DOCUMENT RESUME

ED 078 473 CS 500 316

AUTHOR	Richards, William D., Jr.; Monge, Peter R.
TITLE	A Computer Simulation of Human Communication.
PUB DATE	Apr 73
NOTE	24p.; Paper presented at the Annual Conference of the International Communication Association (Montreal, April 25-29, 1973)
EDRS PRICE	MF-$0.65 HC-$3.29
DESCRIPTORS	*Artificial Intelligence; Automation; Behavioral Science Research; *Computers; *Feedback; *Information Theory; Research Reviews (Publications); Technological Advancement; *Technology

ABSTRACT

Of the many intellectual models available for conceptualizing the communication process, one of the most appropriate is cybernetics. The logical and empirical requirements of a cybernetic model of communication are presented. Based upon a review of relevant findings in the social science literature, these requirements are utilized to create a closed system constituted of open subsystems. The results of that procedure are presented, along with the modifications which were necessary to create the basic propositions. The macrostructure of the simulation and several important issues--the probabilistic nature of the model, cause and effect, feedback, and interaction--are discussed. The conclusion contains an assessment of the utility of the simulation, suggestions for modification, and a brief discussion of the requisite methodology for future empirical validation. (EE)

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A COMPUTER SIMULATION OF HUMAN COMMUNICATION

by

William D. Richards, Jr.
Stanford University

and

Peter R. Monge
California State University, San Jose

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A Paper presented to the
Information Systems Division
of the International Communication Association
Montreal, Canada
April 1973

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ABSTRACT

A Computer Simulation of Human Communication

by
William D. Richards, Jr.
Stanford University

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Peter R. Monge
California State University, San Jose

Submitted to ICA Division I session entitled "Yet Unspecified Topics in Systems"

Of the various methodologies currently available for the analysis of systems of human communication, one of the most potentially useful is computer simulation. Of the many intellectual models available for conceptualizing the communication process, one of the most appropriate is cybernetics. By combining the power afforded by each into a single algorithm, the attempt is made to capture the non-linear, adaptive, feedback-controlled, complexity of the communication process. Such a procedure generates a logical calculus, the juxtaposition of which with empirical reality constitutes a systemic explanation. It is the purpose of this paper to present the first half of this process, the simulation, leaving the problem of empirical validation to another time.

At the outset, the logical and empirical requirements of a cybernetic model of communication are stipulated. These are utilized to create a closed system constituted of open subsystems. Rather than base the model on a single theory as was done in the well known "Homunculus" simulation of <u>The Human Group</u>, the current endeavor is based upon a review of relevant findings in the social science literature. The results of that procedure are presented along with the modifications which were necessary to create the basic propositions. The macrostructure of the simulation is discussed

as are several important issues: the probabalistic nature of the model, cause and effect, feedback, and interaction.

A representative output of the simulation is provided as a basis for describing its operation. This includes probabilities governing the occurance of communication and the formation of communication structure, as well as input/output procedures. The simulation is examined for conditions which determine equilibrium states and those which augur system disintegration. The implications of variations in system parameters are also explored.

The conclusion contains as assessment of the utility of the simulation, suggestions for modification, and a brief discussion of the requisite methodology for future empirical validation.

I. INTRODUCTION

The role of the systems perspective in guiding the research efforts of communication scholars has significantly increased in recent years. The reason for this may well be that the systems approach presents solutions to problems that seem otherwise insurmountable to researchers utilizing traditional research paradigms.

These problems are revealed by assessment of the current state of communication research: First, while the complexity of the communication process is generally acknowledged, traditional research strategies employ simple designs which are generally inadequate to capture the richness and complexity of the phenomenon under study. Second, while communication scholars conceptualize communication from a processual viewpoint, the typical research paradigm is static rather than dynamic. Third, despite the fact that many relations in communication are known to be nonlinear, most communication research <u>assumes</u> that relations among variables are linear. Finally, ignoring the frequent call by leading scholars for the synthesis of knowledge, research remains fragmented, and only rarely is it integrated with and built upon the diverse findings already extant in the discipline.

At an abstract level it can be argued that the systems approach provides a general solution to these problems. For example, we assert elsewhere that the advantages of the systems approach are " . . . a shift in the particular set of variables which are selected for study, an increase in the complexity of analysis which may be employed, and the ability to integrate current research into a wider perspective (Monge, 1973)." On a concrete level, however, it remains to be demonstrated that specific system approaches will yield these benefits. Such is the task of this paper.

A. Advantages of Simulation.

Of the various methodologies currently available for the analysis of human communication systems, one of the most potentially useful is computer simulation. Before turning to the simulation presented in this paper, we shall examine the problems in current conceptualizations of communication identified in the Introduction and show how computer simulation in general offers a reasonable solution to each.

1. The Problem of Complexity. Conceptualizing communication as a system generally implies a significant increase in the complexity of the analysis necessary for description and explanation. As Beer (1959) says

> A system consists of n elements. Before we started talking about systems, this would have meant n investigations to find out what this set of things was like. Once we declare the set of things to be a system, however, there are not only the n elements themselves to examine, but n(n-1) relations between the elements to be examined. (p. 10)

While this may seem like a significant increase in complexity, it in no way exhausts the total complexity that is inherent in a system if we were to examine all possible system states.

Even more important than the number of variables and relations, is the question of how we approach the study of complex systems.[1] As Ashby (1956) notes

> . . . there are complex systems that just do not allow the varying of only one factor at a time--they are so dynamic and interconnected that the alteration of one factor immediately acts as cause to evoke alternations in others, perhaps in a great many others (p. 5).

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[1] The only communication scholar that we know of who has attempted to deal with this problem is Krippendorff (1972), who developed an algorithm for reducing the representational space of a complex system without altering its dimensionality. Application of this algorithm simplifies the system under analysis but does so without significant loss of information.

The solution which simulation offers to the problem of complexity is two-fold. First, it permits a significant increase in the number of variables and relations which may be studied. Second, it permits exploration of the implications of varying one or several variables both sequentially and simultaneously.

2. The Problem of Process. The concept of process has thoroughly permeated the communication discipline. Unfortunately, the methodology of process has not. Numerous scholars in the social sciences have turned their attention to this problem (e.g., Simon, 1957; Coleman, 1968; Blalock, 1969) but little of their methodological advances have been adopted by communication scholars.

The simulation approach has the advantage of control; all processes, including time, can be completely controlled by the simulator. For example, it is possible to modify the time scale in such a way that the "resolution" of the simulated process is increased or decreased to any desired level.

Using Fourier analysis, Arundale (1971) has examined the issue of the degree of resolution necessary to capture the processual nature of any phenomenon. It is necessary, he suggests, to gather data at a maximal time interval that is no greater than one half the period of the smallest period of oscillation of the fastest oscillating component of the overall system. Data plotted at this interval will reflect the entire process no matter how complex (i.e., how many constituent parts) it is.

3. The Problem of Linearity. The problem of linearity is not an easy one to solve. It has at least two dimensions. First, the relations among many communication variables have been found to be nonlinear, as for example, in the case of the relation between language intensity and persuasion, or between fear appeals and attitude change. More precisely, most communication

variables have been shown to be (1) linear over only a limited range of variation, (2) curvilinear, or (3) more complexly nonlinear.

The second problem is that many of the data analysis techniques that are employed by researchers are based upon the assumption of linearity. For example, statistical analyses such as correlation and regression make this assumption. Occasionally, a researcher will test this assumption; usually, however, this occurs only if he hypothesizes a nonlinear relationship. Likewise in mathematical modeling the typical procedure is to make as many simplifying assumptions as possible, which usually yields a linear model. As more sophistication is developed, higher order components (quadratic, cubic, quartic, etc.) are incorporated in the attempt to provide a better fit between the data and the mathematical model.

Both aspects of this problem can be handled by simulation. Forrester (1969) points out that nonlinearity is very easy to handle if rather than employing analytic solutions to systems of equations we accept the "less elegant" approach of system simulation. While mathematical analytic solutions are most powerful and often provide information regarding the general nature of the system, they are much more difficult to obtain and are virtually precluded in the case of complex systems.

In the present simulation, any relationship that was known to be nonlinear was represented that way rather than assumed to be linear. Furthermore, since the simulation permits several interacting linear relations to produce their own nonlinearity, we provide for the possibility of emergent nonlinearity. Thus, the simulation is true to the research findings, and undesireable effects of simplifying assumptions are minimized.

4. The Problem of Integrating Research Findings. Communication has long been an eclectic discipline, drawing as it does on the wide diversity of findings across the spectrum of the behavioral sciences. Such bredth is both an asset and a liability: while it permits the pursuit of communication knowlege wherever it may occur, it also tends to produce a plethora of isolated, unintegrated findings.

The process of simulation can help with this problem. Since a large number of variables and their relations can be examined, and since the focus is on these variables viewed collectively and simultaneously, then separate findings must be related and integrated in order to make the entire system work.

Some simulations, for example Gullahorn's (1963) well known "Homunculus" simulation of Homan's (1961) Human Group, are restricted to tests of the internal consistency of the propositions of a theory. We have chosen a different tact: specifically, to review many of the findings in communication literature and build our propositions upon a judicious selection of them. Such a strategy was chosen in the hope of contributing to the integration of research so badly needed in our discipline.

B. System Simulation and Explanation.

Before discussing the simulation itself, it is important to note the part which simulation can play in the explanatory process. We have cited elsewhere (cf., Monge, 1973) the criteria for providing a system explanation. In brief, that process consists of

1. Establishing a formal calculus which entails or warrants logical expectations,
2. Loading the terms of the calculus with empirical referents by rules of correspondence, and
3. Establishing isomorphism between the logical calculus and empirical reality.

A simulation represents the first part of this process, i.e., a simulation is a formal calculus which entails logical expectations. The process of validation represents the second and third parts of the process. Thus, neither simulation nor validation can by themselves be considered explanatory; both are required.

II. THE MODEL

A. Rationale and Conceptualization.

Three processes are central in the construction of any simulation: simplification, abstraction, and substitution. One of the advantages of simulated systems over their real-world counterparts is directly related to the relative simplicity of the model; only the relevant variables and processes need be included. Thus, distracting and complicating details can be ignored, allowing the relations between the more important central variables to be better understood.

Similarly, the amount of conceptual abstraction that must be done in translation from the real-world system to the simulation-model system is related to the kinds of isomorphism expected to obtain between the two systems. For example, instead of simulating all aspects of a complex process, one might choose to include only the effects of the process in the model. This would be done for different reasons:

a.) economy--it is sometimes easier to abstract to a higher level process than to deal with the lower level processes of which it is composed;

b.) practicality--with very complex processes it is often not possible to include the constituent lower level processes simply because they are not understood; and

c.) utility--the relative value of representing the lower level parts of a complex process rather than only the effects of the process may be very little if one is interested in the gross effects the process has on a system of complex processes.

The kinds of substitutions used in a model system are usually dictated by the particular goals, constraints, and needs of the investigator. Some simulations will be concrete, substituting smaller or fewer components; others will be abstract, substituting words, mathematical expressions, or computer programs.

With these comments in mind we can introduce the model we have chosen to use in this preliminary attempt to simulate the communication process. Specifically, we have adopted a fairly abstract, simplified representation. For example, our model ignores specific verbal content, but includes what we feel to be relevant variables describing the effects of the interaction process. We look at factors leading to initiation or termination of communication, the effects of past interactions, perceptual distortion, generalized attitudes, and so on.

The set of variables and their interactions fit together to form a network of recursive influence. We have constructed a simulation that expresses this network as a cybernetic stochastic model with open and closed systems at different levels of analysis.

Our choice of the cybernetic model for conceptualizing communication is not arbitrary. Rather, it is the model which best fits what we consider to be the relevant variables and their interactions, and in that context, the minimal conditions for a definition of communication. These conditions are that communication be viewed as:

(1) goal oriented

(2) controlled by feedback, and

(3) adaptative (c.f., Capella and Monge, 1973, p. 2).

If we review the necessary and sufficient conditions for a cybernetic system the appropriateness of the model can be seen. A cybernetic system must exhibit:

(1) goal parameters (reference signals) set in a control center,

(2) influence exerted by the control center, i.e., an attempt to achieve the goal parameters in the part of the system being controlled,

(3) feedback provided to the control center, i.e., information regarding the effects of the output on the part of the system being controlled,

(4) comparator test conducted by the control center, yielding an error signal, and

(5) corrective action taken by the control center, if necessary (c.f., Buckley, 1967, Pp. 172-174).

When this logic is utilized to conceptualize the communication process, the following obtains:

(1) a goal oriented, purposive system, which

(2) emits messages to effect systemic change (achieve its goals), and

(3) must receive feedback, so that it can

(4) generate an error signal by comparison of desired and obtained effects, in order to

(5) decide whether to (a) change its goals, (b) continue in its present behavior, or (c) alter its behavior.

This is the logic upon which the simulation presented in this paper is built (For other research utilizing a similar model see Cappella and Monge, 1973).

B. Building the Model.

The main purpose of this simulation was to assimilate the relevant empirical findings of the behavioral science literature into a single stochastic model that would include all the variables and preserve the interrelationships among them, and in so doing, allow the nature of the whole set of relationships and variables to be examined as an integrated unit. With this idea in mind, the literature was searched for studies treating what were felt to be relevant variables. Studies with inconclusive results or weak operationalizations were avoided. This search resulted in a network of about twenty-five variables and over eight main-effects type of relationships. Very few of the studies found dealt with interaction effects at any level.

A matrix was then constructed, with one row and one column for each variable. A "one" was entered in row i column j if variable i had been shown to have a "causal effect" on variable j. Variables which were linear combinations of other variables were then eliminated from the matrix. The result of this operation was a set of about twelve non-redundant independant variables. Some of these were present in only one or two of the original set of studies. Others were not present in the final form in any of the studies, but they were constructed from the relationships demonstrated in several studies by the elimination of intervening variables, by re-operationalization of equivalent conceptual relationships, or by re-analysis of old data. A few of the final set of variables were operationalizations of previously untested hypotheses. These concepts, however, did have support in the literature, and were felt to be valid concepts that were necessary to the model.

Curves were then drawn for the final set of relationships between variables, using empirical data whenever it was available. From these curves, a set of algebraic functions was constructed. These functions are the heart of the model. They express each variable in terms of other variables.

C. The Final Variables.

There are basically two types of variables used in the simulation. The first type includes the parameters used to describe several key properties of individuals. (These variables characterize the system that is the individual.) They include:

Distance - Individuals are imbedded in a matrix which specifies functional physical distance from each individual to all others. (For brevity, references to the variables and propositions will be indicated by number rather than name. 4,21)

Attitude - Each person is given a position on a continuum which functions as a simplified model of his attitude structure. One possible conceptualization is a "liberal-conservative" scale. (8, 10, 11, 28, 29, 30, 35)

Optimum Level of Interaction - Each person is given a value that represents what for him is the best amount of interaction. If he interacts more or less than this amount, the discrepancy between actual and ideal will be used to adjust other variables to bring about a reduction in the discrepancy. (11, 12, 33)

Rigidity - Each person is given a value for this parameter. It can be thought of as the converse of reactivity or sensitivity. It determines the magnitude of response the individual will make to discrepancies in level of interaction. (11, 17, 18, 29, 30)

Latitude of Acceptance - Each person is given a number which is used to aid in the judgment of where other people fall on the attitude scale. People who are less than this number of units away from the individual will be perceived as more similar than different. People who are more than this number of units away, however, will be perceived as more different than similar. (8, 10, 11, 13, 27, 30)

The preceding variables are all individual variables. The second type of variable includes the variables that come into play in the interaction process. These are:

Knowledge - How much the actor knows about the other. This is based on the history of prior interaction experiences between these two individuals. (11, 12, 21, 27, 35)

Power/Status - This is an indicator of departure from symmetry in the prior interactions between the actor and the other. (16, 17, 26, 33, 34)

Perceived Difference - This is the difference between the actor's position on the attitude continuum and his perception of the other's position. It is influenced by latitude of acceptance (10, 11, 13, 27)

Each person has a "memory" which allows the history of a limited number of prior interactions to be retained. Interactions taking place in the "distant past" are "forgotten." From a person's memory several variables are calculated: Knowledge and Power/Status discussed above as well as the individual's Actual Level of Interaction, which is compared to his ideal level.

D. Propositions.

The following are some of the major propositions which relate the variables to each other.

1. The farther apart people are, in terms of physical or functional distance, the less likely they are to interact. (4, 21)

2. The greater the history of prior interaction, the less effect the distance factor will have. (4, 6, 12, 21)

3. The greater the history of prior interaction, the greater the accuracy of perceptions of the other's attitude. (6, 12, 20, 21, 30)

4. There will be assimilation and contrast effects when judging the position of others on attitude scales so that for persons with similar attitudes the perceived difference will be less than the actual difference, while for those with different attitudes, the perceived difference will be greater than the actual difference. (10, 11, 13, 28, 30, 36)

5. Discrepancies between actual and ideal levels of interaction will influence:

a) the latitude of acceptance--making it wider or narrower, depending on the direction of the discrepancy (17, 36)

b) overall probability of interaction--making it higher or lower, depending on the direction of the discrepancy (8, 17, 29, 30)

c) for large discrepancies in the negative direction (very low levels of interaction) attitudes will be made more similar to those the individual interacts with the most. (17, 33)

6. The overall probability of interaction is dependent upon perceptions of attitudinal similarity, past history of interaction, and perceptions of power/status differences. (6, 8, 10, 11, 12, 16, 17, 18, 26, 28, 29, 30, 33, 34, 35)

E. Macrostructure.

Each individual is an <u>open system</u>. The <u>boundary</u> is the interface between the individual and all others. The <u>history</u> of the system is contained in the individual's memory. The <u>state</u> of the system is dependent on interactions between its history, its own characteristics (the parameters read in at the beginning to describe each person), and the nature of the input at the boundary (other individuals interacting with this individual). There is a <u>filter</u> at the boundary which transforms input to the system. This filter is operationalized by latitude of acceptance and perceived difference functions. Both the state of the system and the state of the filter are controlled by the interaction of history, individual characteristics, and the characteristics of the input.

The simulation has a major loop, which is executed a specified number of times. Each time through this loop all pairs of persons go through the processes of deciding if there will be an opportunity to interact (distance function), evaluating each other, deciding how to interact, and then interacting.

The model of the individual is an open, probabalistic, cybernetic system. It is cybernetic because it compares a goal state (optimum level of interaction) with the actual state and modified its behavior on the basis of the comparison. For example, if an individual has a high optimum level of interaction, but has low actual levels of interaction, there will be a discrepancy. This will modify the latitude of acceptance by making it wider, which makes it easier to find someone with similar attitudes. This increases the probablity of interaction, which should reduce the discrepancy between actual and ideal levels of interaction. There is thus a recurrent feedback loop of causal effect. There are several loops of this kind in the program. The effect of having a comparator variable in a control loop like this is to give a system which seeks to maintain an equilibrium at some level. Outside influences will be compensated for and have little effect on the system. This simulation is made more complex by having several such systems interacting with each other. As each system tries to reach its own equilibrium it influences other systems, which later influence the first system, and so on. This is where the emergent nonlinear properties become evident.

The model of the individual is probabalistic because it uses random numbers to make decisions at several points. This implies that the exact behavior cannot be predicted; only a probability distribution of the possible behavior can be predicted. Although this makes the model more complex, it makes the simulation more valuable and more interesting.

III. USING THE SIMULATION

A. Input.

The program requires the following input:

1) number of people = N (up to 20)
2) number of times through main loop
3) an NxN distance matrix = D, where D_{ij} = distance from person I to person J. $D_{ii} = 0$

4) values for each person for these parameters:
    a) optimum level of interaction
    b) attitude
    c) lattitude of acceptance
    d) rigidity

B. Output.

For each pair of individuals in a major loop, the following information is printed:

1) identification information
2) values related to distance; whether or not distance was overcome
3) all values related to person I's evaluation of J
4) all values related to person J's evaluation of I
5) information about the interaction of I and J

Every fifth time through a major loop the memories of each person are dumped.

C. Typical Output Information.

Several data sets have been run on the simulation program. On the whole, the results seem to be totally plausible; that is, the individuals in a run will behave exactly as one might expect them to, were they real persons with the characteristics of the simulated persons. Groups of individuals form and break up as the people "get to know each other" and as they "form power and status hierarchies." That these kinds of macro-behavior emerge from a combination of statements at the micro-level is evidence of the power of simulation as a device to synthesize a diverse set of findings into a coherent powerful model.

In a typical output the following things usually occur: Initially, random-appearing groups, based mainly on distance, form. As people get to know each other by interacting with each other, groups tend to re-form on the basis of attitudinal similarities. As persons establish relatively long histories of interaction, hierarchies of power/status-related differences tend to develop. Depending on the distribution of optimum-level of interaction values, together with other parameters, groups tend to constantly change and re-form. Some conditions can lead to development of instabilities and the program will abort in a few of these cases, if the instability is great enough. Usually, however, a relatively stable equilibrium is reached.

D. System Behavior

An analysis of a group of interacting individuals from a systems perspective reveals several kinds of patterns. In our simulation we find that the behavior of the overall system is most influenced by the comparator and sensitivity variables.

We can make the following general observations about these two variables:

1.) Overall increases in the comparator variable--optimum level of interaction--across individuals will lead to an overall increase in system activity; there will be more interaction. Groups are more likely to form and seem to be stable.

2.) Wide variation in comparator levels across individuals in a single run lead to various kinds of instability as well as an increase in hierarchicalization. Individuals tend to become differentiated on the power/status dimension. The situation here is one of conflict as individuals attempt to reach their respective, incompatible equilibrium points.

3.) Levels of the sensitivity variable--rigidity--interact with comparator discrepancies to produce changes in the amount of adjustment individuals make in response to these discrepancies. In general, if the variation in sensitivity across individuals is low, the system tends to be relatively stable. Wide variation within a single run, however, leads to extremely complex adjustment processes and generally unstable systems.

Depending on comparator and sensitivity levels, there are several kinds of stable equilibria that can be obtained. Some are:

1) Stable, well defined groups.
2) Stable, diffuse interlinkage with no groups.
3) Combinations of the first two.
4) Cyclic groups.

In the last type of equilibrium, groups seem to break up and re-form in a fairly regular pattern. An example is a situation with two groups and two people who alternately switch from one group to the other, over and over again.

System instability, if severe enough, can lead to total disintegration. This is likely to occur when there is sufficient variation between individuals to prevent the individual systems from reaching equilibria simultaneously. The feedback loops gain control of the system, causing it to oscillate wildly and eventually disintegrate.

E. Implications of Parameters.

Parameters can be varied in several ways:

(1) They may be held constant across individuals but varied at different levels;

(2) They may all be held constant except for variations in a single individual;

(3) They may all be held constant except for variations in a single parameter; and

(4) Various combinations of parameters may be varied in order to follow system interactions and effects.

For example, the classical experimental approach of "everything else held constant" could be replicated by making all the individuals the same and varying single parameters for all individuals. The opposite approach is to do runs with a variety of different kinds of individuals so that there is variation within each run.

In testing the parameters of our simulation we have been primarily concerned with the extent to which they are "critical" to the system's operation. Preliminary analyses indicate that the most important property of the system is the overall level of heterogeneity: the more individuals differ on anything, the more activity there will be and the less stable the system will be. More specifically, the most critical variables appear to be the comparator and sensitivity variables.

IV. CONCLUSION

The simulation described in this paper can be an extremely powerful theoretical, heuristic, and educational tool--as can any simulation. It can be used to integrate diverse research findings, to study complex predictions that are not intuitive when simpler models are used, and it can be highly instructive to classroom students who are struggling to understand the intricacies of the communication process.

As was indicated in the introduction, however, as an explanatory device the simulation is insufficient by itself. A validational study is required which will obtain empirical data that may be compared with predictions generated by the simulation. Ideally, data should be gathered in several different environments and at several points in time.

The authors are currently seeking support to undertake such a validational study. Specifically, we propose to develop a research instrument designed to measure all twelve variables, and to administer it to at least two different groups at a minimum of four points in time. Data from each study will be analyzed and compared to the output from the simulation.

Where discrepancies occur, modifications in the parameters of the simulation will be made in order to adjust the program to empirical reality. It is assumed that each of the four data gathering waves will produce closer approximations between the simulation and the empirical world. When a close enough fit occurs, the explanatory process will be considered complete.

REFERENCES

1. Arundale, R. B. The concept of process in human communication research. Unpublished doctoral dissertation, Michigan State University, 1971.

2. Ashby, W. R. An introduction to cybernetics. London: Chapman & Hall, 1956.

3. Bales, R. Interaction process analysis. Cambridge, Massachusetts: Addison-Wesley, 1950.

4. Barnlund, D. & Harland. Propinquity and prestige as determinants of communication networks. Sociometry, 1963, 26, Pp. 467-479.

5. Beer, S. Cybernetics and management. New York: Wiley, 1959.

6. Bieri, J. Changes in interpersonal perceptions following social interaction. Journal of Abnormal and Social Psychology, 1953, 48, Pp. 61-66.

7. Blalock, Jr., H. M. Theory construction. Englewood Cliffs, New Jersey: Prentice-Hall, 1969.

8. Broxton, J. A test of interpersonal attraction prediction derived from balance theory. Journal of Abnormal and Social Psychology, 1963, 66, Pp. 394-397.

9. Buckley, W. Sociology and modern systems theory. Englewood Cliffs, New Jersey, Prentice-Hall, 1967.

10. Byrne, D. Interpersonal attraction and attitude similarity. Journal of Abnormal and Social Psychology, 1961, 62, Pp. 713-715.

11. Byrne, D. Interpersonal attraction as a function of affiliation need and attitude similarity. Human Relations, 1961, 3, Pp. 283-289.

12. Byrne, D. & Nelson, D. Attraction as a linear function of proportion of positive reinforcements. Journal of Personality and Social Psychology, 1965, 1, Pp. 659-663.

13. Byrne, D. & Wong, T. Racial prejudice, interpersonal attraction, and assumed dissimilarity of attitudes. Journal of Abnormal and Social Psychology, 1962, 65, Pp. 246-253.

14. Cappella, J. A. & Monge, P. R. A cybernetic model of human communication. Paper to be presented at the VII International Congress on Cybernetics, Namur, Belgium, September 1973.

15. Coleman, J. S. The mathematical study of change. In Blalock, Jr., H. M. & Blalock, A. (Eds.), Methodology in social researc., New York: McGraw Hill, 1968.

16. Deutsch, M. The interpretation of praise and criticism as a function of their social context. *Journal of Abnormal and Social Psychology*, 1961, *62*, Pp. 391-400.

17. Eisenstadt, S. Conditions of communicative receptivity. *Public Opinion Quarterly*, 1953, *17*, Pp. 363-374.

18. Festinger, L., Schachter, S., & Back, K. *Social pressures in informal groups*. Stanford, California: Stanford University Press, 1950.

19. Forrester, J. *Principles of systems*. Cambridge, Massachusetts: Wright-Allen, 1968.

20. Grossack, M. Cues, expectations, and first impressions. *Journal of Psychology*, 1953, *35*, Pp. 245-252.

21. Gullahorn, J. Distance and friendship as factors in the gross interaction matrix. *Sociometry*, 1952, *15*, Pp. 123-134.

22. Gullahorn, J. & Gullahorn, J. A computer model of elementary social behavior. In E. A. Feigenbaum and J. Feldman (Eds.). *Computers and Thought*. New York: McGraw-Hill, 1963.

23. Homans, G. *Social behavior: Its elementary forms*. New York: Harcourt 1961.

24. Krippendorff, K. An algorithm for simplifying the representation of complex systems. Paper presented to the International Congress of Cybernetics and Systems, Oxford, England, August 1972.

25. Monge, P. R. Theory construction in the study of communication: The system paradigm. *Journal of Communication*, 1973, *23*.

26. Mulder, M. The power variable in communication experiments. *Human Relations*. 1960, *13*, Pp. 241-256.

27. Newcomb, T. An approach to the study of communicative acts. *Psychological Review*. 1953, *60*, Pp. 393-404.

28. Newcomb, T. The prediction of interpersonal attraction. *American Psychologist*, 1965, *11*, Pp. 525-586.

29. Newcomb, T. Stabilities underlying changes in interpersonal attraction. *Journal of Abnormal and Social Psychology*, 1963, *66*, Pp. 376-386.

30. Radloff, R. Opinion evaluation and affiliation. *Journal of Abnormal and Social Psychology*, 1961, *62*, Pp. 578-583.

31. Sherif, C., Sherif, M., & Nebergall R. E. *Attitude and attitude change; the social judgment-involvement approach*. Philadelphia, Pa.: Saunders, 1965.

32. Simon, H. A. Models of man. New York: Wiley, 1957.

33. Stotland, E. & Hillmer, M. Identification, authoritarian defensiveness, and self esteem. Journal of Abnormal and Social Psychology, 1962, 64, Pp. 334-342.

34. Thibaut, J. & Reicken, H. Authoritarianism, status, and the communication of agression. Human relations, 1955, 8, Pp. 95-120.

35. Triandis, M. Cognitive similarity and communication in a dyad. Human Relations, 1960, 13, Pp. 175-183.

36. Zajonc, R. The process of cognitive tuning in communication. Journal of Abnormal and Social Psychology, 1960, 61, Pp. 159-167.