, or low regional spatial perception. Both the lower and upper classes have their highest proportions (72 percent and 50 percent, respectively) in the medium regional spatial perception level, while the middle class has its highest proportion (50 percent) in the high regional perception level. By adding gray background densities to the percentages, there is an additional visual element that makes the nature of the curvilinear pattern even more obvious. Either the use of Zipatone or photographic use of line screens yields the desired gray densities. The researcher may find these options helpful in discovering nonlinear patterns operating within the data as well as in illustrating select patterns to a wider audience who is less familiar with the data.

In addition, it is helpful to examine social class and regional spatial perception with reference to the percentage of lower-, middle- and upper-class peasants in each level of regional spatial perception. Figure 9 shows that of those peasants

Figure 9
Peasant Social Class by Regional Spatial Perception Level



with high regional spatial perception, four out of every five (80 percent) are in the peasant middle class, while of those with low regional perception, slightly more than half (57 percent) are in the upper class. Thus, it is obvious that a much larger group of peasants within the middle class has a good grasp of distances between and the sizes of regional centers than do the peasants in either the lower or upper classes in Aldea San Francisco. This ability to understand the spatial network in which the peasants operate daily ultimately leads to a more dynamic group of out-migrants. Of 99 out-migrants studied using this variable, only one in five (22 percent) of those who moved one time came from families with high regional spatial perception. This figure rose to two-fifths (41 percent) for two moves, and for three or more moves three out of five (59 percent) came from families with high regional spatial perception (Wilkie, 1972B).

Analyzing the Relationships among Four Variables

The discovery of a nonlinear pattern that appears to be significant may provide very little insight into the analysis unless other variables which have been collected also back it up. The real meaning behind the pattern will show up through a logical consistency in the relationships from one set of variables to the next. By adding two new variables for each family--regional movement and sources of communication - we are able to enrich the interpretation of the analysis. The relationship between social class and regional movement (see Figure 10), for example, shows that the relationship is nonlinear except for one subgroup of upper-class peasants which has the highest frequency of regional movement in spite of the fact that the upper-class peasants have the lowest mean scores in accuracy of regional spatial perception. Thus it appears, at least among this one subgroup, that a greater frequency of regional movement to other centers does

Figure 10
Scatter Diagram: Total Regional Movement and Social Class Position
(correlation coefficient: 0.47) n = 39

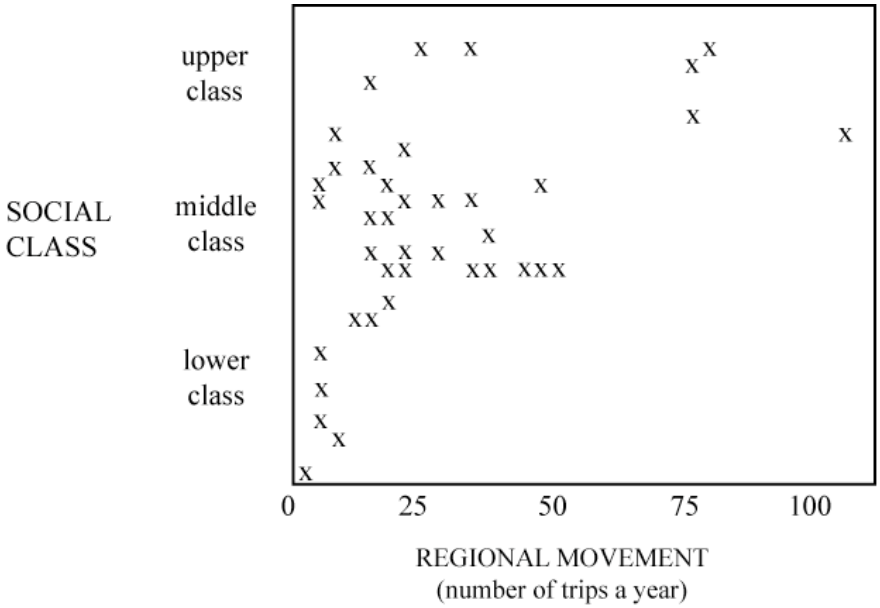
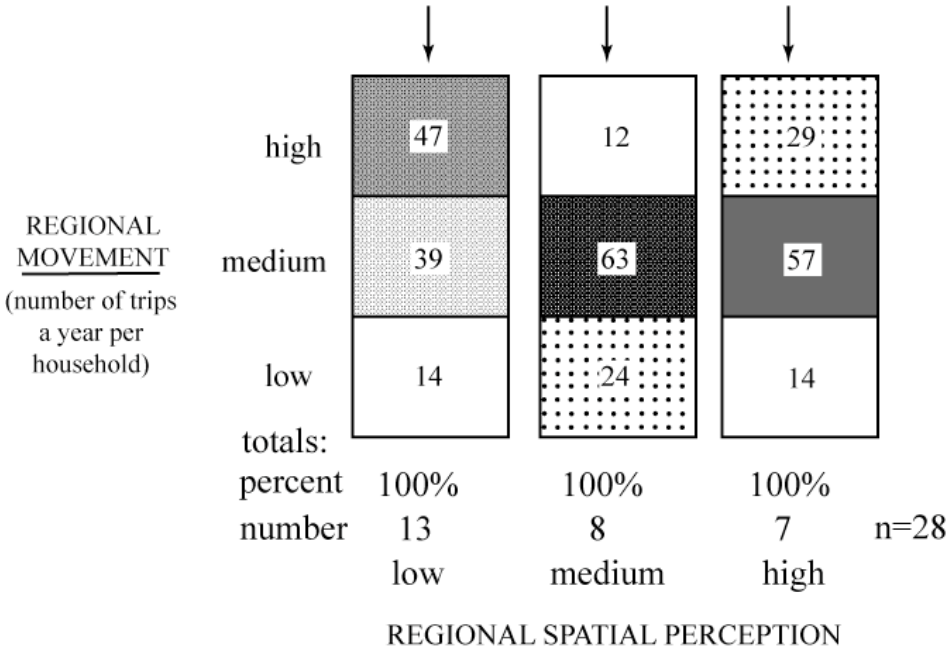


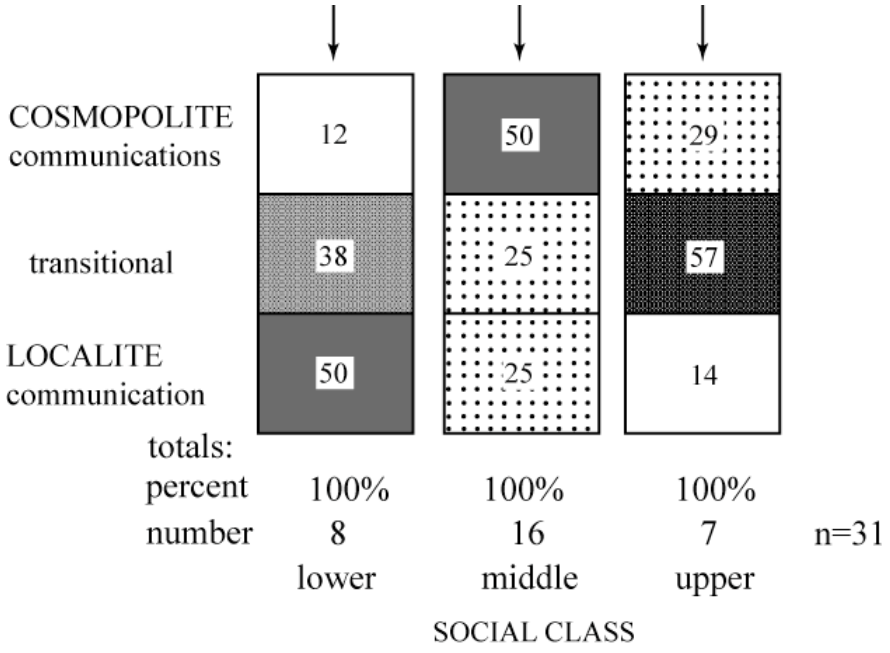
Figure 11
Regional Movement by Regional Spatial Perception Level



not necessarily lead to an increased perception of community sizes and distances. Surprisingly, it may be noted in Figure I I that nearly half (47 percent) of those peasants with low spatial perception have high regional movement, while over one-half (57 percent) of those peasants with high spatial perception have only medium regional movement.

The final variable added to the analysis concerns the sources of communication (information) entering the household. At one extreme, orientation of the peasant toward the national and urban life for sources of information is used to designate the peasant as a "cosmopolite" (Merton, 1957, p. 18). At the other extreme, dependency on only local sources for information classifies the peasant as a "localite." Interaction between source of communication and each of the other three variables is found in Figures 12 and 13 (social class), Figure 14 (regional movement), and Figure 15 (regional spatial perception).

Figure 12
Sources of Communication by Social Class Levels



In analyzing the relationship between source of communication and social class, observe in Figure 12 that the middle class is highest in cosmopolite communication (50 percent), the upper class is highest in the middle transitional category (57 percent), and the lower class is highest in localite communication (50 percent). By examining only the localite level in Figure 12, we see that there is a decline in the percentage of localites as the social class level goes up. This trend

Figure 13
Peasant Social Class by Source of Communication Level

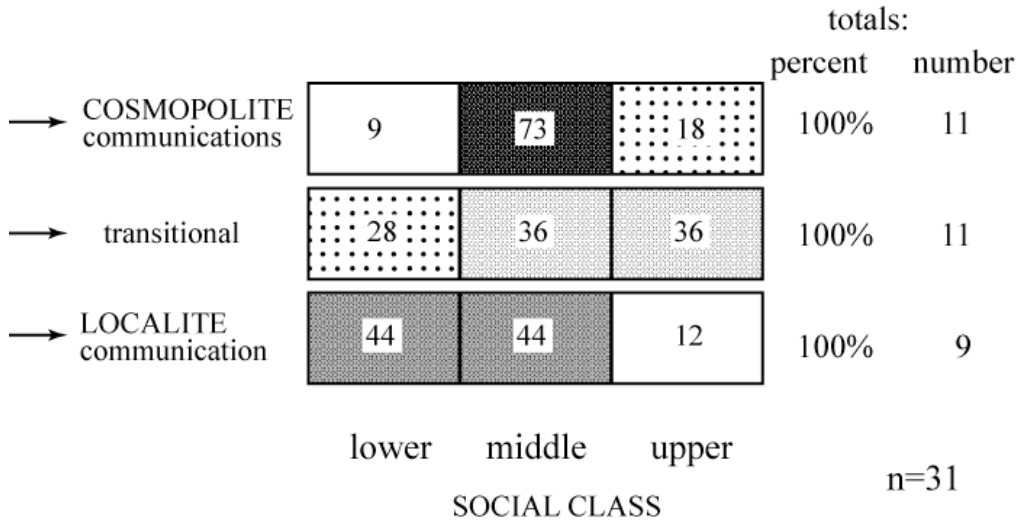
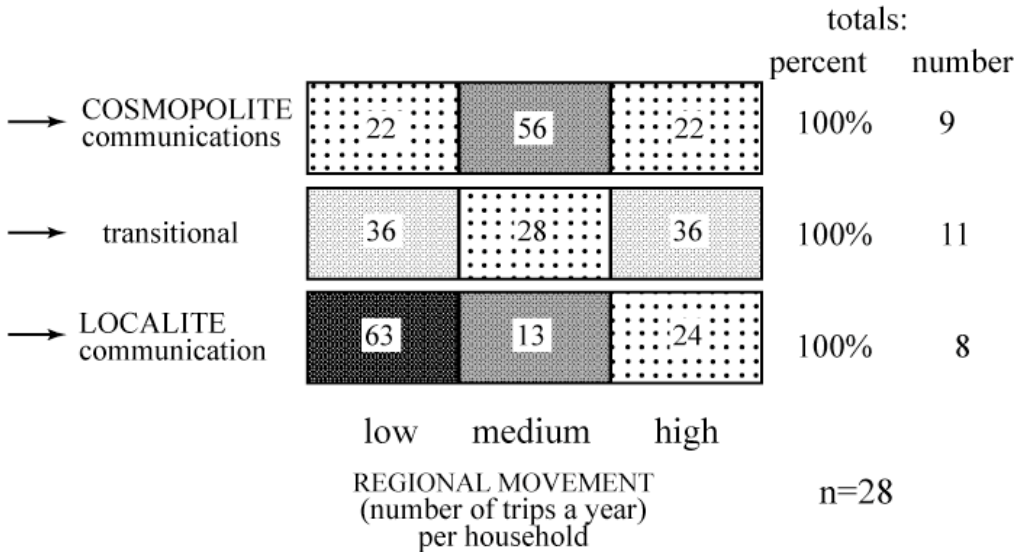


Figure 14
Regional Movement by Levels of Communication Orientation



does not lead to a cosmopolite orientation in the upper class, but to a transitional orientation where a mixture of both rural and urban sources of communication is found. A cosmopolite orientation is found most often in the middle class (50 percent).

Several observations can be made by analyzing Figures 12 and 13 together. First, although only one-half of the middle-class peasants are cosmopolites, they

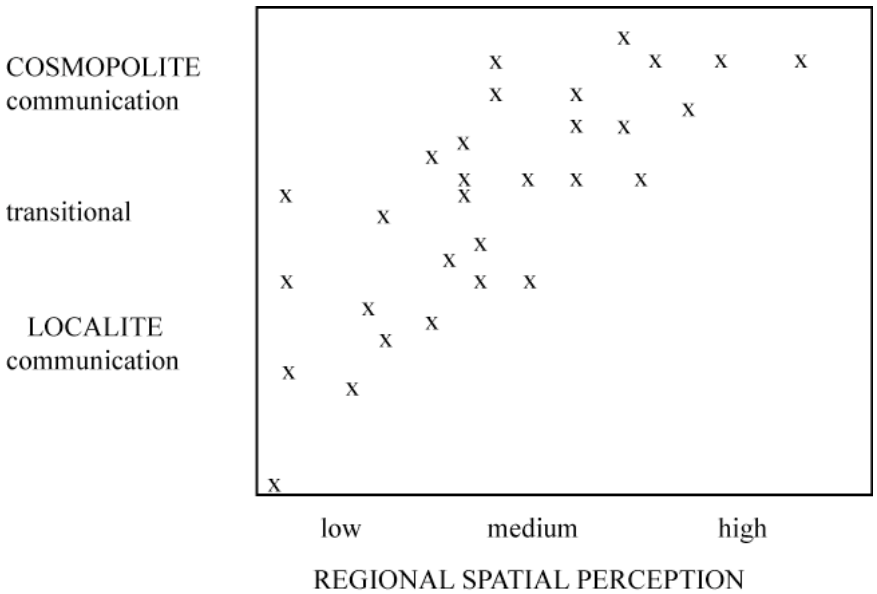
make up nearly three out of every four (73 percent) of all cosmopolites in the community. This is partially explained by the fact that 45 percent of the community is middle class, 30 percent lower class, and 25 percent upper class. Second, more than one-half (57 percent) of the upper-class peasants are transitional, yet they make up only slightly more than one-third of the community members in that category. Finally, in the localite level one-half of the lower-class peasants are localites, and they make up slightly under one-half (44 percent) of all localites in Aldea San Francisco.

Since the largest group of cosmopolites falls into the middle class and the middle class moves about in the region less than the upper class, we may hypothesize that cosmopolites also have lower regional movement. This in fact is the case. Figure 14 shows that higher regional movement does not correspond highly with cosmopolite orientation, just as it does not lead to greater spatial perception of the region. The largest group of cosmopolites (56 percent) is found in the medium level of regional movement, while of those with high regional movement, only about one peasant in four (22 percent) is a cosmopolite. No clear pattern emerges in the transitional communication level, as it is evenly divided between low, medium, and high regional movement. In the localite level, however, nearly two out of every three peasants (63 percent) have low regional movement. Thus low movement corresponds with localite, but high movement does not correspond with cosmopolite- medium movement does. In fact, among medium regional movement types, the percentage at each level of source of communication increases monotonically as we move up from localite (13 percent) through transitional (28 percent) to cosmopolite (56 percent). This pattern is reversed among low regional movement types, and both of these patterns help to accentuate the curvilinear nature of the relationship.

At this point in the analysis we can ask an important question: Why do those peasants who have (*a*) a cosmopolite orientation to information and (*b*) a high spatial perception of their own region have less regional movement than many others? Here we can hypothesize that since they know more about their own region and the outside, they plan more carefully the trips that they do make, and their trips tend to be less random in frequency compared with those of other groups who seem to travel more on whim than on rational planning. Using the Process Method (which does not exclude the testing of Process Hypotheses but lets the results of the data help to generate hypotheses), it is possible to turn to a number of other variables that may interrelate with frequency of regional movement, such as planning and life reflection, attitudes of parents toward child exploration, trust versus mistrust of the environment, ambition versus resignation, and/or many others. In fact many of these variables do support this hypothesis (Wilkie, 1973), but it is not feasible to go into them here. If the standard Hypothesis Method had been used from the beginning. the hypothesis most likely would have been that higher regional spatial perception and interest in cosmo-

polite sources of information would lead to higher regional spatial movement. Having discovered that this is not the case, the researcher would probably have discarded the variable and missed the real implications of the data. Furthermore, items relevant to the problem would not have been collected.

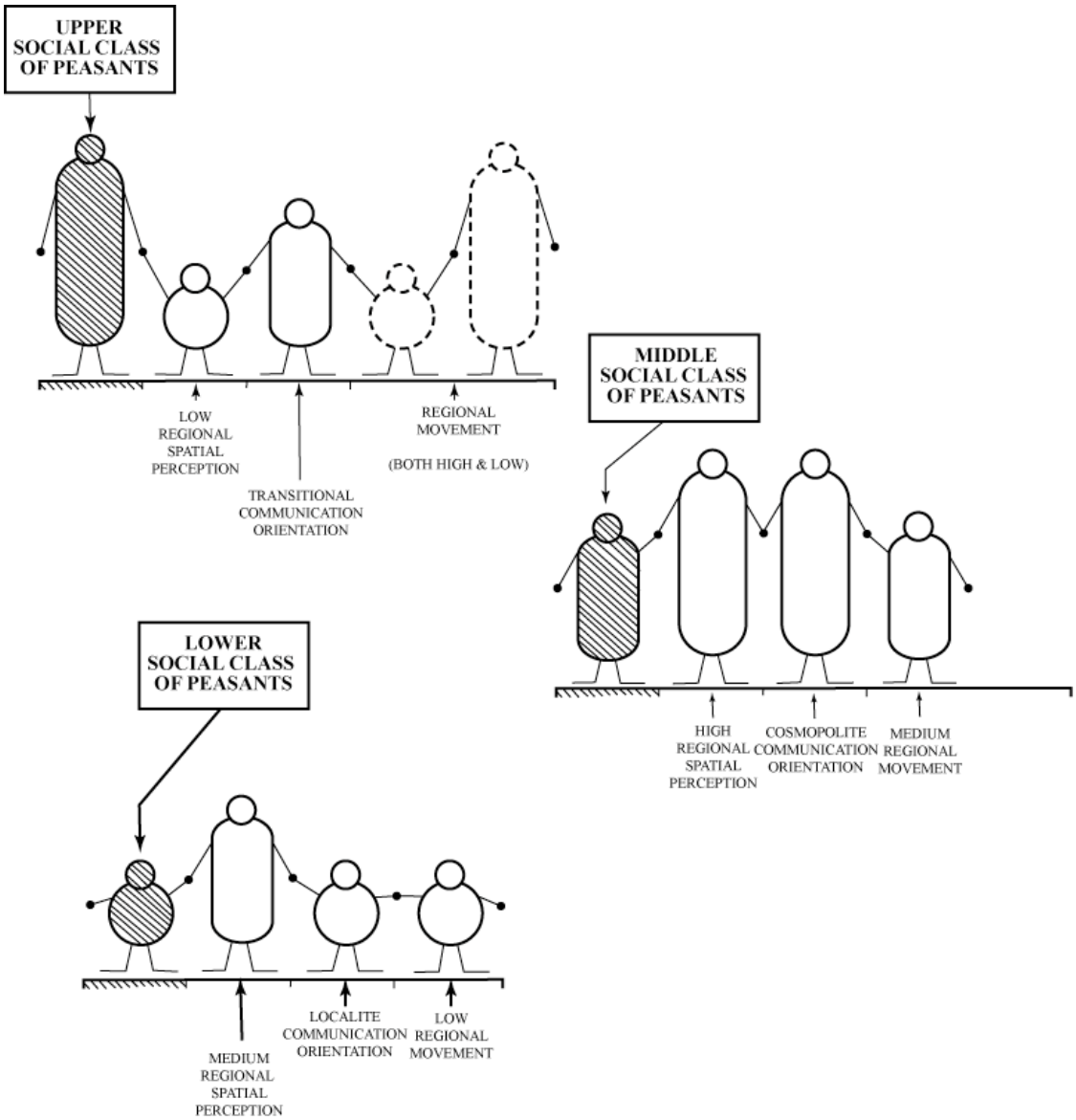
Figure 15
Scatter Diagram: Regional Spatial Perception and Communications Orientation
(correlation coefficient: 0.71) n = 31



All of the relationships examined to this point have been nonlinear, yet have been quite revealing. One last analysis of the relationship involving the original four variables, that of source of communication and regional spatial perception, remains to be made, however, and Figure 15 illustrates that the relationship is linear and has a correlation of 0. 7 1. Thus, the more a peasant understands and perceives properly the spatial system in which he functions from day to day, the more he is also oriented to communication from the outside world. Knowledge of one's own habitat and confidence in that knowledge seems to create cosmopolites; and, in addition, as one's interest in the outside world increases. there is an increased awareness of one's immediate environment. These influences can become circular and part of the behavioral system for that particular subgroup.

A major purpose of this analysis has been to develop techniques for isolating the different behavioral systems in Aldea San Francisco. We have seen that both nonlinear and linear analyses serve to enlighten our understanding of these systems. Figure 16 is a simplified pictograph of the way these four variables fit

Figure 16
Behavioral Families Related to Peasant Social Class Levels
(Aldea San Francisco, Entre Ríos, Argentina)



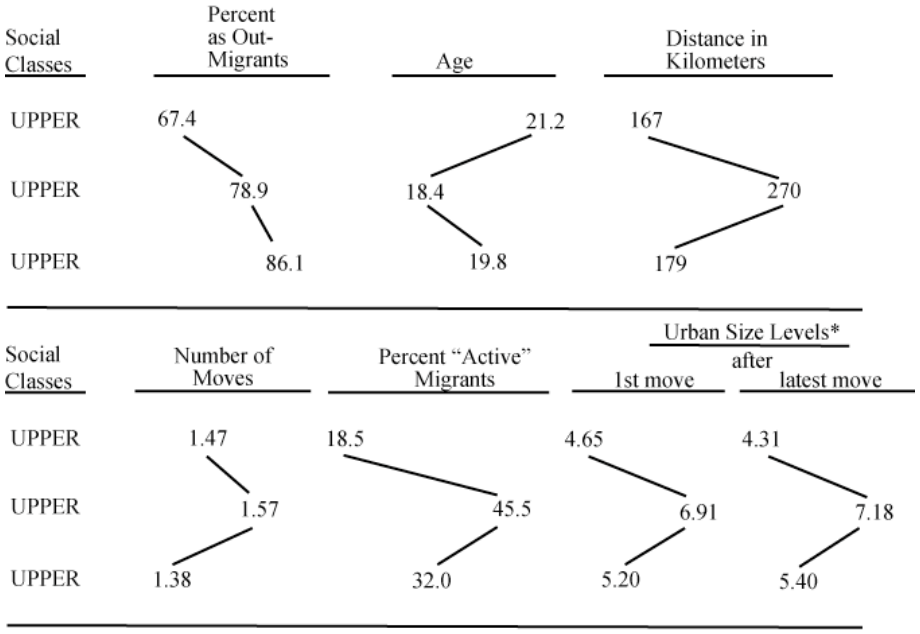
together into a behavioral family for each of the peasant social-class levels in the community. Behavioral Family A (the upper-class peasantry) is associated primarily with low regional spatial perception, a transitional orientation to communication, and either low regional movement or high regional movement (two groups). Behavioral Family B (the middle-class peasantry) has predominately high regional spatial perception, a cosmopolite orientation to communication, and medium regional movement. Finally, Behavioral Family C (the lower-class

peasantry) has medium regional spatial perception, a localite orientation to communication, and low regional movement. These groupings are not meant here to be final, but they may give some behavioral insights into a small peasant community in Argentina.

Limitations of This Case Study

Clearly the major problem in the example of Aldea San Francisco is the limited number of cases with which to determine the relationships. Ideally, a total sample for every variable of every member of a small group would be the best approach in a process study. While lacking that complete data for a number of variables that later turned out to be important, this author found that the results from about half the households in Aldea San Francisco were entirely consistent with the patterns established in those variables where every member of the community was included. For example among the 243 out-migrants, similar nonlinear patterns continue to show up in the data, especially with regard to the variable social-class position. Figure 17 shows the mean migration behavior by social class ,f 116 females who left the community between 1920 and 1967 (Wilkie, 1972,

Figure 17
Female Migration Behavior by Social Class
(Aldea San Francisco, Entre Ríos, Argentina; n = 116)



*The mean urban size levels area as follows: 4= 5001 to 10,000 population, 5= 10,001 to 20,000 population, 6= 20,001 to 50,000 population, 7= 50,001 to 100,000 population, and 8= 100,001 to 500,000 population.

p. 98). In each case, with the exception of the percent of females as out-migrants, the middle-class females were the most dynamic of the three groups. In contrast, with the exception of average number of moves, the upper-class females were the least dynamic. It is this insight into the consistency of the majority of the relationships tested in this study that strengthens the interpretation (Brodbeck, 1968; Cattell, 1966; Morrison and Henkel, 1969; Oisson, 1969B; Turner, 1968), and it shows that decision-making processes are vastly different within each of the population subgroups in Aldea San Francisco, especially by social-class level. This is clearly a case where substantive inference reveals more than statistical inference.

A second problem is that only four variables have been presented out of 136 that were collected in the field. Obviously, the more variables that are included in the analysis the more complex, yet more revealing, the interpretation becomes. The inclusion of more variables into the analysis in this paper, however, is not possible because the major purpose has been to illustrate that most nonlinear relationships add as much insight into the behavioral interpretation as do the linear relationships. The purpose of the Process Method is to examine the particular sets of relationships (some high, some medium, and some low) that lead to different kinds of spatial behavior.

Conclusions

This illustrative case has been used to (*a*) show that at times dependency on only linear analyses obscures relationships that actually exist in the real world, but only among certain subgroup levels, (*b*) develop a lower-level technique for analyzing nonlinear patterns that result from different subgroup behavior, and (*c*) give theoretical insights into the processes which are changing and evolving the spatial behavior of social-class subgroups in a small peasant community.

All too often the linear rut pushes us into almost total acceptance of correlation coefficients as the sole criteria of importance which may further obscure some relevant but nonlinear phenomena that need to be explained. Utilizing data from Aldea San Francisco, Entre Ríos, Argentina, this study has shown that significant and complex nonlinear relationships exist in five out of the six relationships tested for the entire community. These relationships most likely would have been ignored in simple linear analyses using aggregated data. Through the use of techniques devised to analyze and illustrate nonlinear relationships, consistent patterns within the data are revealed which help to isolate the subgroups of similar behavior where tests of linearity for significance do prove meaningful. In the sixth case, a linear relationship of aggregated data for the entire community is found which logically supported the conclusions derived from the nonlinear analysis at that level. Thus the Process Method, utilizing both nonlinear and linear forms of analysis, leads to an understanding of the way in which many variables interact to bring about change. Key to this discussion was the question of what

role the data plays in the development of a body of theory and laws concerning spatial behavior.

Since change is constant and evolving structural systems are normal, it is essential to include the process dimension of study within the social and behavioral science disciplines. The Process Method, which involves the development of Process Hypotheses, is quite different from the traditional Hypothesis Method which tends to focus only on linear correlations while testing a limited number of variables involved with studies of structure. Both studies of process and structure are important, however, because the study of the processes of change is not possible without, as a first step, carefully establishing the nature of those structures which are changing. If we are to base theory and development policy only on past structures (most often established through aggregate linear analysis) and to ignore the processes that change the structures and the behavior within different subgroups and levels of society (often discovered in nonlinear analysis), then our planning will not only be several steps behind current and future reality but also may at times be wrong. The statistical canceling out of many different forces does not necessarily negate their reality.

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