COMPLEMENTARITY AND THE LAW OF BIG NUMBERS*

by

Robert Douglas and Paul Lightfoot

Department of Geography

University of Michigan

> "Clara, trying not to reveal too much of the secret of her involvement, told him that she was working with prisoners who had been described to her as the bloodhounds of imperialism, but that on getting to know them better they had turned out to be quite different. And one question kept bothering her, and she let Lansky answer it: were there, after all, innocent men among them?
>
> Lensky listened carefully and replied calmly, "Of course there are. That is inevitable in any penal system."
>
> "But Alexei! That would mean that they can do whatever they want! That's terrible."...
>
> "No," he said softly but convincingly," not 'whatever' they want. Who 'wants' anything? Who 'does' anything? History. To you and me that sometimes seems terrible, but Clara, it's time to get used to the fact that there is a law of big numbers. The bigger the scope of an historical event, the greater the probability of individual errors, be they judicial, tactical, ideological, economic. We grasp the process only in its basic, determining forms, and the essential thing is to be convinced that this process is inevitable and necessary. Yes, sometimes someone suffers. Not always deservedly. What about those killed at the front? And those who died meaninglessly in the Ashkhabad earthquake? And traffic fatalities? As traffic increases so will the number of traffic victims. Wisdom lies in accepting the process as it develops, with its inevitable increment of victims."

---

* The authors wish to acknowledge the particularly useful conversations and encouragement of Gunnar Olsson in the preparation of this manuscript. Comments and suggestions made by Bonnie Barton should also be noted.

> But Clara shook her head indignantly.
> "Increment!" she exclaimed.... "The law of big numbers should be tried out on you!" (24)

PART I

Epistemological Problems

a. Introduction

Our paper is about the law of big numbers; or alternatively, it is about the relationship of individuals to the society in which they live. This is not a new issue, of course; it is an issue which has very many different facets, and which might be looked upon as one of the most fundamental of socio-political problems. Our purpose is to treat this problem and its methodological implications in the context of spatial epistemology.

Our motivation results from the fact that most studies in geography are conducted using data at a high level of aggregation. (11) In our view, the emphasis on macro level analysis has led to the use of behavioral assumptions which do not accurately represent the generating processes underlying spatial form. In many cases moreover, where studies have been designed to examine individual processes, the relationship of the results of these studies to the macro level spatial theories on which they have been based has not been fully determined. It is the contention of this paper that an exploration into this relationship could perhaps strengthen the explanatory bases of spatial theory.

Part I of the paper consists of a brief summary of a development which took place in physics during the 1920's. From this discussion, two alternative viewpoints emerge: the principles of reductionism and complementarity. A methodological analogy in the social sciences is identified, and in Part II each of these principles is discussed in greater detail, particularly with respect to geography and the social sciences. Finally, in Part III abbreviated extracts from the authors' respective dissertation proposals are presented, as examples of further applications of the principle of complementarity in geography.

b. The Bohr-Einstein Controversy in Physics

Einstein (8) writing in 1924, said: "We now have two theories of light, both indispensible, but, it must be admitted, without any logical connection between them, despite twenty years of colossal effort by theoretical physicists." Einstein was referring to the quantum paradox between the wave theory and the particle theory as explanations of the propagation of light. On the one hand, certain observations, while contradicting the particle theory, could be explained in terms of the wave theory. For example, light undergoes diffraction, which can only be explained by adopting the wave model. Yet, in the photo-electric effect and in photon scattering experiments, the predictions of the wave model cannot be demonstrated, and the observations must be explained by postulating quanta, or particles of light. (4) Therefore, unless simultaneous observations of light are performed, it is not possible to obtain a complete interpretation of its behavior in terms of both waves and particles. However, such simultaneous observations have not been shown to be feasible; thus, the observational paradox presents itself.

For the physicist who conceives of light as something which is fundamentally a single objective entity, how is this apparent paradox to be explained? One explanation which was offered was that the theories which were currently available in physics were inadequate. The need arose, therefore, to formulate a new, more general, theory of light (or a modification of existing theory) which demanded that both wave and particle requirements be satisfied. Simultaneously, Einstein steadfastly held to the opinion that a generalized theory, combining both wave and particle notions, had to be developed. Einstein's argument was seemingly based on a reductionist viewpoint that the quantum theory could ultimately be reduced in a 'new' deterministic theory. As Heisenberg writes (14): "Einstein would not admit that it was impossible, even in principle, to discover all the partial facts needed for a complete description of a physical process".

On the other hand, it was argued by some physicists that such a reductionist viewpoint was not only unnecessary, but meaningless, since the two theories of light were in terms of observational measurement logically non-compatible with each other. An alternative epistemology was put forward by Niels Bohr in his principle of com-

plementarity. With this principle, Bohr attempted to show that in quantum mechanics there is (a) no one experimental arrangement of simultaneous observations of waves and particles; and (b) therefore, no one interpretation adequate to all experiments (15)

Bohr emphasized that in the context of quantum physics, the idea of complementarity had nothing to do with any renunciation of rational objectivity in science, which characterized the deterministic descriptions of classical physics. For example, Bohr states: "Within the scope of classical physics, all characteristic properties of a given object can in principle be ascertained by a single experimental arrangement... In quantum physics, however, evidence about atomic objects obtained by different experimental arrangements exhibits a novel kind of complementary relationship... Far from restricting our efforts to put questions to nature in the form of experiments, the notion of complementarity simply characterizes the answers we can receive by such (different experimental) enquiry..." (4) Stated in another way, in the case of macro physical theory, the inter-action between the means of observation and the object itself is negligible, whereas with micro physical objects this inter-action is not negligible, because the very application of the means of observation disturbs the observed objects in a way which requires a complementary interpretation.

In conclusion, rather than subsuming the wave model into a general theory of particle behavior, or vice versa, complementarity accepts the different explanations as logical results under different experimental conditions. However, although these explanations are mutually exclusive, they nonetheless complement each other in a non-contradictory sense. To put it simply, an explanation of light through complementarity would not only argue that the wave is more than a mere summation of its particles, but also that the wave and its parts are inseparable for a complete understanding of light. It is in this manner that two modes of interpretation introduced to describe the same phenomenon are not in an explanatory sense contradictory, but rather mutually dependent or complementary to each other.

What does this brief summary of the controversey in physics over the explanation of light suggest to geographers in search of explanations of spatial form and process? The analogy to geography concerns not simply analyzing phenomena at different scales of

observation. More importantly, geographers must either (a) consider non-compatible theories and models as complementary explanations of the same phenomenon or (b) attempt to relate observations from non-compatible theories and models by reduction to a common set of explanatory laws. We will now examine both of these alternatives in greater detail.

PART II

Reductionism and Complementarity

a. Reductionism

Reductionism in its extreme form holds that all scientific explanations can ultimately be subsumed under the fundamental laws of physics. For example, Hobbes (21) suggested a method for the explanation of human behavior, working from geometry to social science via mechanics, physiology and physics. More recently, Hull has stated that "natural science theory will be able to deduce the making of moral judgements along with other forms of behavior". (21) While we are not concerned with reductionism in this extreme form, there is nonetheless a more general and appealing thesis in reductionism which suggests that there is in some sense a single notion of what may be accepted as "good" explanation. Such a thesis implies that a phenomenon observed at different levels of aggregation within any particular scientific field may be explained by reference to the same laws. This view would seem to be a reasonable approach in fields where summation of the basic elements does not produce a qualitative change in the aggregate results of the observations and tests applied to the phenomena concerned. Conventional engineering is a field where reasoning of this sort is probably generally reliable. Where human beings constitute the basic particles of the field, there are some situations where a similar viewpoint seems to be acceptable: in medical science it is reasonable to assume that there are certain "universal" attributes among the population; or at least, the range of expectation is well defined. To take a non-medical example, it is clear that Chomsky's approach to linguistics entails a concept of "universals" in virtually all humans in respect of the processing of verbal inputs and outputs.

To conceive of universals (or laws) of this sort would seem to be a sufficient condition for the assertion that there is a strictly definable relationship between analyses carried out at the aggregate level on the one hand, and the individual level on the other. If this is the case, we may speak of a reductive relationship between observations and inferences made at and from different levels of analysis.

Can such universal attributes be assumed, however, in the study of human behavior? In the social sciences, it would seem that if such a reduction is possible, it will subsume all social science concepts to concepts regarding only individual behavior. (12) Adherents of such a reductionist viewpoint might find support in the philosophical position advocated by, among others, Popper, called "methodological individualism". This asserts that any attempt to explain social phenomena must be rejected unless it refers exclusively to facts about individuals. According to Lukes, (17) Popper is quoted as stating that "...all social phenomena and especially the functioning of all social institutions should always be understood as resulting from the decisions, actions, attitudes, etc. of human individuals, and ... we should never be satisfied by an explanation in terms of so-called 'collectives'". The implication is that any phenomenon observed at the aggregate level results from, and could be predicted through, knowledge of the individuals' attributes observed at the micro, or individual, level. Similarly, Gellner states: "that the whole can be reduced in a sum of partial biographies and character studies is indeed the paradigm of explanation as conceived by the 'individualists'". (9)

Individualist methodology in geography is captured in many studies which seek psychological explanations for aggregate spatial behavior patterns. The increase in "perception studies" (22) by geographers can in part be attributed as a reaction to the spatial analysists' treatment at the aggregate level of people as automatons and not as individuals. A recent paper by Harvey (13) takes an apparently reductionist stance in that a case is made for using the "role of space in one's biography," the understanding of the perception of space by individuals, as part of the basis for spatial models at the aggregate level.

However, in spite of continued research it seems that as yet we have no psychological laws of individual behavior to which aggregate spatial models can be reduced. It is true that we make generalizations in respect of, for example, territoriality and distance minimization; but these can only be classified as laws of spatial behavior in

a very imprecise and restricted sense. (10) Likewise, while it might be a useful excercise to ascertain the relationship between geographical and sociological variables, any result can only be a partial solution to the problem of the inadequacy of geographic theory, The effect of distance on social structures and networks for example, might aid in providing meaning to distance-dependent models in geography, but it cannot simultaneously provide the answer to the problem of individual differences.

If we accept this conclusion, can adequate grounds be established for adopting another alternative, namely the consideration of non-compatible theories as complementary explanations of the same phenomenon?

b. Complementarity

Although Bohr never precisely defined the logics inherent in the principle of complementarity, it is clear from his subsequent writings that in its general conception Bohr saw a broad application of complementarity in many diverse fields. In a series of papers and essays, he considered its application to biology (5), psychology (6) and to other problems of scientific contradiction.

Recently, Bedau and Oppenheim (3) have specified the logic of complementarity within quantum mechanics. They also note, however, that "as to the application of complementarity in fields other than quantum mechanics, no one to our knowledge uses a generalization of (or even a very exact analog of) the concept of complementarity in quantum mechanics, or elsewhere". (3) Clearly then, Bedau and Oppenheim see their formal interpretation of the principle in the case of quantum mechanics as the model for all applications of the principle.

From the point of view of the social scientist this seems to be a rather inflexible position. We suggest that at the present state of knowledge there could be no direct translation of the Bedau-Oppenheim interpretation into terms more applicable to social science, principally because of the entirely different nature of the law statements derived in respect of social behavior. It is arguable in fact that there are no laws in the social sciences if the criteria of the physical sciences are applied.

Consequently, our interpretation of the principle in the case of social science is a very general one, i.e., in any situation where there are different theories and models proposed as explanations to a common phenomenon, and where each methodology leads to different inferences concerning human behavior, the different theories and models may be termed complementary to each other. In other words, our present definition of the complementarity principle is that it applies where we are unable to demonstrate a formal relationship between observations and inferences derived from two or more explanations of the same phenomenon.

Mackay (18) and Blackburn (4) have outlined the prerequisites necessary for complementarity. They are as follows:

1. The conflicting theories and models purport to have a common reference, i.e., both seek to describe a single phenomenon.

2. Each is in principle exhaustive (in the sense that none of the entities or events comprising the common reference need be left unaccounted for).

3. They make different inferences because,

4. The logical preconditions of definition and/or of use of concepts and relationships in each are mutually exclusive, so that significant aspects referred to in one are necessarily omitted from the other. In other words, neither mode can be reduced into the other.

5. Because they refer to a single entity, the theories and models are not independent of each other.

There are examples in the social sciences of methodologies which implicitly recognize such "pre-requisites" in distinguishing between differing levels of observation and analysis. According to Neibuhr (19), "there are collective forces at work in society which are not the conscious contrivance of individuals." In other words, it is contended that there are phenomena observable in the aggregate whose existence could not be logically inferred from an analysis of their constituent parts.

It is no exaggeration to say that this last assertion constitutes

one of the most basic tenets of sociology, and there are numerous examples of its central importance in the work of Emile Durkheim. Durkheim's 'collective representations': "...are outside of individuals originally and exercise a sanctioning power over individual behavior. Individual psychology cannot study them with its tools of investigation; they must be studied by collective psychology, or sociology." (23)

A statement by Kapp (16) succinctly points out the different characteristics of individual and aggregate behavior patterns: "The behavior in a large scale domain is continuous and determinate because it represents the outcome of a statistical regularity of interaction...; we are faced with a determinate and predictable situation despite the fact that the behavior of each individual is indeterminate..." Kapp's statement suggests that the potential usefulness of complementarity to geography lies in the application of different theories and models appropriate to different levels of aggregation. It would seem, for example, that the applicability of highly aggregated, deterministic models could be enhanced by corresponding stochastic models at the level of the individual.

c. Applications of Complementarity to Geography

While many spatial problems would seem to lend themselves to complementary explanations, only a few studies have explicitly employed such a methodology. Furthermore most, if not all, of these studies have dealt with the classical process-form problem. For example, Olsson (20), in his study of the colonization of a part of Sweden, applied different models to attempt to explain the same settlement forms. Specifically, colonization maps from Northern Sweden were subjected to both trend surface analysis and cell-counting analysis. These techniques were said to complement each other in the sense that surface fitting focuses on large scale variations in the spatial arrangement of settlements, whereas cell-counting focuses on a more micro analysis of point distribution. Although in a strict sense these models were not shown to be mutually exclusive, they do however illustrate the increased explanatory power which may result from applying several models to the same data.

A different approach to complementarity, although similarly dealing with settlement distributions, has been proposed by Barton. (2) Rather than analyzing settlement forms from only a spatial point of view, Barton contends that a complete description of such

a complicated social process requires a dual methodology, i.e., the combination of both a spatial and a sociological-historical approach. In essence, this kind of complementary reasoning has also been put forward by Harvey. In a recent paper, (13) Harvey has outlined some of the problems inherent in adopting a so-called "geographical imagination" to the exclusion of an alternative "sociological imagination". A basic argument is that social space is not isomorphic with physical, or Euclidean, space. To paraphrase Harvey: "We cannot expect that the kind of geometry appropriate for discussing one kind of process (say a purely spatial process) will be adequate to deal with another, say social process".

Eichenbaum and Gale (7) in a function-process study of various hexagonal tessellations observed in wasp' and bees' nests concluded that "similarity of form by no means permits us to deduce similarity in process or function". Translating their findings into a particular spatial problem, they further concluded that the process resulting in regular hexagonal market areas could be that which Lösch suggested, i.e., competitive adjustment within economic equilibrium conditions. However, in a planned economy the same form might conceivably be the result of axial addition, i.e., simply a regular hexagonal grid imposed on a plane by a social planner. Similarly, it has been shown that a number of cell-counting models (e.g., the Neyman Type A and Thomas' Double Poisson) can yield very similar spatial forms, even though the generating processes may be entirely different.

In concluding this review, the above studies share one characteristic in common, namely that a complete explanation of spatial form may require more than one conceptualization. In other words, it is the inability to deduce relationships between observations and inferences made at various levels of aggregation in our spatial theories and models which motivates a complementary explanation. Two additional examples of investigations into the use of complementarity to spatial problems will now be presented in the form of abbreviated extracts from the authors' respective dissertation proposals.

PART III

Further Applications of the Principle of Complementarity in Geography

a. Complementarity and Relocation: A Problem of Individual and Societal Choice

The major objectives of a relocation plan for displaced persons can be stated in problematic form as:

1. Given the power to relocate people, maximize a region's aggregate welfare. That is, prescribe a set of locations for resettlement and distribute those relocatees to yield the maximum regional economic welfare.

2. Simultaneously, insure that individual preferences and choices with respect to the prescribed locations be satisfied.

To many investigators, this problem presents itself as a contradiction, i.e., to maximize an aggregate (regional) welfare function and at the same time take consideration of individual preference functions. The currently accepted proof of this contradiction has been demonstrated by Kenneth Arrow. (1) In summary, Arrow showed that to derive an aggregate function from individual preferences is pre-conditioned to violate: collective rationality, citizen sovereignty, pareto-principle, positive association, non-dictatorship and irrelevance of extraneous alternatives. If we accept Arrow's so-called "barrier", as true in all cases, then it seems that the notion of treating the proposed relocation plan as a problem in complementary methodology has validity. For example, if it can be demonstrated that the aggregation of individual relocation choices and preferences does not conform to those prescribed by the aggregate regional plan, then Arrow's barrier holds in this case of explanation and complementarity offers an alternative solution. In short, such a solution would attempt to ascertain the areas of agreement and disagreement between the aggregate plan and the individual preferences.

The empirical investigation could be directed toward answering such questions as:

a. What locational choices are in agreement between the normative regional plan and the descriptive explanation of individual or group relocation, i.e., where and why do they complement each other?

b. What social and economic barriers may exist to prohibit individuals from selecting a relocation in conformance to the regional plan? How might these barriers be eliminated to result in a better "fit" of the regional plan with reality?

c. Are different types of people more or less suited to cope with and adjust to different prescribed locations within the regional plan? If so, then the aggregate plan should be as relocationally flexible as possible to permit individuals a wide choice of permissible alternatives.

Relocation, thus, has a dual interpretation. On the one hand, maximization of a region's economic welfare through resettlement is treated as a normative theory. On the other hand, an explanation of relocation patterns is taken as a description of reality. Therefore, where individuals relocate and where society or a social planner think they ought to relocate requires a complementary conceptualization and methodology. It is only in this manner that societal plans can continually be readjusted to minimize individual injustices.

b. Dual Approaches to Migration

The gravity model related migration intensities to distances separating places of origin and destination. The many applications of the gravity model, to various types of human interactions, have lent support to the spatial theorists' view that in general people are distance minimizers: they tend to move, or interact over, short distances rather than long distances.

Criticisms of the gravity model have largely centered around the highly simplified notions of process which are imbedded in it; that is, that the distance variable can "explain" migration intensities. It has been recognized that distance is in fact a "proxy" for a variety of other factors which are more directly linked to movements of people. Consequently, the basic model has been restated in several different forms which attempt to improve upon the use of linear distance, and hence to improve on the model's predictive power.

Intuitively it seems obvious that distance of itself, as a linear concept, has little direct impact on migration decisions. However,

we would suggest that the inability of the gravity model to provide more useful insights into the processes of migration is inevitable, given the highly aggregated nature of the data with which it works. We suggest, therefore, that instead of attempting to relate migration to other, perhaps more realistic, variables at an aggregate scale, attention should be given to the relevant factors in individual cases of changes of residence.

We hypothesize:

1. that individual choices of migration destinations will depend on individual perceptions of distances to possible destinations;

2. that these "perceptual distances" may have very little to do with linear distance, but rather will reflect the attractiveness of each possible destination in terms of the expected problems of assimilation there.

Consequently, the perceptually "nearest" place, i.e., the most likely destination from a number of alternatives, would be the place wherein the individual has personal contacts, good prospects of finding a job, perhaps cultural affinities, and so on, the importance of each of these factors varying between individuals.

Such a conceptualization suggests the following hypotheses:

$$\text{i.} \qquad M_{ij} = f\,(D_{ij})$$

$$\text{ii.} \qquad D_{ij} = f\left(\frac{\sum_{i=1}^{n} d^*_{ij}}{n}\right)$$

$$\text{iii.} \qquad d^*_{ij} = f\,(y_j)$$

where M_{ij} is the migration intensity, from i to j.
D_{ij} is the linear distance from i to j.
d^*_{ij} is a particular individual's perceived distance, i to j.
n is the number of people in some large sample.
y_j represents some measure of the expected assimilation problems at place j.

Hypothesis (i) represents the gravity model; hypothesis (iii) represents a model at the individual level, which is complementary to (i) in the sense outlined above, i.e., it is essentially concerned with the same phenomenon, migration, but leads to quite different inferences about migration processes. There may still be a correspondence between hypotheses (i) and (iii), analagous to Heisenberg's correspondence principle in physics. Such a correspondence is provided in this case by hypothesis (ii), which suggests that the average perceived distance ij for some large sample of individuals is related to the linear distance ij.

c. Summary and Conclusion

From the two research proposals presented, it is clear that the application of complementarity to such broad and complex problems as relocation and migration are open to different interpretations, depending on the nature of the problem and the disposition of the researcher. Thus, in no way do these last two examples attempt to typecast or restrict the possible use of complementarity in geography. However, they were intended to illustrate our basic contention, that a complete description of spatial form and individual behavior requires more than one frame of reference.

To summarize what we have said throughout the paper, we initially attempted to draw attention to the general tendency to "devalue" individuals in propostion to the magnitude of a particular process or event: this is the essence of Solzhenitsyn's "law of big numbers". Whether this general attitude results from, or itself fosters, a stress on aggregate analyses within the social sciences is very much a moot point. However, the paper as a whole attempts to find some methodological framework which avoids the apparently inevitable submergence of individuals, as individuals, within the larger scale "determinate" processes described by Kapp. Difficult as it is, the establishment of such a framework within the social sciences seems to be an important step in a more "humane" conception of the workings of society.

It would seem at this early stage that the principle of complementarity could be part of the framework for which we are looking, and we have tried to demonstrate why we think this to be the case. It remains to be seen whether the principle can be fully interpreted logically, particularly in terms of the compatability of aggregate

and individual approaches. If it does, Solzhenitsyn's Law of Big Numbers is not the same as the statisticians' Law of Large Numbers.

REFERENCES

1. Arrow, Kenneth J.: Social Choice and Individual Values. New York: John Wiley and Sons, 1951.

2. Barton, Bonnie: New England Settlement 1600-1800: An Inquiry into the Comparability of Social Science Methodologies. Ph. D. Proposal, 1970, Department of Geography, University of Michigan.

3. Bedau, Hugo and Paul Oppenheim: "Complementarity in Quantum Mechanics: A Logical Analysis," Synthese, Vol. 13, 1961, pp. 201-232.

4. Blackburn, Thomas R.: "Sensuous-Intellectual Complementarity in Science," Science, Vol. 172, 1971, pp. 1003-1007.

5. Bohr, Niels: Atomic Physics and Human Knowledge. New York: John Wiley and Sons, 1958.

6. _____: Essays 1958-1962 on Atomic Physics and Human Knowledge. New York: John Wiley and Sons, 1963.

7. Eichenbaum, Jack and Stephen Gale: "Form, Function and Process: A Methodological Inquiry," Economic Geography, Vol. 47, 1971, pp. 525-544.

8. Einstein, Albert: "Das Comptonsche Experiment," Berliner Tageblatt, 1924.

9. Gellner, Ernest: "Holism versus Individualism," in Brodbeck, M. (ed.): Readings in the Philosophy of Science. New York: The Macmillan Company, 1968.

REFERENCES

10. Guelke, Leonard: "Problems of Scientific Explanation in Geography," Canadian Geographer, Vol. 15, 1971, pp. 41-47.

11. Hagerstrand, Torsten: "What About People in Regional Science?," Regional Science Association Papers, Vol. 24, 1970, pp. 7-21.

12. Harvey, David: "Behavioral Postulates and the Construction of Theory in Human Geography," Department of Geography, University of Bristol, Seminar Paper Series A, No. 6, 1967.

13. _____: "Social Processes and Spatial Form: An Analysis of the Conceptual Problems of Urban Planning," Papers of the Regional Science Association, Vol. 25, 1970, pp. 47-69.

14. Heisenberg, Werner: Physics and Beyond: Encounters and Conversations. New York: Harper and Row, 1971.

15. Holton, Gerald: "The Roots of Complementarity," Daedelus, Vol. 99, 1970, pp. 1015-1055.

16. Kapp, Karl W.: Towards a Science of Man in Society. The Hague: Martinus Nijhoff, 1961.

17. Lukes, Steven: "Methodological Individualism Reconsidered," in Emmet, D. and A. MacIntyre (eds.): Sociological Theory and Philosophical Analysis. London: The Macmillan Co., 1970.

18. Mackay, D. M.: "Complementarity II," Aristotelian Society Supplementary, Vol. 32, 1958, pp. 105-122.

19. Niebuhr, Reinhold. The Children of Light and the Children of Darkness. New York: Charles Scribener, 1953.

20. Olsson, Gunnar: "Complementary Models: A Study of Colonization Maps," Geografiska Annaler, Vol. 50, Series B, 1968, pp. 115-152.

21. Peters, R. S. and H. Tajfel: "Hobbes and Hull - Metaphyscians of Behavior," British Journal for Philosophy of Science, Vol. 1957, pp. 30-44.

22. Saarinen, Thomas F.: Perception of Environment. Commission on College Geography, Association of American Geography, Resource Paper No. 5, 1969.

23. Simpson, George: Emile Durkheim. New York: Thomas Y. Cromwell, 1963.

24. Solzhenitsyn, A.: The First Circle. New York: Bantam Books, 1969.