Order Number 8910383

The evaluation and measurement of physician and patient communication

Ward, Shedrick Ervin, Ph.D.

Wayne State University, 1988

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300 N. Zeeb Rd.
Ann Arbor, MI 48106

THE EVALUATION AND MEASUREMENT OF PHYSICIAN AND PATIENT COMMUNICATION

by

SHEDRICK ERVIN WARD

DISSERTATION

Submitted to the Graduate School
of Wayne State University,
Detroit, Michigan

in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

1988

MAJOR: EVALUATION & RESEARCH

Approved by:

Marvin J. Alkin

Clayke C. Irwin

Roger A. Dehnert

James S. Merrill

ACKNOWLEDGMENTS

Gratitude is extended to Professor Martin J. Hogan for his availability, encouragement, and friendship throughout the development of this dissertation. Its contents have benefited enormously from his leadership, criticisms, and stimulating suggestions.

Special thanks are also extended to Professors Claire Irwin, Juanita Collier, Richard Gallagher, James Measell and Roger Demont for their positive support and generosity in reviewing the dissertation manuscript and influencing my thinking on research skills and design including communication and the behavioral and statistical strategies useful in an analysis of communicative behavior. The staff members of the Department of Educational Services and Research of the Wayne State University Medical School have been cooperative and supportive.

And finally, I wish to thank the many students and faculty members that have tolerated my sensitivities and directness while working on this project. I'd like to thank God for the family that was there when I needed them and for their patience about my absence in family affairs during the writing of this dissertation. A special note of appreciation is given to my son, Shedrick Jr., a very special person, for being considerate enough to allow me to complete this project.

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CHAPTER 1

INTRODUCTION

The diagnosis and treatment of patients begins with the medical interview. Physicians and health care professionals collect clinical information for evaluation and discussion and allow the results of data analyses to be shared with the patient. The primary focus of this dissertation is the development of a method for the measurement and evaluation of the medical interview. This interaction includes the construction of a medical treatment plan and the monitoring of the course of a disease or complaint brought to the medical care team.

The medical interview represents the central core of the many relationships the patient creates with multiple levels of medical personnel. It seems reasonable to expect that the greater the skill of the interviewer, the more complete and reliable will be the information on which a diagnosis is dependent. A "good" doctor/patient relationship requires effective interviewing skills and increases the probability that the patient will cooperate with the health care team.

This research project is designed to reveal a method to investigate the interdependent nature of evolutionary growth as a result of communicative behavioral exchanges in the various interactive modes which are established between two cooperating individuals. Communicative interaction is defined

in this study as a feedback system of operations which may occur between individuals, groups of individuals or environmental fields. Communication is hypothesized to be the vehicle which transmits information from one communicant to another. As a consequence, communication will be defined as an interdependent process. The purpose of this research project is to provide support for a "new" frame of reference for a science of clinical communication measurement which, in theory, seeks to minimize the deterministic notions that have been the central focus of scientific explorations for many years.

More specifically, the direction of communicative evolutionary growth in living organisms, as represented by physicians and their patients, is not governed by any single set of laws but an interdisciplinary composite of many laws. The evaluation and assessment of this evolutionary growth can inevitably lead researchers to the measurement of the topological variance, which phenotypically is associated with any evolutionary change. The direction of any assessment in the communicative behavior of research subjects is best done in naturalistic environments because to do otherwise will violate the integrity of the analysis and subsequently introduce contamination and errors in the interpretation of cause and effect of any hypothesized relationships.

The relationship with "reality" should be preserved for any further consideration at different points in time. The end of the century is quickly approaching and the

transitional fluctuations evident in conversations within contemporary social structures must be understood, if we are to collectively continue with the evolution into a society which values the individual and the necessary associations and interactions of that individual with the remaining components of the universe.

Physicians are the primary individuals within a therapeutic, clinical universe endowed with the professional responsibility for assessing the nature of the interactional components, active or passive, which may direct us to certain health or illness conditions. It is necessary for physicians to evaluate, holistically, the etiological factors responsible for the conditions which precipitate diseases and assist individuals and families in coping with these conditions until a state of health and well being is attained within the individual and between individuals of a society. This study assumes that reality is an everchanging and unpredictably stochastic condition which maintains a constant state of flux. And this constancy requires a more varied set of coping skills for all people, patients and physicians alike.

ANALYSIS OF THE PROBLEM

The topological nature of the universe has been available to the scientific community that investigates such physicial realities. The construction of methods to understand communication as a quantitative dimension is contained in the label of "Information Theory". Extensions of the concepts of information theory are useful in understanding biological and medical notions of communication. If information exists, then a probability also exists that the information may be distorted, lost or misinterpreted. Information can be quantified and information content may be manipulated mathematically.

The problems associated with the documentation of objective reality were first encountered by Hereaclitus (Stokes,1968). This Greek philosopher introduced the notions of process, interactions and conflicts as the required antecedent events in the development of living forms and includes the various levels of systems which are composed of elemental forms of organic and inorganic matter. The core of the problem is associated with the development of mathematical methods to account for the perturbations and slow variations in nature's unfluence over the communicative feedback between and within individuals, as represented by the physician-patient dyad and the other life forms of our environment.

The communication in health care environments is determined by factors which allow an accurate perception and

transmission of verbal and non-verbal information. The health care of children requires that communication exist between the physician and the significant people in the child's world. The mother is significant and has a major role in meeting the health care needs of the child. She is a valuable source of information for the physician wishing to provide medical services. Ideally, the establishment of a communication network with the mother should occur early in the birth of the child. Clinical interviews can indicate which patients should be considered at risk. This study investigates the communication channels of the physician and mother as they discuss and plan a strategy for the health care of a newborn child. The hypotheses generated for this study involve the physician and the caregiver, represented as the mother. These individuals participate in interpersonal communication which is characterized by:

1) The presence of expressive acts
2) The conscious or unconscious perceptions of expressive actions
3) The observation that such expressive acts have been detected by others

Interpersonal communication should not be confused with intrapersonal communication. In the interpersonal situation, the effects of purposive or expressive actions can be evaluated and corrected as required by the interaction. While intrapersonal situations do not allow an accurate description or measurement to occur using without contamination or undesirable effects on the subjects of the study.

MAJOR HYPOTHESES

Null hypotheses for statistical testing in this investigation are the following:

1. There are no statistically significant differences (alpha = 0.05) between the mean activation times for the physician verbal communication signals and in patient (Caregiver) verbal commmunication signals in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance".

2. There are no statistically significant differences (alpha = 0.05) between the mean activation times for the physician non-verbal communication signals and the patient (Caregiver) nonverbal communication signals in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance".

3. There is no statistically significant difference (alpha = 0.05) between the amount of information transmitted in the active verbal communication signals of the physician and the amount of information transmitted in the active verbal communication signals of the patient (caregiver) in a clinical environment as mapped by the topology of the "Hogan interactional Profile of Physician and Patient Performance".

4. The Pearson product-moment correlational coefficients between the amount of time required to transmit verbal signals by the physician and the amount of time required to transmit the verbal signals of the patient (caregiver) in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" will be "negligible" when evaluated according to Best's criteria.

5. The Pearson product-moment correlational coefficients between the amount of time required to transmit non-verbal signals by the physician and the amount of time to transmit non-verbal signals by the patient (caregiver) in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" will be "negligible" when evaluated according to Best's criteria.

6. The Pearson Product-Moment Correlational Coefficients between the amount of information transmitted by the physician and the amount of information transmitted by the patient (caregiver) in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" will be "negligible" when evaluated according to Best's criteria.

MAJOR SUB-HYPOTHESES

1. There are no statistically significant differences in the distribution of the spectral coefficients in the active verbal communication signals for the physician and in the distribution of the spectral density coefficients of the active verbal communication signals for the patient (caregiver) in the clinical environment as identified with the "Hogan Interactional Profile of Physican and Patient Performance".

2. There are no statistically significant differences in the distribution of the spectral density coefficients in the active non-verbal communication signals for the physician and in the distribution of the spectral density coefficients of the active non-verbal communication signals for the patient (caregiver) in the clinical environment as identified with the "Hogan Interactional Profile of Physician and Patient Performance".

3. There are no statistically significant differences in the distribution of the spectral density coefficients in the amount of information transmitted by the physician and the spectral density coefficients in the amount of information transmitted by the patient as transmitted in the clinical environment as identified with the "Hogan Interactional Profile of Physician and Patient Performance".

MINOR HYPOTHESES

1. There are no statistically significant differences in the spectral density coefficients across all analytical frequencies for the active verbal communication signals of the physician in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicated by the Kolmogorov-Smirnov statistic.

2. There are no statistically significant differences in the spectral density coefficients across all analytical frequencies for the active non-verbal communication signals of the physician in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicated by the Kolmogorov-Smirnov statistic.

3. There are no statistically significant differences in the spectral density coefficients across all analytical frequencies for the amount of information transmitted by the physician in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density

coefficients for white noise as indicated by the Kolmogorov-Smirnov statistic.

4. There are no statistically significant differences in the spectral density coefficients across all analytical frequencies for the active verbal communication signals of the patient (caregiver) as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicated by the kolmogorov-Smirnov statistic.

5. There are no statistically significant differences in the spectral density coefficients across all analytical frequencies for the active non-verbal communication signals of the patient (caregiver) in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicted by the Kolmogorov-Smirnov statistic.

6. There are no statistically significant differences in the spectral density coefficients across all analytical frequencies for the amount of information transmitted by the patient (caregiver) in the clinical environment as mapped by the topology of the "HIP4" and the spectral density coefficients for white noise as indicated by the Kolmogorov-Smirnov statistic.

A Historical Review of the Problem

Issac Newton bequeathed problems of cyclicity in communication exchanges to his successors and failed to provide an agreement with the mathematical position of Laplace's demonstrations that natural variations are cyclic. This position was antithetical to the theoretical view held by Newton which maintained that only a "spiritual" intervention could prevent living and non-living systems from the proposed depressive degenerations and increasing entropy that should be expected from the natural flow of energy as as an informational source in nature and natural events (Pannekoek, 1961). It took the scientific revolution of the seventeenth century to reform the naturalistic philosophy in vogue during this embryonic phase of the modern scientific revolution. It was only a short time before this that the recognized religious and philosophical prophets attempted to destroy their existing order and replace it with a "better" system. Their collective effort was directed towards the achievement of TRUTH and they were committed to the belief that this could only be achieved by utilizing a particular approach to the problem. This is aptly reflected in Galileo's classic statement:

> If this point of which we dispute were some point of law, or other part of the studies called the humanities, wherein there is neither truth nor falsehood, we

> might give sufficient credit to the acuteness of wit, readiness of answers, and the accomplishment of writers, and hope that he who is proficient in these will make his reason more probable and plausible. But, the conclusions of natural science are true and necessary, and the judgment of man has nothing to do with them (DeSantillana, 1953, p.63).

This galilean commitment remained the tradition for many decades and was frequently renewed during the institutional and ideological struggle for philosophical dominance in many active scientific explorations. During the nineteenth century, a description of the thrust for self-consciousness in scientists as well as the philosophy of science was given by Karl Pearson's publication, "The Grammar of Science". In this writing a discussion occurs about the fact that science has had to carry on a type of "warfare" with the metaphysicial and other dogmatically fixed philosophical orientations. The exigencies of this struggle explained the deliberate concealment of the obscurity which surrounds the principles of measurement in science. Pearson believed that the position of science had been distorted and its content would become convoluted with any prolonged philosophical comparisons. It was not long afterward when the views of Pearson would be shared by others in the documentation of the war between science and philosophical idealism (White, 1986). The European continent was soon involved in the clash of ideas. The Germanic became involved and began to experience the bitter struggle for the establishment of science as a worthy discipline that was

different and independent of the religious and academically relevant philosophies of earlier times. It took the travels of an englishman, Charles Darwin, to provide a massive body of evidence for science. This single individual provided the fuel for a hysterical debate over the orgin and properties of the variance within the many life forms existing on this planet. In the "Theory of Evolution" empirical evidence was provided for a scientific interpretation of the variance in life forms.

> He who believes in separate and innumerable acts of creation will say that in these cases it has pleased the creator to cause a being of one type to take the place of another type. But, This seems to me, only restating the fact in dignified language. He who believes in the struggle for existence and in the principle of natural selection, will acknowledge that every organic being is constantly endeavouring to increase in numbers; that if one being varies ever so little, either in habits or structure and thus gain an advantage over some other inhabitant of the country, it will seize on the place of the inhabitant, however different it may be from its own place.
>
> (Darwin, 1859, p.217)

The autonomy of scientific goals and the methods available for scientific investigation was at stake in these struggles. The freedom of scientists to arrive at conclusions based on empirical data provided by diliberate design or chance operation was preferred over the irrelevant Judeo-christian teachings or other equally nebulous metaphysical doctrines.

This opened the possibility for rejection due to the nature of the differences and in fact was tantamount to a confession of atheism or agnosticism. As a consequence, the

orientational difference of the galilean commitment to TRUTH in science has continued. Because of its unquestionable success, natural science has appeared to be the paradigm of genuine knowledge. And, in many ways the disciplines of science, or the popularized notions of science have functioned as a religion for those predisposed to such an orientation as a substitute for or in opposition to the traditionally accepted metaphysical doctrines established by religious institutions. More pragmatically, the concept of having established a truth that will live after physical death provides an acceptable motive for the personal and dedicated efforts of many scientists.

But, since dogma and metaphysics are not the locus of the concern in discussions within the scientific community. The academic identification of the humanities and other traditions, which have been classified under the rubic of "The Arts", and the debates over the differences between the views of the artists and the defenders of science will continue for as long as mankind continues. This debate seems to oscillate between two levels:

1) The scientific knowledge itself, and

2) The applications of that knowledge.

> The arts are certainly central to life. Yet they are not the kind of thing that will inspire men to push to new heights...even the works of shakespeare, which are essentially an exploration of human character, are really wonderful, glorified gossip.
> (Rabi, 1965, p.20).

The achievement of a historical perspective towards science allows an orientation towards understanding the nature of the entity known as "facts". There is no magical formula to explain the success of science. There is no special property of the physical world which makes it uniquely available for human reason. The scientific knowledge available to us has been the result of the social interactions of scientists which may result in the production of explorations. Over the centuries these explorations have developed an approach, appropriate to the goals, allowing the products from each individual to be influenced and controlled by the other members of the scientific community.

There are many sorts of human experiences within the medical and scientific community in which facts will frequently appear as hard, massive and impenetrable units of scientific knowledge. Facts are the candidiates for the bearers of certainty and truth. They are exhibited by teachers and professors in the higher academies of education. Many youthful scientists are exposed to hard facts as the foundation and proof of the scientific theories they represent. In the long term retrospective analysis of any mature scientific discipline there are few facts which exist as pronounced survivors of the erroneous theories of the past. Many of the illuminating and magnificant products of scientific effort exist in the theoretical synthesis which can be operationalized with adherence to a specific

set of verifiable and replicable methodological procedures. The foundations of experience must depend on facts, it must predict new experiences which prove to be real and it must survive the inevitable collision with "antifacts". And regardless of the intensity of the effort to illustrate the necessity of creativity in scientific inquiry or to demonstrate the bold theorizing and speculation that are incorporated into scientific advances, it must be acknowledged that science can be surreptitiously described as the preferred mode of increasing the quantity and the quality of the factual knowledge available to process the available information from and about the nature of our environment as it impacts on our behaviors as we attempt to communicate with one another.

But the atomicity of facts cannot and should not be absolute. Any philosophical discussion on the belief that significant assertions can be free of theoretical assumptions is obvious. The physical assertions within science are classes of intellectually constructed images and events. This obviously fails to remove the epistemological significance of facts within the scientific realm because it can be further assertioned that the theory associated with any particular fact may be independent of the relevant aspects of the theory being tested by an encounter with that fact. Excluding epistemological evidence, experience indicates that historical events demonstrate that the hardest facts are not quite as hard as believed.

Analytically, the achievements in science involve skill and judgment art every point in the evolving creativity and assessment of the activity known as scientific research. The evaluation and determination of what constitutes a fact appears to be the result of a social phenomena subject to the same influences of peer pressure and errors to be found in any other social encounter. The errors of scientific exploration are available for inspection in the archives of the myraid of scientific literature. A fact today is at risk of being dismissed in the future as an erronous conclusion which was based on crude data, interpreted by an incorrect theory. But the common fate of erroneous facts is similar to that for a old soliders, they merely "fade" away.

A classic example of a refuted fact is the principle which maintained that the orbital motions of the planets were a series of uniform circular motions, considered and defined as the ptolemy system. This system maintained the earth as the rotational center of the known universe. This notion adhered well to the accepted laws of physics, known at the time, and was correlated with the empirical facts. It was the natural physical interpretation of the mathematical tools used in any ancient or modern calculation of cyclic processes. More recently, the conservation laws of mass as elucideated by Aton Lavoisier was a basic and fundamental fact until Albert Einstein provided the necessary evidence for its refutation. It now appears that the objectivity and certainly of science is a questionable paradox. Any abstract

epistemological analysis will be insufficient to resolve this issue. It becomes necessary to accept the notion that scientific growth is dependent on the directed interactions of scientists. These interactions govern the processes controlling the direction of the interpretaton of verifiable factual information obtained from experimental or analytical methods.

Any attempt to understand the logical structure of the body of scientific knowledge that exists reveals that there has been a plethora of analyses on the status of facts, laws, hypothesis and models within the scientific community as they relate to specific experiences. Some of the classic laws of nature have been derived by particular experiences by scientists using the inductive method. Examples include kepler's laws of planetary motion and Robert Boyle's gas laws as they relate to density. There are other laws which have been produced as axioms for an elaborate theoretical description which has been very remote and isolated from the experiences associated with their discovery. The structure of the cyclic benzene molecule (1,3,5 Cyclohexatriene) by Kekule is a prime example of the creativity required by the attentive scientific researcher. Additional examples can be found associated with the laws of motion and thermodynamics. It appears that a particular set of laws may be more solid than those facts which provide the support for the laws generated by those facts.

The establishment of facts in education using research

methods is a very recent phenomena. The application of valid scientific principles and interests can be correlated with the expansion of education as a multidisciplinary concern. The interest in educational research was stimulated by the cooperative research act in 1954 which is directed at the improvement of education at every level and in every possible subject, medicine notwithstanding (Clifford, 1973). The establishment of the National Institute of Education in 1970, serves as an impetus to generate the required momentum for the directional thrust of educational research on substantive issues. The support for the educational researcher had undergone logarithmic growth as a result. And yet recent governmental discussions have provided evidence for an increasing ignorance on the value of educational training and skill in the funding for 1986-1989 budget years in the American political system. But, controversy still exists about the goals of the educational researcher. Some maintain that a cautious attitude is warranted and educational research should have as its goal the production of "knowledge" and a theory to understand phenomenological concerns (Jackson, 1977; Kerlinger, 1977; Tyler, 1978).

The expectations of the American Public have revealed and appears to be logically related to the faith placed in the scientific paradigm and the influence of a pragmatically relevant philosophy. Athough pragmaticism does not dominate educational philosophy, it does influence the appreciation of educational research. James (1961) explains the pragmatic

research method is an "attempt" to interpret each notion by tracing its respective practical consequence. To attain a perfect clearness of our thoughts of an object, we need to consider what conceivable effects of a practical kind the object may involve. This pragmatic consideration is substantiated by fact and is considered within the nineteenth century faith in science and the evolving technologies (including the micro-computer) resulting from significant scientific effort and cooperation. The problems associated with educational research are complex. Many professional practitioners, administrators and other individuals are not aware of the major findings in educational research. They frequently express skepticism and doubt about the applicability of the research product.

Research problems can be generally be segregated into two major divisions, the theoretical and the practical (Schubert, 1980). The theoretical orientation is directed at the study of events with the goal of establishing generalizable conclusions for further application or directional support. The practical approach is directed at resolving some unique and special issue which concerns educators. Within the traditional research paradigm, basic research and applied research have a theoretical thrust while "action" research is considered as being more pragmatic. Many investigators have addressed this basic and applied research dichotomy. Shaver (1969) is adroit with his position when he maintains and deposits a description of the

differential aspect of this dichotomy.

> Basic scientific research attempts to generate knowledge and theory. The researcher is not primarily concerned with practical consequences or moral implications of the research. On the other hand, applied research seeks to explain and understand teaching and education where validity of practice is tested with the hope that results will be generalizable beyond the specific setting of the study and sometimes, even directly applicable to theory building. (p.4)

Kerlinger (1977) indicated that because the basic researcher is not clearly associated with a specific problem, some of the results will be more significant than others. The results can be generalized to many other areas of interest. Applied research is believed to be more limited in its impact on the scientific community. This does not indicate that applied studies are minimally significant, but they are different. Shaver further suggests, that the facts of applied research...

> At the least, suggest boundaries of generalizations...The delimitation of applicability can be as important as theory conformation to those who want to use research evidence to make decisions about practice. (p.5)

Begle and Gibb (1980) summarize the discussion of relevance of basic and applied research and their progressive associations with the ever changing fluctuations which are characteristic in the artistic nature of professional learning demonstrated in education and

medicine. The research must be translated for the professional pratitioner into comprehensible forms. The significance of this translation has been noted by substantial numbers of interested writers (Lancaster, 1978; Singer, 1970; Stark, 1978). Since this project is concerned with a problem of magnaminous proportions, TRANSCULTURAL COMMUNIATION PATTERNS, the orientation dictated by the problem situation is an important issue. Schuber (1980) addresses this point by indicating that the end products of practical research is situationally specific requiring decisions and action. Problems should be viewed as specific events and the researcher must become a participant and experience the problem if results are expected.

> Action research is undertakern to act as a guide in the solution of an immediate problem. It is willing to forgo scientific rigor in its primary concern for a usuable answer to a problem existing here and now. (Mouly, 1969, p.1150)

A model of pragmatic research is the concern of Strikes (1979) when discussiong the orientations of research which can be categorized by the Schwabian term "practical research". A central commitment of this model is that it fails to be theoretical (p.13). Educational research varies in many ways. Differences can exist in the population of interest, the topic of the investigation, the experimental or investigational method used, the geographic locus of the study, the history the subjects bring to the research design as well as the variables which may be of interest. Gage

(1979) analyzed educational research and his findings seem to support the heterogeneity of the research conclusions, regardless of the orientations taken by the researchers. He believes that...

> Overall, the empirical findings seem to favor some degree of both specificity and generality. The findings are not yet abundant enough to support firm conclusions, but they suggest that when more adequate evidence becomes available, the resulting picture will not be either completely general or completely specific.
> (p. 278-279)

He goes further to suggest that a hierarchical model of the structure of the dimensions related to the effectiveness of professional interactions should be considered when evaluating the nature of research and its effect on the artistic practice of professionals in medicine or education. By using empirical data, the hierarchy can be validated to identify those variables which are generalizable and those which are situationally specific. This hierarchical model would provide a set of logically consistent directives for establishing an appropriate frame of reference for research which is scientifically valid and situationally reliable. Evidence supports the notion that research should be used as an instrument for change (Russell, 1961; Slavin, 1978). However, most research designed for educationally relevant purposes requires a significant amount of time before it is incorporated into practice. Thorndike stated in 1921 that it is reasonable to expect a time lag of thirty to fifty years before significant research facts would be implemeted

(Clifford, 1983).

When physicians maintain a purely organic view of disease then no other available orientations will be allowed for investigation of our understanding of pathology. If a discovery is made, or a hypothesis is refuted, that unit of activity has ended. The facts will be established and the next pertinent unit of activity will be initiated. We may, metaphorically, construct the walls of academia by providing one brick of knowledge in this majestic edifice. And eventually, according to plan, the structure will be complete; we will understand what is available to be understood. But in science, this orientation is not acceptable and very much inadequate. A "solved" scientific problem is not, and should not be a closed and perfected structure. A "cure" is not a cure.

Instead, the solution is an imperfect product of a unique process which is dependent on the type of data or information presented or produced, the analytical tools available for processing that information as well as the skills and perceptions of the researcher. As tenative conclusions are developed, the scientist assumes that the research task is incomplete and those addressing the work may find it to be significant in the way in which it is designed, the construction of the analytical tools utilized or by the modification of previous views maintained prior to the research. From these possibilites a new set of problems can be designed and further investigated.

It will then appear that the original problem will have a set of descendents. And as with all descendents, concrete or abstract, they will have their unique identities. Is it not appropriate to look at a problem and consider its evolutionary path as a linear sequence having a predictive coefficient. Instead, problems evolve within a lattice of decendency. They would be better described by the evolutionary associations which underlie the characteristics of the problem. It is from this orientation that Newton may be considered as the father of classical dynamics and Einstein, the father of contemporary relativistic physical science.

There is a simple orthodoxy which exists to explain the approach to understanding relationship between the various life forms currently in existence. This orthodox position maintains that a newtonian or predetermined, mechanistic description of life forms is appropriate. This paradigm considers all living organisms, plant and animal alike, as physico-chemical machines and all associations with these machines can be described within the disciplines of Chemistry and Physics. This predictive mechanistic paradigm has existed for many years and its popularity exists because it gives the perception of "working" well. (Kuhn, 1962, p. 112)

This reductionistic, mechanical paradigm is popular with the traditional scientist and has allowed a detailed elucidation of the genetic proponents of life. Medical

science has not been remiss in exploiting this paradigm for the obvious benefits it brings to the health care arena. But when it comes to human behavior and its various indirect manisfestations, the mechanistic paradigm is meeting unanticipated obstacles. This paradigm certainly has significant contributing points which cannot be disputed, but it is not the final "stone" in the structure, maintanance and understanding of life forms.

This topological structure remains incomplete and continues to evolve and as a result must be modified to account for the empirical evidence available for inspection. The incidence of hypertension and other idiopathologic conditions classified under the guise of psychosomatic illnesses and "miracle" cures are well documented in the literature (Weiner, 1977). Yet, these conditions, with their obscure etiologies remain unsolved problems for medicine. It is apparent that an additional factor could exist and assumed to be interacting with the physico-chemical systems and processes which govern life and its multiplicity of forms. This additional factor has been defined as being "vital" for life (Driesch, 1908; Bergson, 1911; Sheldrake, 1980) but has not been adequately supported by appropriate research methods. A holistic philosophic foundation is necessary for radically revising the mechanistic doctrine is underconstruction. This disseration (research project) will serve as an additional brick in this "new" paradigm for understanding the communication patterns of life forms.

A vitalistic philosophical framework denies that all of the events associated with life forms are available for inspection on either the microscopic or macroscopic planes. It maintains that the "patterned" order and rationality of life forms exists within the multi-associated hierarchies of the systems associated and responsible for any living form. These hierarchies communicate together to produce new structural entities that are identified as being either a tree, a bird or a patient. To state the gestalt that "the whole is greater than the sum of its parts" would be antithetical to the abstractions of geometric rationality. Yet, this is the best method available to describe life. As Alfred N. Whitehead maintains, life is Biology and Physics interrelated through chemistry (Whitehead, 1928). Many researchers have advocated this approach for explaining life forms (Woodger,1929; VonBertalanffy,1933; Whyte,1949; Elasser,1966; Koestler,1967; LeClerc,1972). Each of these theorists have created propositions which contain a common factor which fails to have more than a mere superficial influence on the contempory definitions of life, namely, they provide us with no testable predictions. This controversy allows critics to point to the fact that "it makes no difference to realtiy if one maintains a reductionistic or a nonreductionistic philosophy for a view of life" (Ayala, 1972, p.85).

A plausible and verifiable notion on life has been proposed (Weiss, 1939). In this proposal, the evolution of

life can be described by factors outside of the life forms, evolving in much the same way that electrical fields exist outside of non-neutral substances or the gravitational field exists outside of physical masses. And just as predicted, some scientists have quickly dismissed this notion without these sufficient additional considerations. They have finished building their academic structures and any modifications of those structures will reduce the significance of their time honored positions. (Elsasser, 1966,1975; VonBertalanffy, 1971).

It is necessary for scientists to introduce a method to address the complexity found in the mechanical physico-chemical systems of life forms, from the unicellular organisms to the multicellular complexities termed "Man" (Waddington, 1969). This study seeks to continue with the construction of evidence in support of a "field" which is necessary and fundamental to the organization of man's evolution in both a physico-chemical and psychcological realm. No level of complexity is immune to the effects of this evolutionary field, because this field allows the concept of potentiality in the evolutionary nature of life forms to exist.

This concept of an evolutionary pathway potential has an apparent order which may be linear (predictable) or nonlinear (indeterminate) to developmental processes. From an energetic framework, the indeterminate factors of the universe are stochastic or probabilistic in nature. And

these proposed evolutionary fields are associated across time allowing the past to have a significant effect or force on evolving perceptual topologies or realities. In otherwords, this evolutionary field has the ability to communicate and interact across space and time producing life forms capable of affecting other life forms, even those not yet in existence. This means that one member of the universe can be treated by a particular research design or methodology which will affect the probabilistic occurances of future members to understand the research paradigm without direct communication or physical association with the member producing the original treatment. The evolution of scientific thought is preceded by a history of prior conceptual thought. This is illustrated in Whyte's study demonstrating the factors from which S. Freud extracted his notion of the unconscious processes operating to direct observed behavior or the thought processes which support the continuation or initiation of the observed behavior. (Whyte,1960).

Alfred N. Whitehead (1925) established the concept of a "system of systems" in his publication, "Philosophy of Organisms". This has lead to the common definition of a system as that factor which consists of a group of interacting, interrelated or interdependent elements forming or regarded as forming a collective entity (Morris, 1982). And as such, life forms may be considered as a set of living systems, comprised of non-living components. This notion has

received the support of Ludwig VonBertalanffy, Roy Grinker, Karl Menninger and James Miller. The concept of a field theory is supported by the theoretical frame of reference established by Kurt Lewin and Fritz Heider whose field theory concepts could be described as a variation of the systems concept.

Their field include the totality of coexisting factors which are conceived as being mutually independent (Lewin, 1951). But, their theory is restricted to psychological factors at the exclusion of important physiological factors. So this field concept should be extended to include the biological, social, economic and cultural factors. George Engel (1954, 1977) and Fritjof Capra (1982) have proposed that a need exists for a more comprehensive model to account for the difficulties experienced in contemporary medicine. Early studies have demonstrated the effects of various factors on the behavior and course of patients receiving medical treatment within a hospital environment (Stanton & Schwartz,1954). This has correlated well with the generalized systems approach that has been proposed by Thomas and Chess (1980). Larry Dossey (1982) indicates that illness cannot be thought of as a mistake within the organism, but rather as a response or an error in the mode of behavior of the living organism to various forces acting on the organism as it moves through space and time (p.174). As a consequence, the cause and direction of any illness or health condition should be investigated in the dynamic

communication and interaction between the nature of the living system and the environment at all points in time.

General systems theory is a proposed set of related definitions, assumptions and propositions which deal with reality as an integrated heirarchy between matter and energy. This directs scientists to a more fundamental notion of living systems as collections of matter which exist in space during various times with the implicit purpose of extracting information from the spaces in which the living systems exist. Confusion is certain to exist in the notion of "space" without the required clarity. Space in the physical sense can be defined as a set of elements or points which satisfy specified geometric postulates. For example, Euclidean space consists of points in three dimensions which conform to the theory set forth by Euclid. Or, Space can be considered to have metric dimensions, a measure of distance or if it exists as a topological space it will involve the consideration of "neighborhoods". These space fields may be considered multidimensional in character. Physical space can been considered as the extension of the universe around a single point.

Geometric space has classically been simple to understand, but the contemporary notions of Einstein's generalized theory of relativity has demonstrated that physical space is better considered as the popularized Riemannian space which is a geometric arrangement of four nouniformly curved dimensions. The systems theory as

applied to living organisms employs two major types of spaces, physical and conceptual.

The analysis of physical space allows a description of its characteristics and restrictions. The properties of physical space affect the activities of all living systems, living or non-living. For example, within the nuclear envelope of some cellular types exist patterns of molecular configurations between specific moieties which have the potential to demonstrate multiple forms in space-time, these configurations determine the amount of information that larger macromolecular substances are able to transfer to other molecules or retain for evolutionary purposes. It is within this physical space that information is readily transferred between living and non-living substances.

In addition, this space is shared by physicians, patients and all scientists because all scientific data originates or is collected within the dictates of this common parameter. This is true for both the behavioral and the physical sciences. If any individual learns that a particular space exists, then the location of any specific entity may be specified using a cartesian coordinate system as a set of reference points and when coupled with the additional dimension of time, the object will occupy a unique position in both space and history. The events of the examiation room will not be replicable in any exact manner whatsoever. If the occasion exists when one of the dimensional properties is lost, then confusion is possible,

entropic factors become maximized and communication will be difficult if not impossible.

It is well known that the the available sense modalities have the potential to demonstrate distortions within this space-time matrix because of organic pathologies such as astigmatism or other dysfunctions. The degree of tactility can be disturbed by various paresthetic conditions. But it is possible, nonetheless, for living forms of matter to determine with a degree of precision the properties of this common physical space.

The other type of space, known as conceptual space, is abstract in its properties. This research project assumes the domain of this space is exclusive for living forms of matter. Physical dimensions have no meaningful metric in this frame of reference. The exclusivity of the conceptual space is dominated by the forms of matter which transmit information. For example, a physician may view a patient as "a living system existing within the space abstracted from the phenomena of intrest". This interest might include the concept of territorial or social dominance as related to communicational behavior or, the cultural space between different societies, the political distance between different social orders or the semantic space of a psychometric instrument as in Osgood's rating scales. These spaces do not have the properties attributed to the concrete dimensions of Euclid and are not subject to the same constraints as that physical space.

The physician and other social and biological scientists must be cognizant of their influence on this space and on the multiple interactional planes available to living organisms. It may be that this conceptual plane transmits a bulk of the information that eventually becomes processed on the physical plane. If isotopically labelled Iodine is allowed to enter the body, unassociated with the molecules of 3,5,3',5'-Tetraiodothyroxine molecule or any of its derivatives, it will become increasingly associated with the thyroid gland, regardless of its point of entry or orgin in the universe.

Similarly, it can be hypothesized that the frequency of interpersonal interactions may seem to be substantially greater and of different quality for individuals having similar sociopolitical positions and attitudes than those of geographical neighbors regardless of their respective biological (genetic) orgins. As a result of this type of discrepancy, problems occur when attempts are made to transform the dimensions of this non-physical space to the concrete relativistic space of contemporary science.

If a researcher makes empirical observations and obtains measures in other than physical space, then a special theory is in the process of evolving. This is permitted as long as the process does not fractionate the properties of interest to that researcher. Any transformation of one space to another space is permitted until the transformations can be made from any space to a

specified space field (Deutsch,1961; Isard,1961). And, If the researcher is not aware of the precise nature of the transformations required from one space from the observational space, a profitable study is still possible. For example, the observational measurements of thermal energy in temperature units is possible, even if the transformation to the units of the CGS or MKS dimensions of work unknown. This study uses the informational unit having relatively different weights for different individuals and incorprates this unit into a standard communicational unit the intact phrase. Any of the scientific observations about a given space which is not immediately transformable to other spaces should be the focus of special theoretical formulations which can incorporate the element of time for consideration and analysis.

Time is the major factor represented in the fundamental fourth dimension of Einstein. As a definition, time may be considered as "the instant" in which a unique structural entity exists or a transformational process occurs or continues to occur if initiated in a different time. (Morris,1982). The modern general theory of relativity makes it clear that in "large" systems, time cannot have any accurate or absolute certainity for descriptive purposes, especially if transformations are made from one system of interset to another. Time is a factor which is dependent on the relative frame of reference of the researcher or observer. As a result, an evolving system can be moved in

any direction in the three dimensional axis of Euclid's space, but only "forward" in the temporal dimension. This irreversibility and unidirectionality of time is correlated with the second law of thermodynamics which maintains that any "closed" conceptual system will have the tendency to maximize its entropy over time. And without significant inputs this process of forming low energy structures cannot be reversed. This principle is frequently considered as "times arrow" (Franklin,1910).

Living systems have the ability to process matter or information and provide meaning to the informational inputs. The informational input also provides the energy necessary to instigate the evolution of structure. This evolution of structure and form does not occur in a vacuum. It occurs from some previously organized system regardless of its apparent simplicity. During the evolution of the "higher" structural forms, the sources of the evolution become associated with an evolutionary field. The nature of this evolutionary field may be associated with concrete physical systems just as the mass of objects in Newton's gravitational fields are associated with the properties of objects. As a consequence, an evolutionary "seed" may become associated with an evolutionary field. This field-seed association should be considered as a component of the yet to be formed sturcture or process of concern to the researcher.

The evolutionary field must become associated with the

seed containing the unstructured or underdeveloped form. And, it becomes easy to become confused in the semantic complications possible, if the distincton is not made on the cyclic conceptualizations involved in evolving structures. In the absence of any interactions between the evolutionary seed and the evolutionary field no new structural forms are established. The evolutionary field is undetectable without the appropriate interactions. It can only reveal itself through the manner in which the interactions are ordered within the evolutionary field. This is an interpretation of the properties of morphological evolution as revealed by Rene Thom (1975). The construction of analogical notions of magnetic fields around a polarized quantity of lodestone illustrates a point. The spatial orientation of this field is not realized until interactions occur with secondary substances that are themselves uniquely constituted the respond to the invisible potential for organization.

The element Iron is an appropriate secondary substance for detecting the evolutionary field around a polarized body. The absence of Iron does not indicate that the absence of a potential evolutionary field. H.S. Burr (1972) provides evidence that perhaps life forms are organized because of the association with electromagnetic fields which change as life forms mature. The final product of evolution has a structure which could be attained by any number of evolutionary pathways in much the same manner that water will flow from a high position to a low position by any

number of paths and the path taken by the water is indeterminate and dependent on the obstacles or interactions which are experienced between the initial position and the final position. This type of evolutionary pathway has been called a chreode by C.H. Waddington (1957).

Living organisms have the innate ability to retain their evolutionary directions by the nature of the regulatory considerations available to those organisms. Any attempt to destroy or alter the final state of an evolutionary scheme may result in an attempt by the organism to restabilize the processes which establishes the final product. This probably is the way regeneration occurs. The conceptualization of a collective evolutionary direction is possible in simple organic systems when temperature reductions force the molecular configurations to assume new structural identities by attempts to coalesce and aggregate into a more stable evolutionary arrangement. Molecules of gases, within the appropriate evolutionary field, have the potential to collect into molecules of the solid phase. This is a well known and useful arrangement for the evolution of new isomorhic structures.

The concept of chemical evolution is closely linked with the notion of human communicative evolution on either a concrete morphological plane or a socio-political plane. For example, if a chemist removes electrons from the structure of an atom, the orbital paths for these substances are not destroyed. Externally, it will not appear that a potential

exists for a structurally organized entity until the evolutionary components, the primarily nuclear core, interact with the subatomic particles that are eventually associated with the evolutionary field to produce the product, a neutral atom.

Additionally, the location of the electrons may further be associated with the emission of quantum factors known as photons, if those electrons become associated with higher than expected energy levels of the field. These stabilizing forces can be emitted and detected as discrete quantites of energy, or frequencies of radiation. Likewise, in human communication the interactants must allow an appropriate level of energy to be available within the informational matrix before the reception of a signal is detected. Without sufficient levels of energy the desired communicational topology is not recognized and continued attempts to communicate using higher energy levels within the information matrix is required. Or, if the mode (i.e, verbal or nonverbal) of the communication signal is altered, a lower level of energy might allow a positive reception of the signal to occur. Each situation is dependent on the previous history of the interactants, including their respective culturally relevant evolutionary fields.

If Atoms are then allowed to represent the evolutionary seeds of the smaller molecules of nature which may in turn become the evolutionary seeds for various macromolecular structures known as polymers (i.e., structural proteins or

the macropolysaccharides of glycogen). And Organic Chemistry has designed an abundance of evolutionary substances which serve as the seeds for more complex substances. Each of these evolutionary seeds has the potential to produce more than a single type of product. The product formed is dependent on the evolutionary field established for each of the myraid of products possible. The evolutionary fields of atoms can be thought of as spatial stochastic events with distributions much like human evolution on the physical, psychological or cognitive planes. Suppes (1970) supports this idea with the concept of causality being a probabilistic event. There seems to be no reason to suspect that the evolutionary fields associated with atoms or molecules are not operational with other events of the universe. Why should molecules or atoms be so privileged in the scheme of things to be? When they are merely demonstrating that an evolutionary field may be associated on a particular plane possessing a specific level of evolutionary complexity. The identification of a particular atom or molecular formation has the potential to participate in multiple reactions and consequently may be associated with multiple evolutionary fields.

If it were possible to consider all the evolutionary fields as singular stochastic events when associated with each evolutionary seed then, all products of the interactions would have the same probability of being formed? It is suspected that the evolutionary products are

associated with a set of probabilities that are associated with each transformation and could be realized by a researcher utilizing the appropriate measuring instruments. In the laboratory, any reactive substance requires unique associations before specified products could be formed. These associations include unique reagents, effective orientations during collisions as well as appropriate energy levels during the collisions. If the evolution of a solid crystalline substance is associated with an atom, should a different mechanism be assumed to be operating? For example, in the laboratory, a chemist may increase the rate of formation for a crystal of a solute from an aqueous solution containing that solute by providing the solution with a "seed" crystal. This will have the tendency to increase the rate of crystallization because a template exists in the seed for the replicative goals of the chemist. The solution will not not have to depend on the time required to search for an appropriate orientation for growth and stabiltiy. The directives for growth are "artifically" provided. This model of crystal formation represents the evolutionary seed, which simplifies the complexity of the communication during physician paient encounters and for understanding the process involved in role models, physical examples and images for learning in animals, including man. A model is a useful creation because it allows the researcher to use:

An analogy that abstracts or selects parts

> from the whole, the significant elements or properties or components of that phenomenon that is being modeled. The model then allows the scientist to observe the interactions of these vital elements from from the confounding of the insignificant elements
> (Fisher, 1978, p.64)

Although the transformation models in non-living systems are considered as aggregates of simplistic images, the complex molecules of higher life forms can undergo similar types of transformations. For example, the important substances found in animals, proteins, lipids and carbohydrates can also go through an aggregative formation to produce complex polymers. Each of the polymers formed will have uniques electrochemical properties. R. Williams (1979) has shown that the possible types of transformations of these substances is dependent on the influences available from the evolutionary fields of these substances. One of the most important considerations for proteins is their respective three dimensional structure, known as their conformational arrangement or tertiary structure. It is possible to alter this structure by changing the environental field of the protein.

> The extreme rapidity of the refolding makes it essential that the process takes place along a limited number of pathways, even when the statistics are severely restricted by the kinds of stereo-chemical ground rules that are implicit in a so called Ramachandran plot. It becomes necessary to postulate the existence of a limited number of allowable initiating events in the folding process. Such events, generally referred to as nucleations, are most likely to occur in parts of the polypeptide chain that can participate in conformational equilibria between random and coperating stabilized arrangements... Furthermore, it

> is important to stress that the amino-acid sequences of polypeptide chains, designed to be the fabric of protein molecules only makes functional sense when they are in the three dimensional arrangement that characterizes them in the native protein molecule. It seems reasonable to suggest that portions of a protein chain that can serve as nucleation sites for folding will be those that can 'flicker' in and out of the conformation that they occupy in the final protein, and that they will form a rigid structure stabilized by a set of cooperative interactions" (Anfinsen, 1975, p.228)

This does not immediately provide an illumination of the "blueprint" for the required evolutionary pathway and perhaps the instructions for the protein's conformational evolution exists within its submolecular identity, namely the chemical bond. But it does indicate the necessity of "interactions" for the evolution of structure at this plane of physical existence.

The chemical bonds associated with complex molecular structures are the links between independent atomic identities. These bonds require electrons and the orbitals of the electrons before they evolve. This system has been adequately described by E.Schroedinger (1928) and models elaborated by the famous Schroedinger equation. And, according to the theory of quantum mechanics the exact nature of the orbits, electrons and their activities can not be predetermined or predicted with absolute certainity. But they can be specified within stochastic fields. These probability fields are the evolutionary paths that the developing complexities can assume. So, it seems that the evolutionary fields for the molecular configurations of proteins is

dependent on the particular probabilities associated with the evolutionary seeds of its atomic configurations representing the electrons and orbitals. This represents substantial support for the premise that "all" evolutionary pathways do not have an equal probability for determining the tertiary structure of complex macromolecular entities.

The original theory of quantum mechanics was associated with the simplest atomic configuration possible, the hydrogen atom. When J.S. Balmar (1885), a high school chemistry teacher, was able to demonstrate the possibility and provide a description of the structure with mathematical formulations which agreed with empirical evidence found in the spectral lines, an important evolutionary seed was established. This created the foundation to establish quantum numbers characterized by discrete distributions of the electronic orbitals.

But the world of physics and chemistry is not the world of biology or the psychology for living organisms. And the notion that alterations of atomic and molecular properties involving the reduction of symmetry and homogeneity are indeterminate and certainly involve probabilistic realities must have some relevance. Consider the climatological fluctuations of the atmosphere, weather conditions undergo changes which cause the temperature to rise and fall according to certain trends. If the temperature is reduced enough, specific molecules aggregate producing crystalline substances. These crystalline substances have similar thermodynamic

activities, yet each has a different structural identity. Each single structure is different form other all others yet their composition is identical.

In the "dissipative structures" of any macroscopic phenomena existing within a open, randomly fluctuating evolutionary field, far from equilibrium, unique dimensional properties may be established. Each evolutionary product being a structural isolate of all similarily produced entities. The establishment of mathematical equations to account for this apparent "order through fluctuations" by using the methods of a non-equilibrium thermodynamics has been provided (Haken, 1977; Prigogine, 1974). Chemists have created a physical system, the Zhabotinski reaction, which readily demonstrates the evolution of order while feedback oscillations are maintained within the established complex. The evolving complex is dependent on the appropriate communicative feedback from various subcomponents of a dynamic kinematical system. This could be the reason for the evidence of struture.

These examples are demonstrations of the dimensional indeterminism which exists in the simple physical and chemical interactions of inorganic substances. In living organisms, plant or animal, a multplicity of well known systems exist which have the capacity to establish multiple feedback mechanisms. As a consequence, the evolving order within these open systems may be dependent on the evolutionary field in which they are intimately associated. When molecular constituents become associated with cellular membranes, having

oscillating electrochemical fields, which are probabilistically determined, the evolutionary seed for "life" exists. When the appropriate evolutionary field becomes associated with this seed the result is an evolutionary product known as life. This structural order does not cease to evolve.

Sir D'Arcy Thompson (1942), produced a publication "On Growth and Forms" suggests that the process of evolving unique topological structures may provide an explanation for life as it currently exists. The anticipation of an objection to an evolving organization and order within systems appears to violate the significant second law of thermodynamics, which has been assumed inviolatable. But the argument is moot and not founded on adequate grounds. Living systems are not closed inorganic systems. They do not exist in artifically designed "predetermined" evolutionary fields. Man is capable of establishing a hierarchy of feedback mechanisms that are associated with the physiological components of his senses. Each level of our existence is involved in the evolution of a "higher" order. The organelles are within the cells, the cells within the tissues, tissues within organs, organs within organisms, and so forth. Each level has its particular properties and contains its evolutionary field with multiple levels and associations.

Physicians are individuals that require an intimate association with others needing assistance to retain or return to "healthy" associations with their evolutionary fields. The

patient arrives to the physical spaces which must be shared with the physician. Both are open, fluctuating systems, capable of communicating by interacting with appropriate evolutionary fields. They are dissimilar in their cognitive structures, dispite their seemingly identical components. If the physician fails to understand the nature of the evolutionary field associated with the interaction, it will be difficult for the goals to be attained. The failure to adequately explore a particular evolutionary field by the physician can allow residual errors and increasing entropy in the informational exchange to evolve, changing the magnitude and direction of the coping system of interest. A recent discussion of this point was made recently by H. Wolinsky (1983) when he reveals:

> After much hand wringing and many heated arguments, Sonya and Sam made one of the most difficult decisions of their lives. After 40 years, they decided to end their relationship-with their doctor.The couple first visited this doctor soon after they were married, while he was new in practice. He had seen their kids through measles, mumps and innumerable other ailments. He had held their hands in difficult times. He even used to make house calls. But in recent years, the doctor seemed less responsive to their needs. He was unwilling to explain things. He dismissed their questions...Frustrated in their attempt to communicate with their doctor they decided it was time to switch to a new physician. Patients should look for compassion, good communication skills and professional limitations.
>
> (Wolinsky, 1983, p.2b)

The communicative encounter between physician and patient has the ability to evolve a unique structure capable for being

the evolutionary field for health and growth. This study will investigate the nature of the stochastic interactions between the physician and patient and identify factors which may fluctuate within the established evolutionary field to assist both in making the required contributions to this world. Barbara Korsch has published a paper on the properties of the doctor-patient relationship. She was specifically interested in the study of their communication network. "The quality of medical care depends on the interaction of the patient and the doctor". She goes further to suggest that an important factor in the discontentment with this interaction involves the "poor" communication between the interactants. "Many physicians no longer attach high importance to personal rapport with the patient". This is a neglected aspect in the care of the patient. She believes that a detailed study of the process of communication between doctors and patients is essential in improving the quality and delivery of health care services. Using observers and recording tapes of 800 physicaian patient encounters she could find "no significant correlation" between the length of the medical session and patient satisfaction.

It appears that physicians are exceedingly technical in their verbal exchanges. This complexity introduces a series destabilizing factors which forces the encounter with the physician to evolve into a new, morphologically significant, structure. It seems as if educational parity cannot reduce the destablizing forces. Her recordings of the hundreds of

doctor-patient conversations did identify specific forms that reflected good communication and patient satisfaction.

> The Analysis of the communcation problem can go far to help the profession gain support and strengthen its performance... The attention to effective communication, should not be difficult for the trained person. Video-tapes can provide a method to study non-verbal behavior and document the instrumental and expressive performance of doctors, including the examination of patients. (Korsch, 1972, p.74)

Most living organisms have the potential to influence the behavior of others by visual, acoustic or chemical means. Most of these interactions can be called communication. Numerous examples of animal communication have been studied and observed. The major issue in research studies has been defining the interaction which constitues communication. Communication between animals involves the production of a signal or substance which is detected, interpreted and translated into an appropriate set of conditions which allow responses to be detected. The study of animal communication and human language was restricted for many years because of the antianthropomorphistic attitudes generated by the philosophic principles of E.L. Thorndike and C.L. Morgan. Certain requirements must be assumed met before any interaction or communication event will occur. These three basic elements are:

1) A signal emitter:
   representing an information originator
2) A signal transmitter:
   representing the communication mode
3) A signal receiver:

representing an information translator

The need to improve the interaction between a physician and a patient on these multiple planes in face to face encounters is important. It will become necessary for each participant to adjust their interactional performance to the demands of the situation and the role of the performers actually engaged in the communication. A major problem develops if the encounter between two individuals is to provide data for the operational clarification of communicational skills. The physician must become a cooperative communicator and recipient for the exchange of information. The physician, as the professional, eventually retains the responsibility for insuring that the health concerns of the patient are adequately met. The communicational acceptability of all interactions must be objectively considered by the physician.

The guidelines for assisting in the establishment of a definition of communicational synchronicity are varied (Wood, 1981; Wood, 1977, Bassett, 1978; Larson, 1978;, Allen & Brown, 1976). Definitions of synchronicity in communication are as numerous as the authors discussing the topic. The definitions provided are not clear about the components of communication and allow undefined areas which are important in understanding the nature of communication. This chaos creates difficulties for the physician hoping to translate the pedagogic theories of medical instruction into a productive clinical practice. It becomes necessary to produce a more specific outline that

reduces the confusion and allows interested medical practitioners to maximize the use of productive studies concerning the establishment of communication and therapy as related to the types and amounts of information expected to be exchanged in the clinical or treatment environment.

Several important issues must be resolved before developing a theory which clarifies the elements of a clinical communicational episode for the physician. First, it's necessary for the statements which explicate the theory in a form which will satisfy the characteristics common to all well developed theories. These characteristics are abstractness, empirical relevance, explicitness, and logical rigor (Reynolds, 1971). A theory of clinical communicational synchronicity must have a structure which is significant for cross-cultural information transmission.

This requires that such cross-cultural phenomena be related in the consideration of a theory for the physician's utilization and maximization of health care strategies for patient benefits. This theory must be explicit in discussing the relationship with other valid theoretical constructs. The most important of these relationships is that which involves clinical performance and clinical compliance. This relationship has not be adequately developed and is a source of difficulty in the physician and patient encounters on issues which relate to the health care concerns of the patient.

The current conceptualizations of clinical

compatabilities, which make the physicians performance an integral component of the concept, allows no clear path for the assessment of the physician's clinical communicational congruence with the patient. Instead emphasis has been localized on the clinical performance as related to recorded "outcomes" or measured error rates in the traditional medical training programs at accredited medical schools across America. This study is an attempt to resolve some of these issues with the development of a conceptual foundation for a theory of clinical communicational performance for the medical community. The health care education of the patient seeking professional assistance in understanding the nature of the "pathological" relationships with and within the many different natural environments to be found in different patient cultures must become an additional dimension of concern in the knowledge and treatment of people.

Reynolds (1971) further indicates that the three characteristics of statements of scientific knowledge are important:

1) Abstractness (time-space independence),
2) Intersubjectivity and
3) Empirical relevance.

In addition, intersubjectivity may be decomposed into two separate components, explicitness (description in necessary detail using terms insuring comprehension) and rigorousness (using logical systems that are shared and accepted by the relevant communicants to ensure agreement on the predictions

and explanations of the theory). These four characteristics, abstractness, explicitness, rigor and empirical relevance are the foundations for the issues of explaining and outlining the nature of the assessment of the clinical interaction as the communicational episode with the patient occurs.

A theory of clinical communication that is constucted according to these outlined criteria will be general enough to account for a wide number of individual cases and specific enough about the behaviors that will apply to individual instances of communication, clinical or otherwise. It will focus on both levels of explanation: the general level that addresses the human interactional behavior observed and the specific level that allows for the generation of causal statements as explanations of the individual behaviors of each physician-patient encounter. The level of explanations will be an operationalization of the general theoretical formulation which support such explanations. And it is assumed that the individual variations which occur in the clinical performance of individual physicians will be adequately presented.

The contributions of an evolving theory of clinical communicational performance would allow a more complete understanding of the interactional behavior of clinical and personal relationships. It will also contribute to establishing a strong foundation for the assesment of clinical "weaknesses" (which may be defined as an increase in the stochastic outcome of the processes in favor of the continuation of a disease.

Any theory of clinical communicational synchronicity must be theoretically based in order to have meaning to the extent that it generates sufficient explanations of the behavior of the communicants. Each case of assessment should provide the data which can be used to further test the theoretical postulations formed in the communicational episode.

All living organisms communicate with one another to a degree (Seboek, 1972; Morris, 1946). As Larson (1978) has noted, children learn to become communicators in the course of normal development. Consider the follwing illustration, while physicians were considered "normative" on many dimensions, they are selected from a population pool of medical school applicants having some unusual characteristics. These include an average G.P.A. of 3.50 or better (on a 4.0 scale), a category considered to be different from the normative universe of students. As a result, the importance of the ability to be academically and socially competitive in the development of communicational skills "could" have received secondary attention when compared with the need to achieve high academic rankings as a "Pre-Med" student.. Although Larson is true in his position, that children learn to communicate, ambiguity exists since communicational "synchronicity" is not the end product of normal development, particularly across different cultural groups. In fact, communicational disharmony is often detected in differential analysis of empirically available communication patterns.

It is this ambiguity that this project is concerned with

reducing. Communicational behaviors that are perceived to be synchronous may culturally determined and normatively referenced. These communicational behaviors are bound by the central culture which allows the behaviors to exist. As a result, multiple episodes of clinical communication that are images of confluence by the medical community may be categorized as being obstacles to communicating by a different culture. Any physician or group of physicians assessing the communicational synchronicity of a resident physician can assign the label of good, average, poor or inadequate based on the cultural translation of the encounter with the patient. As a consequence the label may not be retained by observers existing outside the medical culture, primarily within the patient culture.

Any behaviors which communicate are considered culturally unique and must be interpreted from at least two cultures, the culture of signal source and the culture of the signal receiver. Any physician wishing to become communicationally compatable with patients, as a function of the knowledge obtained from the medical and clinical training received, must understand that this compatability is being measured differently by those individuals with no clinical expertise, and a different set of cultural values. This dichotomous condition can allow a physician to be evaluated by the norms constituting the medical community as being clincally excellent by that common set of values while the patient perceives the technical concerns at the expense of "personal"

concerns. Allowing dissatisfaction, uncompromised attitudes and insensitivity to be the final view the patient retains of the physician's clinical skills and abilities during and after the informational exchange occurs.

The origin of the concept of compatability in communication specifies that levels of acceptability for segments of society. These behaviors are salient to non-white, non-middle class, urban or rural inhabitant. Labov, Cohen, Robins, and Lewis (1968) in a study of communication in subgroups have revealed the wide variance which exists between the norms of a school and the norms of an urban society. In addition, the communicative patterns have been found to be different for rural societies when compared with urban societies. Dumont and Wax (1969) indicate that the goals, norms and values of rural Oklahoma Indians differ from urban norms and values as well as being different from the whites residing within the same geopolitical space. Cross cultural research indicates that a wide variety of norms exist in America for the assessment of communicational behavior.

The impact of individual cultural histories has a control on the type of communicative mode used to transmit or accept information from another interactant. Research indicates that when the observed behaviors of individuals are not superficial representations of a cultural history, but are linked to the values of that society and the identity of self as supported by the culture. (Labov, 1968; Kochman, 1978; Cooley & Lujan, 1982; Siler & Labadie-Wondergem, 1982; Dobkins, 1974; Lujan &

Dobkins, 1978).

The data available in the literature support the notion that the behaviors of the physician are culturally specific. And, any clinical confluence within a single culturally significant group will not automatically translate into communicational compatability within a different cultural set of evaluative norms. A theory of clinical communicational synchronicity that is to account for the multicultural composition of this society must utilize these discrepancies. The cross-cultural transmission of information must have a conceptual and theoretical base in which many different constructs are considered as constitutive components.

Another issue important in the formulation of a therory of communicational compatability is the relationship between the the assessment of clinical skills and the outcome of the performance. McCroskey (1982) indicates the controversy in the problem related to the measurement of communication skills within linguistic studies. He argues that the performance of behaviors judged to be "acceptable" is neither sufficient or necessary for the judgement of communicational compatability. This statement is not a solution to the problem, but does illuminate the difficulties. The issue remains that dispite the method of measurement, formal or informal, performance is the only factor which is being measured. Communication as a physical concept is neither measurable or perceivable, it can only be derived or ascertained by the patterns of the interaction which have been

preserved and analyzed by the interested researcher.

This project maintains that the observations of the clinical behaviors of both the physician and the patient are to be found in the theory that explicitly defines the boundaries of the two constructs (communicational synchronicity at the level of a hypothetical construct and performance on the plane of empirical evidience available) and the interaction of these concepts as they relate. It is expected that this project will increase both the quality and quantity of accurate inferences, prediction and assessment of the performace of the physician and the patient as they attempt to "cooperatively" communicate, exchanging information within the clinical environment.

CHAPTER 2

LITERATURE REVIEW

This section will reveal many of the factors that have been found in the literature to be associated with understanding the nature of the communication which occurs between individuals, in particular the physician-patient dyad. The evolutionary patterns of clinical informational exchange, growth and complexity are also investigated and examined across academic disciplines. The major crux of this study involves the notion that :

1). Illness can alter the communicational patterns of individuals.

2). Communicational patterns are culture specific.

3). The Structure of the communicational model, representing the active channels which carry the information, can be influenced by the degree of synchronicity of the communicated signals.

4). The Energy required to maintain the exchange of information will be related to the complexity of the communicational toplogy.

5). The complexity of the communicational model will be hierarchically related to the evolutionary stages of growth or maturation of the informational exchange network which comprise the descriptive topology of the communication structure.

NON-VERBAL COMMUNICATION

The use of the term "non-verbal communication" is not a new or recently developed subset of potential or actual communication modalities (Ruesch, 1956; Duncan, 1969;

Hinde, 1972; Knapp, 1978). And critics are skeptical that the exploration of this type of behavior can be delimited. And the study of pathological children has resulted in the publication of the text "The Non-Verbal Child" (Adler, 1975) indicates that a serious difficulty exists on the acceptance of non-verbal communication as an accepted mode of transmitting a communication signal from one individual to another. Birdwhistell argues that the non-verbal cues which accompany spoken language are more important than words. The structure of language and onomotopoetic terms defy placing language patterns in such discrete categories. The work of many researchers to understand the general nature of the non-verbal signal supports the notion that it is closely associated with any of the typically verbal signal we send as we speak (Birdwhistell, 1967; Condon, 1971; Dittman, 1972, Kendon, 1972). The arrangement of our physical bodies and the flow of information from these stuctures are clues to the communication system operating between interacting individuals (Scheflen, 1973).

The study of both the verbal and the non-verbal linkage in communication systems allows the complexity of human informational exchange to be better understood. Some have resorted to renaming the term as body language. While more scientific credibility is sought when pasimology or kinesics becomes the phase to be used. But it was Mead that postulated the term semiotics (patterned associations) for any communication system operating. The term used to

describe non-verbal behvior can directly forcus the thrust of the research. The formulation of theoretical principles seem endless. Equilibrium Theory (Argyle, 1965); Personal space expectations (Burgoon, 1976); Proxemic Analysis (Hall, 1974); Arousal Models (Mehrabian, 1976) and Immediacy (Mehrebian, 1972) are concerned with the non-verbal methods which transmit information between us.

Some researchers are concerned about the intent of the communicator in transmitting signals (Scott, 1977; Weiner, 1972). This has been a difficult problem to investigate in research because any outside observer will not have the same interpretation of a conscious process as the originator of the process (Goffman, 1963). The questionaires designed to determine the intent of the orginator of a communication signal will not gauge the need to appear in control of the situation. These self-report inventories may receive the ad hoc support of some theorists (Harre, 1973), but the problematic realities remain nontheless in the actual assessment of the communicational event. The environment of the communication behavior can influence the perception of intent.

The issues involved in investigating the intent of the communicator cannot be satisfied without serious concern. The creative resolution to the identification of intent for the communication requires that animal studies (Tolman, 1932) or infant studies (Lambert, 1960) be reviewed for methods that may further illuminate the issue.

Changes in the frequency speed and length can provide information about the purpose and intent of the signal. For the observer of every day interaction, verbal and non-verbal signals come in clusters, which are represented as patterns. And the need to provide descriptive analyses and hypotheses on multi-variate designs should increase the investigations which examine the patterns of these information clusters (Duncan, 1977). The study of the probabilities associated with specific types of non-verbal patterns (Keiser, 1976) also serves to give credibility to non-verbal research. The holistic movement to study the whole organsims also prevents the easy segmentation or decomposition of language to its component parts. The solidarity or bond between communicants is important (Malinowski, 1923). But the study conducted by Rosenthal (1975) encourages the need to use codes in our message systems and he identifies channels as being necessary to communicate.

VERBAL COMMUNICATION

Harold Lasswell points out that the major elements of communication include who says what in which channel to whom and with what effect (Bryson, 1948). Shannon and Weaver analyzed human communication in terms of five components: 1) a source, 2) a transmitter, 3) a signal, 4) a receiver, and 5) a destination. Berlo synthesized the major components of these early approaches to the study of communication when he

proposes the source - message - channel - reciver (SMCR) model as the traditional approach fo the study of commnication.

Speech and language systems have been examined as a process for the exchange of information while natural language as the code utilized within the system (Jakobson, 1961; Plath, 1961). Berlo initiated a new era in research by establishing the need to view communication from a process orientation. From this orientation it appears that the investigation of human communication may be characterized as a set of analog and digital signals which may be compared to the communicational sytems of other living (and non-living) entities. Gerald Miller (1969) defines this process approach to the study of communication when he states that:

> Process implies that particular instances of communication should not be thought of as discrete events with identifiable beginnings and ends, but rather as parts of a dynamic, on-going whole which has no clearly defined temporal boundaries. In particular, process stresses the transactional nature of communication, rather than conceptualizing it as a unidirectional linear act. (p.336)

Communication Engineering has distinguished two basic types of control mechanisms for signal interpretation. One for counting or determining frequency and the other for measuring the qualitiative aspects of he transmitted or received signals. Observations of the functioning nervous systems of living creatures indicates that it operates via a digital mode. If a combination of incoming signals will not

cause a nerve fiber to fire, it is said to be below the threshold level; otherwise, it is said to be above this threshold level (Weiner, 1950). Nerve activity can therefore be viewed as a set of conditions in which two value markers exist. The presence of a pulse (indicated by the release of acetylcholine) above threshold may represent one condition or value, the binary digit 1, while the absence of a pulse (indicated by the relase of cholinesterase) can be represented by the other binary digit 0. But the living brain, regardless of the organism is not a digital machine but an apparatus which is maintained by a more primitive analog set of conditions and the processes which it controls and monitors may repeatedly change their characteristics from digital to analog to digital with a degree of cyclicity which has been discussed by J.Von Neumann (1958,pp.68-69).

Nerve pulses represented by a set of digital components reflective of a physiological response mechanism, may control a specific stage of the information processing system (for example, the contracation of a specific muscle group or the secretion of a transmitter substance). This relationship may represent the control mehanism for many living (biological) systems. The physiological phenomenon is one which belongs to the analog clssification, and can be the orgin of a sequence of nerve impulses which are being recognized by suitable receptors. When nerve impulses are being generated, the organism returns to the digital state until further changes are warranted. Thus the nerve-pulse

portion of the system is digital while the mechaism involving chemical changes or physical dislocations due to muscle contractions are of the analog type, this synchronicity of digital/analog conditions may give any process the appearance of a dual character.

The decisive property of a digital mechanism is primarily found in one or another of the two extreme (discrete) states. The fact that the dynamic probability of remaining in the intermediate state which forms a connection is small. It then would appear that the phenomenon called digital is also continuous although largely indifferent to the subliminal variations of the input stimuli. This phenomenon can be controlled by ignoring the trasition states and assume that the information is being conveyed by a binary code. This coding represents an operation, goverened by strict and logical rules, aimed at gaining an increased efficiency by having elementary signals organized into patterns of alternatives. The exact nature of the central nervous system has been examined (Gerard, 1951, 1959) and indicates the model discussed has proven to have some heuristic value. Gerard created a model of the nervous system has being composed of unifrom units which can be combined in many ways instead of highly specified units, each representing something specific. This model can be extended to include speech. Speech is the spark that spans the synapse between the nervous system and the liguistic patterns representing information (Shands, 1960).

This study maintains that humans, as represented by the physician and the patient, communicate with symbols that appear to be coded analogically. In speech, the information transmitted may have both digital anad analog components. The digital mechanism of speech may be regarded as a late step in the evolution of the phylogenetic scale and has a major utility in the speech patterns of humans. This does not indicate that other mechanisms do not exist for the transmission of information in communicative exchanges. Research has shown that up to thirteen "universal" properties of language having areas of overlap exist (Hockett, 1959,1960).

Further elaboration on the neurological basis of communication indicate that speech and emotions may be codified in analog terms which requires neocortical and limbic (neurohumoral) areas are simultaneously interacting. The other rational haspects of perception are codified in digital terms involving centrencephalic integration only (Ruesch, 1955). Krober (1952) examined Von Frisch's (1950) classic studies of bee language language and distinguished that signs and symbols were utilized to transmit information and oscillated within the emotive vs. cognitive domain. His study provides the opportunity that subhuman organisms may also communicate using systems of symbols.

COMMUNICATION CHANNELS

Speech is the principal means of transmitting messages directly between people, but it is not the only method of transmitting information between social and task oriented groups. Other communication channels are composed of different bandwidths which allow multiple messages to move in a synchronized manner. The existence of a vocal-auditory band which is able to couple the vocal muscles with the stimulation of auditory receptors is well known. There also exists a gestural-visual bandwidth which couples the movements of facial and body muscles with those of the visual receptors. The interpersonal messages of communication are linked and travel in a simultaneous and synchronized fashion through the auditory and visual tracts physiologically structured and identified for the transmission of information. The other sensual modalities may also participate in the communication process occurring between the receptors of human clinical information exchange (Frank, 1957; Geldard, 1960; Gilmer,1961). These findings have been identified and supported in the studies in the communication systems of sub-human animal species (Haldan,1955; Marler,1959). In addition, clinical information may be transmitted by the manipulational - situational bandwidth of the clinician, which includes the cognition of any manipulated anatomical relationships detailed from within the clinical environment and couples

the relationship between those receptors which identifies the signal source, its interpretation and eventually its its destination (Goffman, 1959; Hall,1959; Hayes,1957; Ruesch,1956; Osgood,1954). The Most general model of a communication network postulates that one system, a source, influences another system, a destination, by dispatching alternative signals that are carried in the channel connecting them. The information source is conceived as producing one or more messages which must be transformed, or encoded, by transmitter into signals which the channel has the capacity to carry; these signals must finally be transformed, or decoded, by receiver back into messages which can be accepted by the destination (Fano, 1961; Shannon,1949). This model of the communication process, developed in connection with certain problems in engineering, was not initially concerned with the transmission of clinical signals or messages between human interactants. It implies a normal type of segregation of source and destination, of tranmitter and receiver, whereas, human interactants function as both.

AN INFORMATION THEORETICAL MODEL

A widely accepted model of information transmission identified three properties of speech (Buhler,1934). They include the aspect of sound which are characateristic of the (I) the source, (II) the receiver and (III) the content.

But, further studies have indicated that an expansion of this triad to a hexagonal structure involving the follwing dimensions:

(I) The Source
(II) The Receiver
(III) The Context
(IV) The Channel
(V) The Message
(VI) The Code

Any portion of a communicated signal that interferes with signal transmission is considered as noise and may be mixed proportionally with the transmitted signal which originated with the source of the signal. The relationship of Buhler's model and the information theoretical model of a communication network can be shown with a Morley Triangle. These six dimensions identify the hierarchical order of liguistic functioning and the verbal structure of any message is dependent on the dimension which doinates or co-dominates with other dimension. Kroeber (1952) also distinguishes an additional dimensions termed a "sign".

> In function, signs that serve to communicate are action responses to sensory or visceral stimuli and are always accompanied by emotional affects. Directly, they convey information on other matters than the condition of the communicating organism. Such external information may be called objective, as compared with the subjective nature of what is communicated by nonsymbolic signs. (p.754)

This dyadic model of sign/symbol represents a simplified image of what occurs in speech, and probably in many other forms of animal communication as well. The Six

communicative functions emotive & phatic, cognitive & conative, and the poetic & metalingual have been found in varous intensities in all living creatures.

EMOTIONAL CODING

A patient may speak or remain silent. If a decision is made to speak a choice must be made on the message to be transmitted. But, the selection of the coding system is restricted and the selection must be made on the available "prefabricated units" among the sets of binary distinctions available to the patient (Halle, 1957), represented as singular elements in an algorithm concatenated into specific sequential patterns. In the process of communicating, the content of the signal can be modified or altered, but the meaning of the symbolic codes must remain constant. The possibility of modulating the attitude about the tramsmitted signal is the pragmatic dimension of the signal which is under the control of the signal source or transmitter, whether patient or physician.

There are situations in which the frequency - intensity relationship may prevail such that substantial changes in the frequency of a response are accompanied by small fluctuations in the frequency of the initial signal transmitted (Morris, 1957). Although humans retain the ability to select verbal transmission or not to select verbal transmission, the other communication modalities (for

example, the olfactory mode) are not under a similar voluntary control of the clinical "subjects". The symbolic information bearing features of speech include the distinctive and unique configurations of the communicants. Linguists are convinced that all utterances can be dissolved and characterized by sets of two valued codes (Jakobson, 1956) while other researchers prefer to have recourse to more complex patterns for understanding the nature of communication and information transmission (Martinet, 1957). Agreement exists that the coding of each such feature transmitted is digital. However, other information carried on the vocal-auditory bandwidth and the nature of the operating systems of codes is not clearly defined for culturally interacting communication systems. Charles Darwin was one of the first to explore an evolutionary interpretation of the nature of the signals assocated with fluctuations in the property of sound. In the fourth chapter of "The Expression Of The Emotions In Man and Animals" he addresses a very 'obscure' subject, the emission of sounds. He appears pessimestic when he states: "It is not probable that any precise explanation of the cause or source of each particular sound, under different states of mind will ever be given." And, fifty years later another researcher (Sapir,1927) echoed the observation:

> The voice is a complicated bundle of reactions and, so far as known, no one has succeeded in giving a comprehensive account of what the voice is and what changes it may undergo. There seems to be no book or essay that classifies the

> many different types of voice, nor is there a nomenclature that is capable of doing justice to the bewildering range of voice phenomena. (p.894)

and twenty-five years later Jakobson (1956, p.38) was obliged to repeat that the systematic study of such "physiognomic indices" still remains on the research agenda.

The position of many linguists has been to emphasize the priority and superiority of the message delivered over the code utilized, and they have essentially given inattention to the expressive language problem. While structural lingusits maintain that the expressive range of morhophonemic, morphological, and syntactic considerations, including coding modifications between a neutral and an emphatic style or between one social dialect and another have been ignored. Only the phonemic level has been seriously investigated by researchers.

The early anthropologists were certain that universal patterns of communication would exist within all cultures. And critics of Darwin contended that the psychic unity of mankind produces elementary ideas which, responsive to different external stimuli produced real divisions and at further levels of evolutionary progression a variation becomes probable. Contemporary anthropologists have produced partial lists of items that have appeared in most human societies. When this ethnography or history is analyzed, many similaries are found (Murdock,1945). While kluckkohn (1953) indicates that linguistics of all brances of anthropology have discovered elemental units of information

which are universal, objective, and theoretically "meaningful". He also questions if such units are in existence in the sector of society associated with investigating the nature of "biological fact". An unambigous position has been discussed (Tiger ,1966; Glass,1967) and emerges as a consistent method throughout cultural and social anthropology of the systems concept that represents the foundation of modern liguistic philosophy. Levi-Strauss (1962) attempted to reformulate or dispose of such notions as archetypes or "collective unconscious", he emphasized the validity of latent relational constructs instead of those founded in the notion of invariance. The more general slogan of Gregaory Bateson, "THE PATTERN IS THE THING", emphasizes that any topology must be constructed by a rigorous elimination of redundancies from the systems assumed to be topologically equivalent.

Viewed in this manner, two different cultures, patient and physician, can be observed as a superficial representations of a single human culture. It is this isomorphism which allows the feasibility of communicating across all cultures. As early as 1808, investigative techniques has been proposed which foreshadowed the notion that behavior unfolds with morphological growth and differentiation, as a consequence of the genetic mechanism. The history of intellectual thought has oscillated between a predominant preference for data collection and the view that languages are separate objects to be described, compared,

and interpreted, in a search for universals. This study involves an understanding of the neurophysiological (Darley, 1967) and the Socio-biological (Lenneberg,1967) characteristics of communiating systems. As Zvegintsev (1967) states "only when viewing them as interconnections with other sciences" will linguistics acquire the importance of the other sciences.

The study of language patterns as traditionally shown (Greenberg, 1963, 1966) or as the formal generative grammarians (Katz, 1964; Chomsky, 1965) indicate are variations on a single theme. A model which is species specific and species consistent is "needed" (Cowan, 1963). The non-productive antithesis between innate and acquired categories of behavior (Hinde, 1966) is reconcilable in our domain if it is assumed that the glottopoetic scheme, intended to approxiamte the Humboldtian concept of inner form, has a biogenetic component, while the environment contributes to the behavioral variablity of any surface or external structures. The development of language within any cultural frame includes a set of universal primes of the verbal code, which is determined by the genetic code which then finds a variety of expressive phenotypic modes through space and time. The feedback from the clinical environment to the expression of the genotypic ratios, represents an interaction between nature and culture, producing the neo-languages of evolving living systems.

THE CONTROL OF FEEDBACK MECHANISMS

The idea of control in living systems was suggested in Claude Bernard's concept of the consistancy of the internal environment through the postulated role of nervous and chemical feedback systems. This feedback process is recognized as the control mechanism of muscle movements, metabolsim and many other physiological functions. In the physical sciences feedback can be identified in the early invention of Drebbel and the centrifugal governor invented by Huygens for using in the clocks he produced. It was adapted for windmills before Watt used it in the development of the steam engine. Maxwell was the first to analyze such relationships and is considered as the originator of modern control theory.

Control theory is a discipline which incorporates many different fields of study. The application of control theory to understand physiological phenomena stems from the recognition that analogies can exist between physical and biological systems. Two systems can be said to be analogous when their behaviors, as defined by a mathematical equation, are identical. The existence of analogies makes it possible to define "generalized" system variables and parameters. As a consequence, the analogy of force and motivation leads to the generalized concept of an "effort" variable. Similarly, the generalized "flow" varaiable comes from the velocity-movement analogy.

These equations represent summaries of the behavior of simple systems in a classical manner. But, in control theory the nature of any system can be described in a topological manner. The functional relationship between the variables of any system can be described by block diagrams, in which the parameters of the system are represented by boxes, and the independent and dependent variables by arrows pointing into and away from each box.

An essentially strong feature of using a block diagram description of a system is the distinction made between variables and parameters. It is important that this distinction is clear. Generally, variables represent those measurable properties of the system which change value during the time span of the observation. In the generalized system shown, the current flowing in the wire is a variable, it changes from one moment of time to the next. Parameters can be considered as those properties of the system which do not change during the specified period. As a consequence, the value of electrical resistance is a parameter and appears as a constant in this system. It is possible for parameters to be modified during a specified time frame. This could occur if the resistance were replaced by a variable resistance potentiometer. In such a case, the value of the resistance could be regarded, not as a variable, but as a changing parameter. The coefficients of the differential equation describing the system would not be constant and the system could be said to be in a state of

flux, "time-varying", or evolving to a higher level of complexity.

The role of parameters in the description of a system can be further emphasized by considering a cause and effect relationship between the variables. The causal (independent) variable acts in a situation, which has been established by the parameters. The effect (dependent) variable is the product of the interaction between the causal variable and the situation. Each block in the diagram can be considered as a bounded sub-system, or "machinery of the communication systems operating. The arrows indicate the relationship established between subsystems and the summation of variables is indicated by the symbol for integration. The use of block diagrams is essential because they provide a topological representation of the communication system in a manner that directs attention to the parameters and sub-systems operating, while simultaneously, describing the communication system in a rigorous and unambiguous manner. It is important to use the conventional symbols since they provide a powerful vehicle for the accurate description of the system for conprehension. This is the "BLOCK-BOX" approach in which the interest of the investigator lies in establishing the relationship between the I/O of the subsystem being investigated. It is the behavioral fluctuations associated between the communication variables which are of importance, rather than the nature of the mechanisms responsible for the patterns.

Transfer Functions

Any block in a block diagram can be considered as a black box and, in specifying the relationship between the input and output variables, it is necessary to describe the operation of the contents of the box on the input, to provide a given output. The operation many be such that the output may be changed in relationship to time as well as magnitude. The operation may delay output. Therefore, every block in a diagram must be considered in terms of the magnitude of the variables involved and their fluctuation behaviors as a function of time.

The behavior of the variables involved in communicating dyads can be calculated by means of a classical calculus. For this project it will be more convienient to handle calculations by employing an operational calculus which is standard practice in control theory.

In operational calculus the differential coefficient, d/dt, can be replaced by a differential operator, p, necessary for later computational transformations.

$$\text{If } Y_{(t)} = dx/dt,$$
$$\text{then } Y(p) = xp$$

The differential operator is useful in understanding the simple aspects of contol theory. Control engineers

employ a more powerful method, based on the Laplace operator, s. The general procedure is to take a function of time, f(t), and transform it into a function of the complex variable s, by locating the Laplace transform of the time-function. Thus Lf(t) = F(s), which represents the laplace transform of the function of time as a function of s. The laplace transform can be formally defined.

It is not necessary to work things out from the first principles, because the Laplace transforms of most simple functions can be looked up in a table of the more common functions. The standard procedure is to determine the Laplace transform of the necessary time-functions from the table, work out the problem in terms of s, and then look for the "inverse" Laplace transform, to obtain the coefficient as a function of time. This procedure is similar to using a table of logarithms.

When the input and output signals of communication variables are described in terms of s, the operation by which one is obtained from the other will be called the transform function of the sub-system. The transfer fuction = y(s)/x(s) for zero initial conditions. A communication system is assummed "linear" if its transfer function is always the same, irrespective of the input signal. An important property of linear communication systems is that their transfer functions can be treated algebriacally thereby simplifying the mathematical procedures involved in the analysis of interacting systems. This facility provides

the primary rationale for using operational calculus from control theory in this research effort.

FLOW GRAPHS

Flow graphs are functionally identical to block diagrams and the difference between the two is one of graphic convention. For some research problems, flow graphs have considerable advantages over block diagrams. Block diagrams can direct attention to the parameters and subsystems, which are represented as boxes. Flow graphs accentuate the identified variables of the communicating systems and represent summation along more natural lines. In the notation used for flow graphs, communication variables are represented by small circles called "nodes", and are connected by lines called branches, which carry a label indicating the functional relationship between the variables. This label consists of an arrowhead indicating the direction of causality anad the associated transmittance representing the type of function involved.

Flow graph transmittances are usually linear and can be manipulated algebrically. When a variable is dependent on two others or more, the branches converge on the dependent variable. Thus, each communication node acts as a summing point in a linear system. Differences in direction are indicated by the transmittance polarities. The main advantage of a flow graph is in its flexibility, which has

been used by engineers for block graph reduction. In flow graph reduction it is possible to short-cut much of the mathematical procedure involved in calculating transfer functions or the behavior of any communication variable during system operation. Most of the procedure for flow graph reduction follows from the two basic rules of construction: the value of the dependent variable is obtained by multiplying the transmittance by the independent variable and branches entering a single node are summed. Nodes which have only one branch entering and one leaving are known as "cascade nodes". These can be eliminated by multiplying the two transmittance units.

Conversely, it is useful in the analysis of a system to insert temporary "dummy" variables into the graph. This can be done by interposing a node into a branch and placing a unit transmittance on one side. When two nodes are connected by parallel branches in the same direction the total effect can represented in a single branch, by summing the transmittances. A single branch can be split into two by the same method. Input branches can be shifted by multiplying the outgoing transmittance. This procedure will result in the elimination of branches entering a closed path, leaving only a "self-loop", which is a node with a branch returning to itself. In any path containing a self-loop the path transmittance G is increased by the loop transmittance g, for each additional traverse of the loop. Therefore:

$$G = 1 + g + g^2 + g^3 + g^4 + \ldots$$

The expression obtained from this series is:

$$G = 1/(1-g)$$

when the magnitude of $g < 1$, which is the basic equation of feedback theory.The use of the flow graph method to demonstrate the transfer function of a system can be illustrated with flow graph reduction. This graphical representation is the procedure for solving simultaneous differential equations by means of operational calculus. In come cases it consists merely of a series of simple algebriac manipulations. Significant transfer functions can also be calculated from flow graphs by a direct method. This method has been found useful for for complex flow graphs (Chow,1962; Lorens,1964). And since its invention (Mason, 1953,1956), the use of flow graphs has found increased utility in branches of engineering. Advances in flow graph theory has allowed them to to be applied in the analyses of linear, non-linear and statistical systems (Lorens,1964; Huggins,1968). The use of control theory in understanding the behavior of living systems has been accepted (Bayliss,1966; Milhorn,1966; Milsum,1966).

INFORMATION SYSTEMS

A system may be defined as an ordered arrangement of physical or abstract entities. The use of the systems approach has been promulgated by John VonNeumann, Norbert Weiner, Kenneth Boulding, Claude Shannon, Ludwig VonBertalanffy. This approach maintains that it is possible to distill from everything that occurs in the natural and synthetic worlds mathematical properties that will be common to all systems. Prigogine states that the character of a system can range from complete stability (known as equilibrium), in which small scale disturbances will fail to produce large scale redistributions to various degrees of instability when non-equilibrium conditions prevail. A behavioral system can be envisioned as a network of functionally related variables, relevant to the behavior being investigated. It will be necessary to distinguish the difference between a "physical system" and the research investigator's abstract "communication system". In addition to the variables which are components of the HIP4 mapping system there are variables outside the system which may affect the behavior of the communication system of the physician-patient dyad. These external variables may be "control" variables which represent the stimuli to which the communicating systems should be responsive. Or, they may be disturbance variables requiring the communicating systems to reduce or dampen its response spectrum. External variables

may be regarded as properties of the clinical environment or be components of other systems related or associated with the system of interest. Engineers are able to specify the external variables which act on the system of interest, so the relationship between the system and its environment presents minimal difficulties. In livng biological systems this is not always the case.

Most of the systems which surround us will display some degree of order or equilibrium. The steady state functioning of the human body, the perpetual rotation and revolution of the earth, a balanced ecosystem and stable socio-political states. But we are also familar with the non-stable or chaotic systems. These systems are capable of moving away or towards equilibrium conditions. The apparent chaos or entropy is found in the decline and death of living organisms affected by disease, the bursting of a star to form a supernova or the ecological disturbances produced by a rapidly fluctuating population. The violence, terror and death in political revolutions dominant in the media are all exaples of unstable systems in a state of transition. Prigogine believes the systems farthest from equilibrium experience a transformation to attain greater levels of order than before the active destablizing forces become operational. The term for this process is "Self-Orgainization". Self-orgainization is the Key to the orgin of life (Prigogine, 1984). The conditions for self-organization require that any system approaching

maximum disorder reaches a bifurcation which will allow the system to continue into a chaotic, energy dissapating existence or move up into a new configuration which has the ability to integrate to a form which is capable of demonstrating more complexities and order than historiclly experienced. The direction of the evolving topology is dependent on the nature of the fluctuation.

When defining the system of interest, the entire living organism is the locus of interest. The abstract system of concern, representing a specific aspect of the behavior is actually a sub-system existing as a component of the larger, dominant control system. The researcher may study a system of manageable proportions, but when confronting living systems with such complexities inherent of living systems one must isolate the sub-system of interest. As a consequence, the major difference between a physical and a living system is that the external variables influencing physical systems are viewed as environmental while those which impact on living systems generally belong to other systems. The difference is important because environmental variables are more accessible to measurement than the internal variables of interacting biological systems. The complexity of such biological systems makes the selection of the sub-system of interest important. The behavior of a single muscle can be studied, but the behavior of the entire limb structure will provide information on the nature of he coordinated movements of the multiple fibres

constituting the limb. In this project large sub-systems will be simulated by simple abstract sub-systems, if the required details are not available. Parts of this simple abstract system will then be isolated for more detailed study leading to an increase in the complexity of the abstracted communication system. The Chemist, biologist or the psycholgist can select a relatively discrete sub-system or make an analysis of a larger portion of the system, hoping to gain insight into methods to analyze the smaller sub-systems. Both of these approaches have been used in the application of control theory to behavior.

The essential purpose of systems analysis is the accurate prediction of the behavior of a "machine" under all possible types of influence by the external variables. In order to describe the behavior of interacting living machines, the investigator must measure certain specified variables. Since, measuring instruments themselves represent machines, it becomes necessary to ensure that the "TRUE" behavior of the system under study is not contaminated by the measuring system. In living systems it is generally possible to measure only a few of the important variables and the behavior of other variables must be obtained from inferences from the direct measurements.

The first stage of systems analysis is to devise a preliminary model which is based on the data obtained from the measurements. This preliminary model consists of an abstract representation of the network of cause and effect,

and is intended to mimic that of physical systems. A preliminary model can only lead to qualitative predictions about the behavior of the system and must eventually evolve a mathematical model by specifying the numerical values of the parameters concerned. From a mathematical model it will be possible to make quantitative predictions about the system which can be compared with direct empirical evidence. After a comparison of the observed and he predicted behaviors it may become necessary to modify the measuring technique, he preliminary model, or the mathematical model. Since systems analysis is an iterative process, it will lead to agreement between the observed and the predicted behavior.

OPEN AND CLOSED LOOP CONTROL

When the value of a dependent variable, Y, is determined by an independent variable, X, the behavior of Y may be said to be controlled by X. When the value of Y in no way influences the value of X, the control is considered to be that of an open loop. In the closed loop, some degree of influence does occur.

In open loop control, the value of the output is liable to be affected by disturbance variables affecting the output directly, or by altering the parameters of the control mechanism. In a closed loop control system these disturbances can be compensated for with a feedback signal

from the output so the input is adjusted. This is the major advantage of a closed loop configuration. Open loop control systems have advantages and can be shown to be effective in the behavioral control mechanisms active during the communicative exchange between living organisms.

An open loop behavioral control can be isolated in living systems in which a disturbance of the output during noraml activity is not likely. For example, the instrument of vision, the eye, is not usually a loaded organ and the control of eye position is expected to be different than that of the limbs, which may experience mechanical loads and other physiological disturbances. The present evidence indicates that eye movement control is achieved without proprioceptive feedback, although visual feedback is used during some types of visual tracking. Studies support the notion that there is no sense of position in the eye muscles (Helmholtz, 1867, 1962). Using the evidence from mechanical manipulations of the eyeball, the positions of after-images, and apparent motions induced by attempts to move the eye when the extraocular muscles were paralyzed researchers have concluded that "Our judgments as to the direction of the visual axis are simply the result of the effort involved in trying to alter the adjustment of the eyes". This position is contrary to the views of other researchers (James, 1890; Sherrington, 1918) but agrees with the more recent work which tends to agree with Helholtz (Merton, 1964; Howard, 1966). Therefore, the control of a limb's position can be

achieved with the aid of feedback from the joint receptors, while the control of eye position is achieved by motor outflow only.

In general, closed loop behavioral systems can be characterized by the fact that the value of the dependent variables can influence the value of the independent variables or parameters. The mechanism utilized to achieve this influence is known as the feedback mechanism. From a mathematical point of view, feedback exists between two variables whenever each affects the other. For example, let W_{in} be the rate of information flow to a patient seeing a physician while W_{out} represents the amount of inormation from the same patient. The amount of information retained by the patient at any single moment of time is equal to the initial amount of information held, plus the time integral of the rate of inflow. Suppose that small changes in the information outflow are proportional to the amount of information retained, outflow being greater when the levels of information are not equal.

This situation can be expressed as a block diagram, and from this it appears that feedback exists between the directional flow of information. There is no feedback in the physical sense, but because feedback exists in the mathematical formulation, a "fictitous" feedback loop is introduced into the block diagram. Physical feedback is always represented as a "feedback" parameter in the block diagram, while fictitous feedback, the value of which

constitutes unity, is portrayed without such parameters. The physical feedback mechanism usually consists of a sensor, a measuring device which monitors the output signal as a variable and a mechanism to convey the information to the control center. Positive feedback exists when the consequences of the monitored signal tends to accentuate further signal output.

In a linear system the feedback is added to the input signals and the controlled device is actuated to an increasing extent. Positive feedback systems should be unstable, since any action and reaction intensify one another forming a cyclic phenomena. Yet, positive feedback systems are present in many of the relationships between living systems, Behavioral reinforcement as a component in learning theory and the population explosion are typical representations of such a feedback mechanism. When the consequences of any monitored signal from a system tends to diminish further output, negative feedback is said to exist. In a linear negative feedback system the output of the feedback mechanism is subtracted from the system input to give an error variable. The error actuates the controlled device, so the output tends to move in a direction opposite to that which produced the error. Thus a large positive error would result if the output signal were much smaller than the input signal and this would actuate the controlling device so as to increase the output signal. The output signal of the communication feedback mechanism would then

increase in rate and the error would be reduced. It can then be seen that a negative feedback system will tend to minimize the error and such systems may tend towords a state of stability.

The attainment of stability (equilibrium) by a negative feedback system can also be achieved through a passive or active communicative control (Milsum, 1966).The distinction between active and passive communicative control is dependent on the response question of whether a comparator is, in principle, physically identifiable within the patient-physician communication system or whether it is possible to identify a reference value or "set point" for the transmitted signals, the value of which is independent of the communicational system under consideration. In the traditional concept of temperature regulation in living organisms, it is maintained that a system exists which operates as a balanced dynamic system, but evidence suggests that the control of body temperature may be achieved through a set-point regulator. The identification of neurons within the central nervous system which are sensitive to local temperature changes supports the notion that living systems evolve their own regulators or comparators. These neurones have been identified in the anterior hypothalamus (Hardy, 1965, Nakayama, 1963). Perhaps a similar comparator with certain set-points will be isolated that demonstrates specificity for the language dynamics active during communication, verbal and non-verbal.

DEFINITION OF TERMS WHICH DESCRIBE FEEDBACK CONTROL SYSTEMS

Input Variable:

a variable which affects the behavior of a control system, without itself being affected by any consequences of such behavior. The boundaries of a sytem, or sub-system, can be defined with reference to the input variables acting on it.

System Variable:

a variable within a particular system, which is affected by input variables or other system patameters.

OutPut Variable:

a variable arbitrarily selected for measurement by an observer and capable of giving useful information about the behavior of the system.

Mixing Point:

A device whose output is equal to some function of two or more inputs.

Command:

A variable, or set of instructions, established by some means external to, and independent of, the system under consideration.

Reference Variable:

A set-point representing an input variable or a command established as a standard of comparison for a feedback control system.

Disturbance variable:

An input variable which causes the value of an output variable to deviate from the level set by a reference variable or command.

Comparator:

A mixing point whose output is equal to the sum, or difference, between two or more variables.

Feedback Variable:

A function of an output variable, which affects other system variables in such a manner that a closed loop is formed.

Actuating Variable:

A system variable which serves as the input to a particular sub-system.

An Error Variable:

The output of a comparator.

Actuated Error:

A Sub-system which is activated by the output of a comparison between a reference variable and a feedback variable.

BEHAVIOR AS A FUNCTION OF TIME

In the study of the genetic or evolutionary aspects of behavior, the patterns of behavioral changes become increasingly important. In Studies of learning behavior, the changes demonstrated have often been shown to be a function of the number or frequency of trials, or some other objective measure of experience. In studying communicative behavior patterns as a function of time, concern is focused to the specific modes of behavior as they continue to create patterns and structures which are associted with the orientation, direction and motivation for the exchange of information. Identifying the nature and manner in which the

communication behavior between a physician and patient is controlled by internal and evironmental control systems is appropriate for this type of study. The degree to which control theory can be useful in applied research environments depends largely on the nature of the behavioral measures employed in the study. As the type of measurement places a number of constraints on the validity of the method used in analysis.

Measurement Of Behavior

Qualitative data exists in the form of words rather than numbers. This type of data has been found in anthropology, history, political science and recently in psychology, sociologu, linguistics, educational research have shifted to a qualitative paradigm (Miles, 1984).

> Qualitative data are attractive. They are a source of well grounded, rich descriptions and explanations of processes occurring in local contexts. With qualitative data one can preserve chronological flow, assess local causality, and derive fruitful explanations. (p.15)

More researchers are committed to qualitative data. While others have gone to denounce this research paradigm. Rist (1980) has denounced qualitative "Blitzkrieg Ethnography" as being "unproductive". Some anthropologists believe that researchers in other disciplines are "reinventing" the wheel (Wolcott, 1980). Those researchers that have been traditionally thought of as being

quantitative in their orientation to problems concerned with knowledge generation have demonstrated a shift towards the endorsement of qualitative inquiry (Campbell, 1975; Cook & Campbell, 1979; Cronbach, 1975; Snow, 1974).

> The most serious and central difficulty in the use of qualitative data is that the methods of analysis are not well formulated. For quantitative data, there are clear conventions for the researcher. But the analyst faced with a bank of qualitative data has few guidelines for protection against self-delusion, let alone the presentation of unreliable or invalid conclusions to scientific or policy making audiences. How can we be certain that an earthy, undeniable, serendipitous finding is not wrong
> (Miles, 1979, p.592)

Some researchers have not focused on issues of qualitative data analysis due to the unequivocal dertermination of the validity of any findings (Becker, 1958; Bruyn, 1966; Lofland, 1971). While researchers having a phenomenological orientation assert that no social reality exists, so it is not necessary to produce a set of methodological procedures to explicate social laws (Dreitzel, 1970). Socially communicative processes are ephemeral and fluid with no existence independent of the communicants.

Stevens (1951) and Siegel (1956) indicate that to perform operations with numbers that have been assigned to observations, there must be some isomorphism between the empirical observations, and the numerical system employed in their measurement. To be isomorphic, the structure of two

systems must be the same in the mathematical operations they allow. The operations allowable on a given set of scores are dependents on the level of measurement achieved. Stevens discusses four levels of measurement and the operations that are permitted at each level.

The Classification of Behavior Patterns

The most obvious mutually exclusive classes of behavior are those which are logically incompatible. No animal can simultaneously stand up and sit down, or move forward and backward. There are other types of behaviors which can be seen incompatible only through the knowledge of the specific muscle groups and reflexes involved. Researchers point out that pairs of reflexes which have some muscular movements in common are neurologically incompatible, so that stimulation of one inhibits the performance of the other (Sherrington, 1906).

In Considering communicative behavior as a function of time, the degree of incompatibility depends on the unit of time measurement employed. If time were measured in only discrete whole number intervals, an organism could perform two neurologically incompatible behaviors within the same time dimension. The measurement criterion selected must ensure that the behavioral categories employed are mutually exclusive and all members of selected categories are considered equivalent. If a nominal level of measuremnt is

achieved then certain types of data manipulations are possible. A ratio scale can be achieved by counting the number of events per unit of time. The problem is to be certain that successive events are equivalent. The bar presses of a skinner box or utterance of a sound by a patient or physician cannot be considered equivalent.

The fact that behavioral measures are not always perfect means that some variation is expected in the measurement of behavioral data sets. A more serious consequence of this variation is that the scale of measurement may be non-linear with respect to the independent variable. Whenever interval or ratio scales are employed in a study it may prove necessary to test for linearity over the full range of the measurment scale.

SELECTION OF TIME-SCALE

In measuring communicative behavior as a function of time it is necessary to select a suitable time unit with respect to the time spent at each activity measured. The lower limit of the time unit should be determined by the time taken to measure a change in the behavioral variables. For example, if it requires an observer a tenth of a second to record a behavioral item, no attempt should be made to record behavioral events occuring faster than this dimension. Likewise, the response time of a measuring instrument should be taken into account in the selection of

an adequately metered time scale.

The maximum amount of information is obtained in communication research by employing a time-unit near to the minimum utterance recognized by the investigators. But in practice a slight enlargement may be necessary. Large time units have the ability to mask any variablity and or natural rhythmicity in the patterns of informational exchange and as a being a method of linearlizing the natural data set which might need to be transformed for analytical purposes. The degree of detail is not always necessary or the most convenient method of recording communication data. The high resolution achieved by the use of a small time unit serves only to emphasize the variability of the data. Larger time units can increase the efficiency without reducing the amount of information obtained by the statistical measure selected. These larger units can also demonstrate the existence of rhythmical components in the process of communicating, exchanging information. Manipulation of the time unit can also be a useful strategy is systems analysis. However, it is necessary to first explore additional aspects communicative behavior as a function of time.

SYSTEMS ANALYSIS AS A FUNCTION OF TIME

Three main approaches can be used in the description of living systems. A system may be described as a function of time, as a function of frequency, or in state-functions. All

three approaches have their strengths. Conceptually, a description as a function of time is a simple, less powerful approach to analysis. In systems analysis, a common approach is to determine the response of a particular output to manipualtion of a particular input. Several classes of input function have been found to be suitable for each analytical operation. These are

1) Transient Inputs
2) Periodic Inputs
3) Stochastic Inputs

Transient inputs are suited to analysis in terms of time functions, called transient analysis and periodic inputs to analysis as a function of frequency, called frequency analysis. Stochastic inputs are related to more sophisticated methods of analysis in terms of time or frequency functions. Restriction of the patient-physician dyad interaction to the elements required for a description and analysis of their communication systems as a function of time is a consideration for this project.

Differential Equations

The input of x and the output of y of a linear system are related by a differential equation of the form:

$A_x + A_1(dx/dt) + A_2(d^2x/dt^2)...$

$An(d^nx/dt^n) = ...$

The important points about this equation is that:

1. It is linear because none of its terms involve products or powers of the dependent variable y.
2. It is time invariant, because the coefficients $a_0...a_n$ and $b0...b_n$ are constants.
3. It is an nth order equation, because n is the order of the highest differential coefficient occuring in it.

Any differential equation can be solved by a number of integrations and the number of integrations necessary is equivalent to the order of the differential equation. Because each integration introduces a constant of integration the solution of an equation of order n will contain n such constants. For example:

$$(d^2x/dt^2) = a$$

first integration:

$$dx/dt = at + c_1$$

second integration:

$$x = 1/2(at^2 + c_1t + c_2)$$

where c_1 and c_2 are the constants of the first and

second integration. Much of classical control theory involves the manipulation of differential equations (Brown, 1965; Milhorn,1966).

Equations containing time functions are transformed into operational notation and in block diagrams takes the integral form allowing for a transformation. This transformation can be represented as a block diagram. The input passes through two integrators to give the output. In order to specify the value of "x" in real terms, it is necessary to account for each initial condition of the integrators. The initial conditions correspond to the states represented by the two constraints of integration. In practice, the initial conditions are incorporated into the flow graph analysis of a system. In the application of differential equations to control systems, it is useful to make a distinction betweeen a state variable and a rate variable. A state variable is one of a set of n variables, knowledge of which is sufficient to describe completely the behavior of the system. Thus, a Nth order system is described by n state variables and the state of the system is defined by the miniumum number of such variables which, together with the system inputs, is sufficient to determine th behavior of the system for all future times (Schultz, 1967; Elgard, 1967).

The rate of change in the change of state is measured in terms of rate variables, so that rate variables are a function of the state variables. In a block diagram

representing a communication system, the state variables correspond to the outputs of signal integrators. The number of state variables necessary to describe a communication system is referred to as the order of the system. A first order system has one essential state variable, a second order sytem will have two such variables. Essential state variables are those which are incorporated into the most parsimonious description of the informational exchange system active at that instant of time.

A communication system possessing sufficient energy to allow an exchange o information must be described in a manner which reflects its physicial composition or generalized behavior across time. For example, the water content of the blood, and gut are the result of storage processes and both can be represented by state variables within the thirst system. These two storage processes act in parallel and can be combined and represented by a single interactional integrator. This rearrangeent makes no difference to the transfer function of the sub-system, but the initial arrangement has more meaning in a physiological sense. It remains important to consider that the time unit employed in the analysis will affect the order of the evolving abstracted communication system.

A time unit of one day, employed in the investigations of the control of drinking, avoids the complications due to circadian rhythms and also serves as a general strategy for reducing the complexity of the commuication problem. In

using a large time-unit the order of the system is reduced, because any rapid processes which operate can be ignored, or at least masked. The delay due to absorption complexities and the transients involved in ingestive processes cannot be detected in an analysis based on daily measurements. The mechanisms responsible for these processes can be regarded as zero-order sub-systems and represented by dimensionally small values in the parameters.

As a first step in the analysis of the complex communication systems typical of physician-patient encounters, this strategy has the advantage of demonstrating that the relationship to be discovered in the slower acting, underlying, processes are analyzed first, giving an overall picture of the system. Subsequent explorations, employing smaller time units, can then be shown to have patterns that are believed to be significant and allows tests of statistical hypotheses based on the generalized pattern produced by the informational exchange rates. Other researchers have utilized his method and found success in the analysis of thirst as a motivational system (McFarland, 1972).

Transient Input Functions

The response of simple linear systems to standard transient inputs are known and such knowledge can be useful in the formulation of a working hypothesis oabout the nature

of the active communication system being investigated. Thus, the response of a cammunication system to a standard signal input can be recognized as being characteristic of a zero, first, or second order system. Three standard transient inputs are commonly used.

a) The unit Impulse: Designated as delta(t), is the limit of a rectangular pulse of magnitude 1/T and duration T, as T tends to zero. The unit impulse is also known as the Dirac Function. The Laplace transform of the unit impulse defines unit. [Ldelta(t)=1] A short pulse can be considered as an ideal impulse when the system does not respond significantly during the pulse. For example, a quick intravenous injection of saline can be said to be an impulse input into the osmotic control system of the body fluids or the production of facial contortions during an otherwise normal greeting pattern can represent an impulse in the signal reception network to signals from a communicant, as reflected in a face-to-face encounter between a physician and patient information exchange episode.

b) The unit step, u(t), has amplitude $x = 0$ at $t < 0$, and $x=1$ at time $t > 0$. The Laplace transform of the unit step, $Lu(t) = 1/s$, indicates that the unit step is the time integral of the unit impulse. The step function involves an infinite rate of change, can only be approximateld. However, if the time-unit of measurement is of such size that no

response can be measured during the time interval in which the step occurs then the input can be regarded as a step function. A Stimulus suddenly presented to a living organism can often be regarded as a step input.

c) The unit ramp, tu(t), is the time integral of the unit step. The Laplace transform of the unit ramp as:

$$Ltu(t) = 1 /(s^2).$$

In practice, the ramp function will involve a variable which increases linearly with time. In the analysis of the communication behavior of a living organisms some researchers state that interest exists only in the final steady-state of the system, the position after all movements have come to rest, all actions and forces come to equilibrium. By deliberately ignoring the dynamic behavior of the system, they were able to construct a zero-order abstract system which was found to be adequate for the purposes of extracting working hypotheses.

Strictly speaking, a zero-order system cannot exist because communication systems must take some time to adjust to a signal input. But when the time interval selected is small, the system can be considered to approximate a zero-order system. Such considerations depend on the time metric used in the measurement. The response of a zero-order system is a direct reflection of the input function, only the scaling factors being altered. The response of a first order system to a step input is exponential in form. This

has been shown in the study of response times as a change in the environment temperature (McFarland, 1970). The researchers were able to gererate a function having the capacity to be classified as being exponential, of the Ae^{-at} type. A is the asymptote, or initial value, of the function, and (1/a) is the time constant of the function. The time constant corresponds to the point on the time axis at which a straight line corresponding to the initial rate of increase cuts the asymptotic value of the independent variable. The work of another researcher (Stark, 1968) demonstrates another example of a transient response that is characteristic of a second-order sytem. A response of this type in which the state of two integrators varies in an alternating fashion. the analysis of any second order transient is more complicated than that of first order systems. The techniques of transient analysis are straightforward with application being dependent on a certain degree of experience.

Behavior As A Function Of Frequency

The recognition of the physician-patient interactional patterns as they communicate identifies a system which is a function of the frequency of the periodic inputs has been established in the analyses of the behavior living systems. This method generally called frequency analysis and has advantages over transient analysis. The response to a series

of periodic signals is itself periodic and can be assessed by repetitive measurements, across the time dimension of a very simple nature compared to the accuracy of the measurements required in transient analysis.

The measuring procedure tends to average out the variablity of the signals in communication systems and leads to a more certain description of its dynamic processes. It is also possible to use a periodic input function of small amplitude, wheras transient signals have to be of larger magnitude to produce a response that is sufficiently distinct to make the probability of accurate measurements maximal. Signal Analysis is a more naturalistic method of describing a system. The practical advantages of signal analysis is supported with a mathematical foundation which provides a conceptual base for the more advances iterative levels of investigating communication systems.

The periodic function most commonly used in frequency analysis is the sine function. By Trigonometric definition the value of the sine of arc which subtends alpha is the ratio of the side opposite the angle alpha and the hypotenuse of a right-angled triangle. If the line xy can be imagined to be the radius of a circle, an arm rotating at a constant rate counter-clockwise around Y, the point X can be seen to trace out sinusodidal function of time. As alpha increases from zero, sine alpha tends to reach a maximum of unity at when alpha is set to equal 90°, it then reduces to zero at 180 degrees, drops to -1 at 270 degrees

and returns to zero at 360 degrees. The value of alpha at any time t can be defined as alpha = (omega)x(time), where omega is a constant, called the angular velocity of anglualry frequency, measured in rads/sec. As a consequence,

X(t) = A sin (omega)t = A Sin 2 (pi)(f)(t)

(f = freq in cy/sec)

A = amplitude of signal

Two sine waves may differ in frequency and/or amplitude, and they may differ in phase, expressed as the index of angular difference ,phi, between waves of the same frequency. It is not always true that x = 0 when t= 0. The principle of frequency analysis indicates that when a sinusoidal signal (input) is applied to a linear system, that same system will produce a sinusoidal output of the same frequency, but differeing in amplitude and phase in accordance with the nature of the communication system. The analysis is conducted on the basis of comparisons of the amplitude and phase differences between input and output signals. These differences will depend, upon the number of integrators and differentiators within the communication system. The effect of these operations on the sine wave is important in understanding the nature of informational exchange theory.

If x(t) = A sin (omega) (t), then

$$dx/dt = A \text{ omega Cos omega } t$$
$$= A \text{ omega sin (omega } t + pi/2)$$

Differentiation of a sine wave produces a sine wave of the same frequency but differing in amplitude and exhibiting a positive phase shift of ninety degrees. A positive phase shift is called a phase advance or phase lead. Further differentiation produces similar changes in the amplitude and the phase shift.

$$d^2x/dt^2 = A \text{ omega}^2 \text{ sin (omega } t + pi)$$

Frequency analysis consists of applying a sinusoidal signal to a suitable input and measuring the response signal at a suitably amplified level. The frequency input is varied over a certain range and the relationship between input and output, with respect to amplitude and phase is calculated as some function of the input frequency. The most commonly used amplitude relationship is the amplitude ratio, AR, defined as the ratio of output and input amplitudes. The phase relationship is the angular difference, Phi. The first problem in empirical frequency analysis is related to the selection of input frequencies. Sinusoidal functions are analytically preferred but are difficult to use in the analysis of the behavior of some living systems. It is sometimes necessary to resort to other types of periodic input frequencies, but the sinusoid is the only waveform

which reproduces itself when sent through a linear system.

If a sinusoidal wave input is applied to a system at rest, the output amplitude will not be constant until the effects of the input have been distributed throughout the system. After the inital preparation period, a sinusoidal steady-state is attained in which the output amplitude is constant from one exchange cycle to the next. The second step in empirical frequency analysis is to ensure that the initial transients have decayed before any measuremnts of amplitude or phase are taken. The third step is to ensure that the system behaves in a linear fashion, under the naturalistic conditions of the clinical environmnt. The response of a linear system to a sinusoidal signal should represent a sinusoidal waveform and any deviation from this expectation indicates that a non-linear mechanism is operating in the exchange of information between he communicants. It is possible to avoid these non-linearities by restricting the input to specific mean values, producing a range of excitation within which the communication system behaves in a linear fashion (Budgell, 1970).

The essence of frequency analysis is to determine the form of the function describing the manner in which the amplitude ratio and phase angle progressively become modified as inputs of higher frequency are transmitted. In physical systems, a direct comparison of input and output frequencies is possible. In living systems, direct comparisons are not possible and it becomes necessary to

construct an arbitrary measure of the amplitude ratio. At very low frequencies there is no change in the output amplitude, because the system can "keep up" with the input. The relationship between the input and output amplitudes over this frequency range can be defined to have an amplitude ratio that is equivalent to unity. In establishing a baseline for AR comparison it will be necessary to locate two low frequecies in which there is no change in output ampliude. A further condition in defining the unified AR is that there should be NO change in the average level of the ouput over the entire frequency range employed in the naturalistic observation. Some researchers (Mcfarland and Budgell, 1970) found that the mean response rate was the same at all the frequencies used in their study. The phase relationship between input and output signals, require no special calibration technique because the phase angle, Phi, is independent of the overall I/O relationship and the nature of the communication variables examined. The phase angle can be plotted as a direct function of frequency.

Bode Plots

After obtaining a series of empirical values of the AR and phi as a function of frequency, the function can be graphically portrayed. The Nyquist diagram and the bode plot are the most commonly used illustrations. For the purposes of system design, in which stability is an important factor,

the Nyquist diagram is will be most useful. In the analysis of living systems, which are customarily considered to be stable, the bode plot is more appropriate. In the Bode plot, logarithmic measures of AR, but linear phi, are plotted separately against a logarithmic frequency scale. In the case of amplitude there is an asymptotic AR at low frequencies. There is also a high frequency asymptote, which is related to the order of the system. There exists a simple integrator, k/s, which exhibits a constant phase shift of -pi/2 and an amplitude ratio = k/omega, so that:

$$\text{Log}_{10}\ AR = \text{Log}_{10}\ k - \text{Log}_{10}\ \text{omega}.$$

The variation of Log_{10} Ar as a function of Log_{10} omega is represented by a straight line having a slope of -1.0, which intersects the omega axis at omega = 1. This is the value characteristic of first order systems. For two integrators in series, where a single output in their product, the logarithmic gain will be equal to the algebriac sum of the gains of the individual factors, when plotted on a logarithmic frequency scale. Therefore the high frequency asymptote for a second-order system has a slop of -2. A strong indicator that the order of the system can be gained from the slope of the high frequency asymptote. In the interpretation of the plotted results, the high frequency slope indicates that a first-order system is involved and is an indicator of the time-constant of this system. It can be

gained by extrapolating the low and high frequency asymptotes to the point where they cross. This point is called the break frequency and occurs when Log_{10} omega T = 0 (omega T = 1.0). The time constant T can be gained directly from this point.

The bode plot of phase is sensitive only to the time constants of the system and not to the gain. For the simple first order system, the phase angle phi = 0 at zero frequency, increases to −45° (phase lag) at the break frequency. In the case of higher-order systems, the bode plots are complicated by other factors such as system damping.

Natural Frequency and Damping

The general form of a second order transfer function can be written as:

$$H(s) = As^2 + Bs + C$$

The system properties A,B and C can be combined into two specific parameters, defined as:

$$W_n = [C/A]^{1/2}$$

and the damping ratio

$$eta = B/[2(A/C)^{1/2}$$

The transfer functions of most second-order systems can

be interpreted using those terms allowing a direct comparison with systems with different components. In the absence of damping, the step response of a senond-order system is a sine wave, with average values determined by the height of the step and frequency called the "natural frequency" of the system. In the presence of damping these oscillations will decay exponentially with a time-constant related to the damping ratio. The figure below illustrates the step response of a generalized second-order system with various values of the damping ratio. When eta < 1, the system is underdamped and will eventually overshoot the final steady state. The lowest value of the damping ratio for which the overshoot disappears is when eta = 1, and such a system is said to be critically damped. When eta > 1, the system is overdamped, and the more eta approaches infiity, more time is required for the response to attain its final value.

Second order systems can be identified by their transient response characteristics, particularly when the damping is low, as shown in the muscle tension studies of the human reflex. When overdamped, the response of a second-order ystem becomes similar to that of a first order system, and transient analysis will demonstrate a reduction in the reliability coefficients. Frequency analysis is a much more accurate method for identifying these type of systems.

The frequency response of a generalized second-order

system is indicated by the bode plot below. Note that as the input frequency approaches the natural frequency of the system the is a rise in the $\log_{10}$ AR, in the underdamped system which is not apparent in the overdamped system. In the lattercase, the frequency response is similar to that of a first-order system, except that the high frequency asymptote has a slope of -2 logs/decade. When the input frequencies approaches the natural frequency of an underdamped system, the two become "in tune" with one another and the output amplitude increases. This phenomenon will be known as resonance throughout this study. As a consequence, a periodic signal applied to an underdamped system is most effective when its frequency approaches the natural frequency of the of the system. Afterall, the best method to push a car from a rut, is to rock it rhythmically, at an appropriate frequency. Less effort is required to attain a given output from a system, if the signals into the system are at a natural frequency. Most individuals have a preferred walking and talking rate and any deviation from this natural pace requires additional sources of energy for sustainng the activity. Research (Cotes, 1960) has determined that the energy expenditure, as measured by oxygen consumption, varied at various frequencies of step movement. They found that energy expenditure was minimal at a frequency sufficiently close to the natural frequency of the system as calculated from leg length and other physical parameters. Similar mechanisms can be operating on the

communication networks established by communicants when exchanging information.

Constant Errors In Control Systems

The ability of a living organism to detect others visually, become oriented to face the subject, and by movements of muscles of the head or limbs, participate in a communicational exchange has been studied. Mittelstaedt found that head-turning movements are controlled by optic and proprioceptive feedback, which enables the organism to correct for any disturbances due to changes in the position of the subject, and the mechanical loading of the head. But the head does not always face the subject of communicational interest but instead exhibits a constant error called the "fixation deficit". This constant source of error becomes apparent when the system reaches a steady state and is typical of a steady state error. The manner in which the error arises can be demonstrated using a block diagram of the system. In the diagram, phi, represents an error variable as the signal transmitter faces the signal receiver, phi = 0. The error variable does not reach this value because the system reaches steady-state before the error variable is reduced. At steady state:

$$mu = sigma\ (QN)/[1+N(P+Q)]$$

$$phi = sigma\ (1+QN)/[1+N(P+Q)]$$

The magnitude of the steady state error depends on the values of the parameters N,P and Q. The steady state error of living organisms facing a stationary subject is an error of position. Other possible types of error can arise in tracking a target moving at a constant rate, when a system shows a velocity error. When the target of the communication is accelerating at a constant rate and acceleration error can be detected. Position, velocity and acceleration errors can be regarded as steady state errors when exhibited by systems subject to inputs which are constant functions of time. The movement of other parameters important in living systems demonstrate that constant fluctuations of certain signals will not support an equivilant fluctuation in response to the signal (Bayliss, 1966). The types of steady state error exhibited by a communicational control system depends on the system dynamics and the type of input to which the system is subjected. The response to standard position, velocity and aceleration inputs is a means of classifying control systems (Milhorn, 1966; Sensicle, 1968). This procedure maintains that mathematical considerations are important in understanding control systems.

Compensation

Steady state controls and other undesirable performance characteristics can be compensated for in the

design of control systems by the introduction of appropriate sub-systems which counteract the cause of the error. In a simple feedback system, the transfer function is:

$$[Y/X] = a/s(s+ab) \qquad \text{from which}$$

$$Y(t) = \text{alpha } (a/ab)(1-e^{-abt})$$

thus the asymptotic output alpha/b fails to meet the target value alpha and the system exhibits a steady state error. The error can be reduced by introducing a simple sub-system onto the input side of the comparator. When the transfer function of the introduced subsystem is equal to that of the feedback path, the asymptotic output will equal the target value alpha.

The correction of any performance errors by such a method is common in engineering and is generally known as "compensation". Support for the suggestion that living systems which derive their input signals from within the cental nervous system may correct for the error-producing characteristics of feedback paths, by means of compensation which can have different forms. The form of the compensation utilized is dependent on the nature of the control mechanism operational and the performance required using such a control mechanism. One method involves the modification of the error-actuated controller. If the controlled system exhibits lag due to the action of integrators, then a compensating lead can be introduced by incorporating

differentiators into the controller (Milsum, 1966).

A second form of compensation is to anticipate the consequences of feedback loops by means of feed-forward controls. Most living complexities classified as mammals control their body temperatures based on the information received from temperature receptors in the hypothalamus. Healthy humans have well developed peripheral receptors which send information concerning modifications in temperature by supressing the thermal lags involved in central reception (Benzinger, 1969). This feed-forward mechanism enables a living organism to anticipate the long term consequences of behavior and to take appropriate action to prevent such consequences. This principle is important in the activities which lead to a communicative homeostatic condition.

Performance Criteria

The notion that inaccuracies can be compensated for by incorporating features into the design of a control system implies that performance can be assessed in relation to definite criteria. Performance has been discussed in terms of error variables in error actuated systems and the significant reduction of such errors towards zero, provides a simple form of performance citteria. But it is desirable to take a variety of criteria into account, escpecially those related to the cost of providing quality medical

health care. In walking, it is clear that the control system operating is designed to minimize the energy expenditure as a function of walking speed. The cost is less when the step frequency is sufficiently close to the resonant frequency of the system. The analogous holds for interacting communication systems. The cost to maintain the signal or informational exchange network with minimal energy expenditures requires that they have initially resonating signals that do not require drastic modifications in the AR or the phi coefficient.

Variable Errors In Control Systems

Variablility in behavioral data is a phenomenon encountered by research workers. Most commonly it is due to the failure to control for random fluctuations in the operating disturbance variables. In some studies, the variability continues when elaborate controls are incorporated into the experimental design of ther study. This leads many to assume that behavioral systems are by their nature stochastic processes (Thurstone, 1919; Miller, 1949; Estes, 1953) While an alternative view that behavioral systems are deterministic, and the problem of variability should be met by the attempts to idnetify the source of the variation and the cause of the variation (Chapanis, 1951). At the qualitiative level it is possible to identify the sources of variation by experimental methods. For example,

the day to day fluctuations of food and water intake are associated with one anoher and tend to be in phase (McFarland, 1967).

The variations in feeding and drinking can be interpreted in terms of the known interactions between feeding and drinking systems. Feeding and drinking vary directly when the feeding system is the main controlling factor, but vary inversely when the drinking system is dominant in the interaction between hunger and thirst. The possible sources of behavioral variability are many. Random fluctuations in many environmental variables, such as temperature, and visual stimuli are important parameters within naturalistic environments. However, in the clinical environment these environemtal parameters are kept near constant levels. Instead, variable errors will arise in the sensory processes as a result of noisy monitoring mechanisms or in the process signal detection at higher levels of the nervous system (Green, 1966). Some of the rearch completed in this area has attempted to account for the variability in living systems by describing decisions in the face of a randomly fluctuating drive (Dawkins, 1969; Gray, 1969; Luce, 1959; Audley, 1960). Variability has been shown to be due to errors in computation (Rabbitt, 1968), the variance inthe feedback signals as a consequence of behavior (Notterman, 1965) or for motot processes (Harter, 1968).The distinctions between the variaous sources of a noise, at a reasonably sophicated level must be made on the basis of quantitative

measures.

The Measurement of Variablity

The degree to wh h repeated behavioral measures exhibit variabilty depends on the unit of the measurement employed. When the unit of measurement has been determined on the basis of criteria independent of variability, the investigator must take the variability into account when interpreting the data. A set of data can be represented by the measures of cental tendency or average. Several types of averages can be defined and when the data are obtained from discrete observations measurements of mean, median or mode are employed, in accordance with the nature of the data and the purpose of the analysis. The formation of a time series data set can have its mean defined as:

$$\mu_x = \lim_{T \to} \left(\frac{1}{T}\right) \int_0^T x(t)\,dt$$

The mean square value about the mean, called the variance is:

$$\sigma^2 = \lim_{T \to \infty} 1/T \int_{-T/2}^{T/2} x^2(t)\,dt = \lim_{t \to \infty} \sum_{m=-\infty}^{\infty} (T[X_m]^2)\,1/T$$

and its positive square root is the standard deviation. In cases where average values are of little interest, the general intensity of random data can be described by the

mean square value:

$$\sigma_x^2 = \psi_x^2 - \mu_x^2$$

and the positive root of this is known as the root mean square or rms value. The variance is equal to the mean square value minus the square of the mean:

$$\sigma_t^2 = 1/T \int_{-T/2}^{T/2} x^2(t)dt = \sum_{m=-\infty}^{\infty} [X_m]^2$$

A random process is said to be stationary when its statistical properties do not change with time. In such case it is useful to record only samples of the time history and to relate the statistical properties of the data to the total ensemble. If the random process is stationary, and the ensemble average and other statistical processes do not differ when computed over different sample functions, the process is said to be ergodic. Considerable progress has been made in the statistical analysis of stationary, ergodic, random processes (Brown, 1965; Milsum, 1966; Bendat, 1966; Cox, 1966). In addition to specifying the mean and variance for a set of data is is necessary to determine the distribution of data in some variable or group of variables. The frequency of events or the intervals between events may be plotted against their amplitude in the form of a histogram. The probability aof occuraence of events at given amplitudes is obtained by dividing the number of

events $n(x_n)$ by the total number of events N.

The probability that the data will assume a value within some specified range during a particular time-interval is given by the probability density function.

$$P_{(x)} = \frac{d\,P(x)}{dx}$$

where the probability of the value for the variable falling between x and (x + delta x) is given by:

$$P(x+\delta x) - P_{(x)} = x.\frac{d\left[P(x)\right]}{dx} = \delta x.P_{(x)}$$

As the value of the signal must lie within the range of infinity. It then follows that:

$$\int_{-\infty}^{+\infty} P(x)\,dx = 1$$

The probability that a value between x and x + delta x will be observed is equal to the fraction of time spent by the signal between these amplitude limits. Allowing T_x to represent the total amount of time that x(t) falls inside the range x to x + sigma x during each observation period T. As T approaches infinity,

$$P\left[x < x(t) \leq (x+\delta x)\right] = \lim_{T\to\infty} \frac{T_x}{T}$$

The probability density function:

$$T[X_m]^2 = C_{xx}(f) = 1/T \left[\int_{-T/2}^{T/2} (t)edt \right]^2$$

The probability density function of any generated signals having a periodic component will often demonstrate a bimodal form, while those of random data have a gaussian distribution. These examples demonstrate how the probability density function can be of assistance in determining the nature of variability in data obtained during experimental systems analysis. Specifically, the Gaussian and Poisson distributions imply that independent processes are at work in producing the observed variation in any time series data (Bendat, 1966; Cox, 1966; Moroney, 1951; Spiegel, 1961). The Gaussian function has important theoretical applications in systems analysis (Milsum, 1966).

Correlation Functions

The variablity of communication behavior with time is a problem in the interpretation of the behavior pattern in terms of the underlying organization and integration of the multiple signals transmitted. A common approach has been to determine transition frequencies between one communicational mode and another. One researcher calculated transition frequencies between various components of behavior (Baerends, 1955) and subject this data to factor analysis (Wiepkema, 1961) to construct rules for the

behavior (Vowles, 1970; Hutt, 1970. While other researchers support indicate the difficulties in the interpretation of the results which depend on studies incorporating sequential correlations (Hinde, 1970). It is critical to assume that two activities are likely to share causal factors if they are associated in time, associations can likely be the result of changes in the external stimulus or signal consequent to the concerned behavior. Further evidence supports the notion that unrelated activities may appear at particular points in a communication sequence as a result of motivational factors or other permissive forces which have a probability of becoming operational (McFarland, 1969). An alternative to correlations of sequences is temporal correlation, in which correlates between activities occurring within chosen intervals. This method suffers from the disadvantages that result when the data varies within the time interval chosen and as a result the sequential information within the time span is dissipated (Blurton-Jones, 1968). A further disadvantage of both sequential and temporal correlations is that no account is made of the fact that behavior can vary in its intensity as well as in duration or frequency. This aspect is well illustrated by the studies which examined patterns in eating times (LeMagnen, 1966; Thomas, 1968; Duncan, 1979).

A function which describes the general dependence of the values of the data at one time on value at another time is the autocorrelation function. The autocorrelation

function of any communicated signal x(t) can be written (phi)$_{xx}$(tau) and is defined as the time average of the product. That is, the product of the value at each point of the time scale T, and a time t units later, is determined for each value of t, and the average taken.

$$T[X_m]^2 = C_{xx}(f) = 1/T \left[\int_{-T/2}^{T/2} (t)edt \right]^2$$

When t = 0 the time history is correlated with an image of itself and (phi)$_{xx}$ = (psi)^2_x, the maximal value. As t is increased the images may seen as being displaced with repct to each other, and the value of (phi)$_{xx}$ < 1, but and periodicity in the data will tend to magnify (phi)$_{xx}$ at the values of t corresponding to the period. McFarland obtained autocorrelations for a data set extending 12 hours. The results of that study indicated that the ingestion of nutrients in living organisms is highly periodic, even though the probability density functions indicated that the variables had independence from their previous time histories.

The pattern seems to be dependent upon a joint function of temperal and intensity factors. The autocorrelation functions obtained were similar and agreed with other researchers on this matter (Fitzsimons, 1958; Fitzsimmons, 1969; Kissileff, 1969).

The dependence of one set of data upon another can be determined by means of the autocorrelation function, the

difference exists in that the correlations is between x(t) and y(t). The crosscorrelation between feeding and drinking behaviors supported the notion that the behaviors are synchronous (McFarland, 1969). The power (mean square value) of a signal may be expressed in terms of the amplitude probablity distribution. In a noisy signal there may be various frequencies represented, and the variation of power with frequency is a measure of the power spectrum of the signal. For mathematical convenience, he power is considered to be equally distibuted between positive and negative frequencies and the power spectral density is chosen to satisfy the relationship.

The power spectrum of a signal contains the same information as the autocorrelation function and each may be obtained from the other by means of the Wiener-Khintchine equations. These two functions are Fourier Transforms of each other. The fourier transform is similar to the Laplace transform and relates the functions of time with frequencies (Douce, 1963; Bendat, 1966).

One of the typical autocorrelation and power spectral density pairs has special interest. In a random signal having every frequency represented, a characteristic horizontal power spectrum can be identified. This identifies the white noise and no correlation exists between different points on a white noise waveform because each value is, by definition, independent of all other values.

The autocorrelation function of white noise is an

impulse of magnitude psy square and zero for t not equal to zero. In addition to empirical analysis of variable data, autocorrelations and crosscorrelation functions are important theoretical tools since they can be transformed from functions of time into functions of frequency producing power spectral density functions and cross spectral density functions (Bendat, 1966). These functions, with correlation parameters allow the researcher to become active in the development of stochastic methods to identify components of behavior operational in communicational exchange between people as they exchange information within unique or specified environments.

Chapter 3

Method & Design

The objective of this project is to demonstrate the production of spectral coefficients which are associated with the regulation of synchronicity, cyclicity, bidirectionality and dominance in the face to face interaction between physicians and patients within a clinical environment. This face to face encounter will be preserved on videotape, digitized and coded using the HIP4 methodology (Hogan, 1979). This method will allow the development of the following encoding categories for both the interactants (physician & caregiver):

1) Vocal-verbal structure
2) Nonvocal behavior
3) Vocal-verbal content
4) Nonvocal content
5) Amount of Information

In the description of the physician and patient behaviors, the physician's nonvocal behavior will be scored for facial expression, handling of the patient, and physical position of any health care provider within the examination room relative to the patient. The nonverbal behaviors of the patient scores will be in the amount of movement, direction

of gaze, and facial expression. Each of these parameters will be coded to represent the degree in which it reflects each interactants behavior during the clinical visit.

Correlations of the scaled sum score matrices for each set of factors will be presented. These correlations will be based on 0.25 minutes (15 seconds) of interaction. These correlations will occur in 5 second intervals. Consequently, the initial correlation is for seconds 1 through 15 of the interaction, the second correlation will be for seconds 5 through 20, the third correlation will be for seconds 10 through 25, etc.

This set of moving correlations is needed to smooth the graphical representation of the results and will not segment the interaction. These correlations will indicate the presence or absence of cycling between both interactants. If any sustained periods exist in which the correlations are high, a measure of the synchrony within the interactional episode will indicate the presence of behavioral resonance. On the other hand, if the correlations remain low, this will be a strong indication that the physician and the patient are in a state of disharmony or out of synchrony.

This analytical method may demonstate that the physician or the patient have the ability to modify the objective and subjective topological components of the communicational exchange structure. If cycling can be demonstrated during the exchange of information, the clinical participants will be indicating that they wish a

continuance of the interaction.

However, if cycling is not present, the values in the behavioral patterns of either interactant will reflect any attempt to modifiy the exchange for a prolongation of the encounter. If the patient is able to successfully communicate with the physician, a sequence of expressive behaviors should occur in serial order while the cooperation for reciprocal communicative exchanges continues. The concept of dominance will be descibed by the asymmetry in the predictive coefficients of the spectral desnsities.

This description will allow an estimate of the hierarchial relevance of the interaction, or any components of the interaction, for either interactant. This asymmetry of predictability for dominance has been supported (Chance, 1976). An important limitiation in the definition of dominance will be the social context in which the interaction occurs. Some social participants deliberately allow the creation of asymmetry of predicatability in order to assist with the cognitive or physical maturation of a "young" social participant. This has been demonstrated in the interaction between mothers and their children (Brazelton,1974). Dominance is a functional dependent of the interactants and the social context of the interaction. (Vaugn, 1978).

STATISTICAL ANALYSES

Regression estimates of the coefficients in a series of mathematical equations representing models which describe the information transfer between a physician and patient within a clinical environment will be calculated.

TIME SERIES: TRENDS, CYCLES AND SEASONALITY

A trend is a long term movement in a time series. A trend can be the vocal-nonvocal ratio which can move from mini units during the initial stages of a social encounter to larger values approaching positive infinity in which no verbal behavior is observed to occur for seasoned friends. Likewise, a trend examined in the short term may be a part of a longer cyclical or seasonal effect. The trend can be a component of a seasonal process. Seasonal effects are easy to understand and distinguish. The activity of a certain communicant may depend on the period of the interview. This cyclical effect may be superimposed on a maturational or developmental trend, and may be affected by random events such as the nature of the problem. A cycle is similar to a seasonal effect when they are periodic. In relationship to periodicity, cycles and seasonal phenomena are the same.

Once the periodicity of the time series is known, an attempt will be made to simulate the data with a series composed of sine and cosine functions. It is possible to

utilize a regression program which uses trigonometric functions of time as the independent variables in the analysis. It will probably be necessary to remove any trend from the data before analyzing for the periodicity, and to find the trend the data will be deseasonalized. If the original series has a period of X units on the time index (I), then a new series composed of terms:

$$YY(I) = Y(I) - Y\ (I-X)$$

should also be deseasonalized, to exhibit the trend without the seasonal periodicity. The "new" series will have N-X terms, and the new index of I will run from X to N. To make the conditions more general, if the timeseries has an offset of M (equivalent to X in the example) then the series runs from:

$$I = M+1...N$$

After completing the process of data manipulation such as deseasonalization, the trend of the data set can then be obtained from the resultant series. This method implies that the series can be "picked" apart and that the parts have meanings of their own. These decomposition techniques have been widely received and are important in the analysis of time series data.

The removal of trends and seasonality creates problems which are difficult to completely resolve. After the removal has been accomplished the series will demonstrate an oscillation around some constant value. If the trends and the seasonal factors were the main components, the remaining

oscillatory values may be very small or even non-existent.

SMOOTHING DATA

It is useful to smooth data before analyzing it for periodicity. If the smoothing process is successful, the rough component will contain only the random elements of the raw data. To better understand the nature of smoothing techniques, it will be useful to establish the following relationship between smooth and rough data. (Raw Data = smooth component + rough component)

Raw data is represented by the Y(I) values of the time-series, and smooth is a second time-series YS(I) which has the rough component removed. Smoothing algorithms operate by making a running average of the original series. For example, an average of 3 would be:

$$Y3(I) = [\ Y(I-1) + Y(I) + Y(I+1)\ ] / 3$$

while an average of 5 would be:

$$Y5(I) = [\ Y(I-2) + Y(I-1) + Y(I) + Y(I+1) + Y(I+2)\ ] /5$$

A procedure called "Hanning" is:

$$YH(I) = [Y(I-1)+2*Y(I)+Y(I+1)]/4$$

THE CROSS CORRELATION OF TWO TIME SERIES

If two time series Y(I) and X(I), exist for which I=1...N and allowing Y(I) to be representaive of the verbal activity of an individual and X(I) the non-verbal activity

of the same or another individual. A researcher might wish to know if there is any correlation between verbal and non-verbal activity. It becomes necessary to define some symbols for the summative calculations (all over I from 1 to N). First, there are the simple sums which define the averages of the two series:

$$Ym = Sum[Y(I)]/N \quad \& \quad Xm = Sum[X(I)]/N$$

The sums which define variances, V for X and Y, and the CoVariance, CV, between X and Y:

$$Vy = Sum\ [(Y(I)-Ym)^2]/(N-1)$$

$$Vx = Sum\ [(X(I)-Xm)^2]/(N-1)]$$

$$CV(0) = Sum[(X(I)-Xm)*(Y(I)-Ym)]/(N-1)$$

The range of summation of Vy, Vx, and CV(0) is from I=1...N.The cross-covariance for lag k is defined by:

$$CV(k) = Sum\ [(X(I)-Xm)*(Y(I+k)-Ym)]/(N-1)$$

The term "Lag" indicates the shift of period for making the correlation. The coefficient of cross-correlation RC(k) is:

$$RC(k) = CV(k)/\ Sqr(Vx*Vy)$$

(This quantity can vary from +1.0 to -1.0)

If the value of Y(I) is not affected by the value of X(I) at period I, then RC(0)=0. The first value of RC(k)

which is non-zero indicates the lag between cause and effect. If non-verbal activity increases as verbal activity increases the RC will be positive, and the researcher can make reference to a positive correlation between the variables of interest. Or, if the RC=0 there is no correlation. If the RC is calculated to be negative (or the lag k is too large), the researcher may conclude that the measured non-verbal activity is reducing the verbal activity of another individual. The Coefficients of cross-correlation between two series can then be calculated.

BOX-JENKINS THREE PARAMETER SMOOTHING

An interesting forecasting method for smoothing has been presented (Box and Jenkins, 1962). Any time-series Y(I) can be either stationary or non-stationary and is comprised of I=1...N terms. For example, Allowing the communicative activity of the physician during the interview to be known as the Doctor's verbal activity, DV, predictions can be made:

F(P) = the forecast made for period P, of DV

Y(P) = the observed value at period P, of DV

E(P) = F(P)-Y(P)

= the "error" of the forecast of DV

The forecast for the period P+1 is given in terms of a

three paramater model:

$$F(P+1) = Y(P) + A*[E(P)-E(P-1)] + B*E(P) + C*Sum[E(I)]$$

where the sum in the last terms is usually (but not necessarily) over I=M+1 to N. The parameters A,B and C are selected to minimize the sum of squares of the errors of the forecast. This forecast is to be made by a "feedback" method of smoothing. For P+1 the forecast is that of period P, corrected by a term proportional to the difference of the errors of the previous two forecasts (first difference control), by a term proportional to the error of the Pth forecast (proportional control) and to a term proportional to the sum of all the forecasting errors from the initial forecast (cumulative control). In summary, the three "smoothing" parameters are:

A = The coefficient of the first difference predictor

B = The coefficient of the proportional predictor

C = The coefficient of the cumulative predictor

Optimization will be attained via "trial and error" by maximizing the sum of squares error. The process is elegant, and allows the investigator to view the patterns in the verbal behavior of the subject (patient or physician). In this project the goal of forecasting is to produce a mathematical model which relates the activity of the research parameters (verbal, nonverbal and amount of information) of the interactants to the outcome of the

interaction. This outcome will be reflected in the asymmetry of the predictive coefficients for this informational exchange process. This outcome (S) is a function of the dimensions used to measure the behavior as it occurs over time is represented as:

$$S = f[DV, DNV, DAI, PV, PNV, PAI]$$

SEASONALITY AND FITTING TRENDS

ARIMA models have a historical development which allowed the term "Box-Jenkins" to be used to identify a technique for the generation of an error series E(I) which represents the difference between the actual value of the series at any I value and the value calculated by the model proposed in the analysis. The purpose of having "adjustable" parameters in the model allows for the minimization of the sum of squares of the errors. The Box-Jenkins technique uses an arbitrary model in the form of:

$$F(I+1) = Y(I) + A*[E(I)-E(I-1)] + B*E(I) + C*SUM[E(I)]$$

The Box-Jenkins smoothing technique is an example of the "feedback" method of prediction. The sum is over all the error terms from 1 to N. This sum relates the forecast to the cumulative effects of the model, allowing the coefficient "C" to represent a cumulative parameter. "A" represents a first difference parameter and "B" is a proportional parameter. The model works according to a "feedback" mechanism which looks at the past error terms

from three different orientations and attempts to correct each estimate which follows. The data set used in the time-series analysis by Box and Jenkins was taken as found and no attempt was made to examine its components separately. In contra-distinction to this feedback method is the decomposition or "pick apart" method in which it is assumed that separate factors can be combined to explain the behavior of the series. According to decomposition methods, one may ascribe to the series, Y(I) a trend component YT(I), a seasonal component YS(I), and a residual error component E(I). Three decomposition attitudes or techniques possible are:

a) Additive Decomposition

$$Y(I) = YT(I) + YS(I) + E(I)$$

b) Multiplicative Decomposition

$$Y(I) = YT(I) * YS(I) * E(I)$$

c) Additive-Multiplicative Decomposition

$$Y(I) = YT(I) * YS(I) + E(I)$$

A cyclical or oscillatory component can be include in the trend YT(I). The construction of such models to describe a time-series will be a matter of judgement and opinion involving some trial and error. If there is some obvious periodicity in the data, its period will be graphed and viewed and the FFT allowed to provide a complete frequency spectrum. The process of deseasonalizing and differentiating

a series can be done to fit a polynomial to the trend exposed in the analysis. This analytical scheme is particularly useful if the data appears to have a nonlinear trend. Potential exists for cubic and quadratic distribution densities after extracting periodic trends in the orginal data set. Generally, a decomposition method of fitting time-series data is a "trial and error" method. Once the time-series is fitted, the resulting equation can be used to make forecasts.

STATIONARY VS NON-STATIONARY TIME-SERIES

A stationary time-series may have a random component or a periodic component. It demands that the amplitudes of the oscillations are "constant" indicating that no systemic effect exists. Statistical theory recognizes series which are stationary. But at the current time, the theory (of stochastic processes) becomes difficult to conceptualize. An autoregressive series of the type:

$$Y(I) = A1 * Y(I-1) + A2 * Y(I-2) + E(I)$$

is stationary when $|A1+A2| < 1$ and $|A2| < 1$

This project begins with the idea that a function could be represented in the time domain as a series composed of an infinite number of frequencies. Using the transformations provided above, a pair of related functions C(w) and S(w) could be produced within the frequency domain. These functions will allow a further investigation of the internal

nature of the data collected across time. A "new" quantity can now be defined as I(w) or the intensity (spectrum) of the time series.

$$I(w) = SQR\ [C(w)^2 + S(w)^2] / (N*Pi)$$

If a graph of I(w) vs w is completed, the spectrum of the active variable in the time series would be created. Some authors refer to this graph as the periodogram (Chatfield, 1979). The correlogram and the spectrum are Fourier transforms of one another. As a consequence, information of the spectrum will provide information about the correlogram. The Fourier Transform is another "prism" which provides a spectrum of the time series, it indicates which frequencies are of importance in the behavior of the series.

The spectrum will indicate that some frequencies are more important than others. It indicates the frequencies to tune if you wish to obtain information. The interpretation of spectral peaks will provide a distributive coefficient for the variance of the signal found in the variable of interest. The correlogram will demonstrate relationships between parts of the series which are separated by time elements. If the nonverbal behavior of the physician and the verbal behavior of the patient are associated, then the frequencies of this behavioral "bond" become energic sources for the destruction of any previous communicative structure and the evolution of a "new" communicative dyad in which further alterations will become a dynamic reality.

For this project, the Fourier transform algorithms will require a complex pair of coordinates (X,Y) in time or frequency and produce a transformed pair of coordinates. The time-series data that are processed are real (indicating the imaginary components summ to zero). The Fourier Transform of a real time-series will have both a real and an imaginary component, which will be used to find the spectrum. The existence of imaginary components involves the concept of complex numbers. Specific considerations will be made in the application of the FFT. First, the sample mean should be subtracted from the series and any trend should be eliminated. Next, the correct quantity of terms must be used. A series with N=2^p terms , where p = any positive integer. That is 2, 4, 16, 32, 64, 128, 256, 512, 1024...etc. terms. If the equivalent number of terms do not exist in the experimental variables representing, Doctor Verbal, Patient Verbal, DAI, etc., then null values, of zero, will be entered to establish the required quantity of terms. The series must then be detrended and adjusted to a zero mean. It has been recommended that the ends of the series be tapered (Blackman & Tukey, 1958). One such tapering method is:

```
Y(I) = I*Y(I)/(R+1)            For I=1 to R
     = Y(I)                    For I=R+1 to N-R
     = (N-R+1)*Y(I)/(R+1)      For I=N-R+1 to N
```

Additional limitiations about the interpretation of the spectrum warrant discussion.

1. If the time interval between adjacent values of the time index I is To, it will be impossible to detect periods smaller than 2pi*To (or angular frequencies greater than Pi/To). As a result, the periodicity of the transformed data matrices will become the analytical barometer for any further transformations.

2. If the time interval is unity (as it is in this project) it is impossible to distinguish between frequencies w and w + or - 2pi*k, where k=1,2,3..N

This second point is very significant. Assume that a physicians verbal time-series has a daily periodicity but the observations are taken only once a week. The frequency associated with the weekly period will become:

$$f = 1/7 = .14 \text{ weeks/cycle}$$

The period associated with this frequency is the reciprocal of this frequency (1/f) or more specifically 1/.14 = 7.14 days. Note that a week is not to be considered as exactly 7 days because of the variations in the calendar. This calculated frequency can be confused with other frequencies which allow a researcher to fall into a trap of associating a weekly periodicity with with data that is actually demonstrating periodicity each day, minute or hour.

The FFT program gives the real and imaginary terms of the transform and the intensity ordered according to the index I and the harmonic oscillator H. The FFT will process data formed by sinusoidal series which contain terms such as

Sin (2pi*t/T). These type of terms will be converted to those having the harmonic oscillator present, Sin (2pi*H*I/N). As a consequence, a line at the Harmonic H will correspond with the period N/H.

Spectral Analysis

The entire theory of spectral analysis of random processess applies to those events having statistical peroperties which remain relatively constant over time. The traditional approach is to transform a process to a stationary form if it is not stationary. This statistical equilibrium allows a comparison of any active processes which may affect the research variables.

Spectral Analysis is also known as spectrum analysis and involves the generation of methods of estimating the spectral desnsity function, or spectrum for a set of data. The search for hidden periodicities has allowed the evolution of methods to provide a behavioral spectrum over the entire range of frequencies. M.S. Bartlett and J.W Tukey have been prominent in the development of modern spectral analysis. This analysis is concerned with purely indeterministic processes, which produce a continuous spectrum. When indeterminate processess are used as a focus a discrete spectrum is produced. Spectral analysis is essentially a modification of Fourier Analysis to allow for stochastic rather than deterministic functions of time.

Spectral analysis is an exploratory diagnostic tool in the analysis of a time-series data set. The interpretation of the spectrum can lead to important clues about the behvior of a varaiable or set of variables. Each spectrum may provide "peaks" and a general shape will assist in indicating an appropriate parametric model. Spectral Analysis is a non-parametric procedure in which a finite set of observations is used to estimate a function defined over a range of frequencies. The function is not constrained to any particular parametric class which allows spectral analysis to be a more general method than inference based on a particular parametric class of models. Attempts have been made to apply spectral analysis to marketing data, but it has been argued that marketing series are usually too short and the seasonal variation too large for spectral analysis to give useful results (Chatfield, 1974). In meteorology and oceanography, spectral analysis can be a useful analytical tool (Munk, 1959; Craddock, 1965; Roden,1966; Snodgrass, 1966) providing minimal results.

A problem exists on whether to plot the estimated spectrum of its logarithm. An advantage of plotting the estimated spectrum on a logarithmic scale is that its asymptotic variance is then independent of the level of the spectrum so that confidence intervals for the spectrum are of constant width on the log scale. For spectra demonstrating large variations in power, a log scale also makes it possible to show greater details over a wide range

of frequencies. Jenkin and Watts (1968, p.266) suggest that spectrum coefficients should always be plotted on a log scale. But, Anderson (1971, p.547) points out that this exaggerated the visual effects of variations when the spectrum is small. Thus the researcher will find it easier to interpret a spectrum plotted on an arithmetic scale as the area under the graph corresponds to power density functions of the variance associated within a variable and one can more readily assess the importance and existence of different peaks. So while this controversy continues, this researcher believes that log scales of the spectrum may be important when attempting to isolate relative truncation points and tests of the significance of the peaks. An arithmetic scale will allow uniformity in spectral comparisons.

The presence of harmonics is another factor which may confound the interpretation of a spectrum. When a spectrum has a large peak at some frequency, then related peaks can occur in the spectrum. These multiples of the fundamental frequency are called armonics and indicate the non-sinusoidal property of the main cyclical componnt of he time series data. Mackay (1973) studied consumer visits to the supermarket and found a basic weekly pattern with harmonics at two and three cycles per week.

The importance of sample size is also of significance. It is recommended that between 100 and 200 observations is the minimum. Granger (1968) tried small values of N and

concluded that only very large peaks can be found.

Significance:

1. This study will demonstrate the transformation of qualitative data into quantifiable analytical data.
2. This study allows further investigation into the nature of the qualitative indices which represent the informational flow between cooperating individuals.
3. This study will reveal the dimensional flux within an open system having oscillatory momenta representing the exchange of information.
4. This study will provide impetus to the investigative prospect of determining the communicative variance which is proposed to coincide with various medical conditions and complaints.
5. This study allows an analysis of transcultural phenomena in the interpretation of communcative patterns.
6. This study will provide information on the time dependent nature of communication systems.
7. This study demonstrates that synchronicity, cyclicity and dominance concepts are important parameters in the investigation of physicians as they relate to the health care concerns of patients.

THE HOGAN INTERACTIONAL PROFILE OF PHYSICIAN & PATIENT PERFORMANCE

This instrument will be known as the HIP4. It was developed at the Wayne State University School of Medicine (Detroit, Michigan) by the researchers associated with the Department of Educational Services and Research under the direction of Dr. Martin Hogan. The investigation of the physician and patient interaction is believed to demonstrate

the laws of nature that are operating in specific non-linear interactions under conditions that are not in equilibrium (Prigogine, 1977). The autonomous nature of communication systems allow their structure to be created by the spontaneity of the communicants and is active in producing the norms accepted by these communicants. Living systems exist within energic environments which have the capacity to alter the order of the processes involved in the exchange of information or energy. The "HIP4" is an encoding system which allows the extension of qualitative information to a quantified dimension. The codes developed for the analysis of the qualitative exchange of information were produced from hours of observation and investigation of various types of medical interactions wihin clinical environments. The codes can describe any of the behaviors possible for either the patient or the physician. The HIP4 codes are given in the table below.

Table of HIP4 codes

I) Verbal Categories

1. Open-ended Questions
2. Direct Questions
3. Explanatory
4. Directive Statement
5. Reflective Utterance
6. Hesitation Phenomena
7. Reflective Statement
8. Crying
9. Joking format
0. Silence

II) Verbal Content Categories

A) Body Systems

1. Eyes, Ears, Nose, Throat and Head
2. Respiratory
3. Cardiovascular
4. Gastrointestinal
5. Geniturinary
6. Neuromuscular
7. Skeletal
8. Skin & Soft Tissue
9. Hematology
10. Endocrine
11. Physical Growth
12. Skills
13. Immunological
14. Nutritional
15. State Continuum
16. Social Relations
17. Social Amenities
18. Open-ended

B) Form:Function

1. Accelerated
2. Static
3. Potential

:Dysfunction

4. Accelerated
5. Static
6. Potential

C) Socio-ecologic Systems

1. Home environment
2. School environment
3. Leisure (recreational)
4. Work environment
5. Church environment
6. Hospital environment
7. open natural environment

D) Personal Referent

1. Patient
2. Physician
3. Caregiver
4. Patient with Family
5. Family member and/or others
6. Non-personal

E) Direction

1. Patient
2. Physician

3. Caregiver
4. Away (non-directional)

III) Non-verbal categories

1. Eye gaze at other
2. Head Gesture
3. Hand Gesture
4. Posture change
5. Posture towards
6. Posture away
7. Manipulation - instrumental
8. Manipulation - noninstrumental
9. Touching other
0. Facial expression
*. Note-taking
H. Movement lateral
C. Movement Toward
F. Movement Away
I. Physician enters/exits room

IV) Non-Verbal Categories

1. Eyes, Ears, Nose, Throat and Head
2. Respiratory
3. Cardiovascular
4. Gastrointestinal
5. Geniturinary
6. Neuromuscular
7. Skeletal
8. Skin & Soft tissue
9. Hematology
10. Endocrine
11. Physical Growth
12. Skills

V) Amount of Information

A measure of the number of intact phrases that occur during the communication. The intact phrase is a word, phrase or sentence which connotes its message by means of:

a) One complete thought
b) A phrase of word with an implied subject
c) Part of an associated chain of words or phrases.

Words or phrases indicating the time or place are considered individual units of information when they contribute information to the intact phrase.

The HIP4 has the capacity to generate a behavioral matrix of

eighty variables for each mode of activity for each active participant. The matrices were translated onto a behavioral template which mapped the behavioral topology of the HIP4 across time. The total interactional episode is divided into 200 units representing N. These dimensional units of time were segmented into subunits of five, representing the proportion of elapsed time in the behavior displayed. Each variable is recorded on the proportion of time it is active in the time unit measured.

I) HYPOTHESES

The generation of hypothesis is based on the observed distribution of measured communication signals as obtained with the HIP4. A description of each variable's activity will include a mean, standard deviation and correlations for pairs of variables will be provided. In addition, the median test for a flat spectrum on the spectral coefficients is completed for each variable. This test is based on the fact that the cumulative spectrum has values which are distributed like order statistics from a uniform distribution under the null hypothesis that the signals consist of white noise. Confidence intervals for the logarithm of the spectral density will also be provided. An exact confidence interval, derived under the assumption that the process is gaussian, and an approximate confidence interval, dervived from an asymptotic distribution will be

provided. The analyses performed assume that the data are weakly stationary data points of equally spaced time intervals.

Chapter 4

ANALYSIS OF RESULTS

The HIP4 has the potential to generate activity scores for 160 variables, generating activity profiles for 35 variables for the physician and the patient. This allows for an analyses of 71 total variables representing 44.4% of the measurements which can be measured. This includes the time dimension in addition to the behavioral dimensions listed below. These active variables as identified in this study are found in table 1.

IDENTIFICATION OF VARIABLES

TABLE 1

SUMMARY OF BEHAVIORAL & CLINICAL INTERACTIONAL
CODES FOR ACTIVE HIP4 COMMUNICATION VECTORS
VERBAL CLASSIFICATION

Physician	Patient (Caregiver)	Vector Name
2. DOEQ	12. CGDEQ	Open Ended Question
3. DDQ	13. CGDQ	Direct Question
4. DEX	14. CGEX	Explanatory Statement
5. DDS	15. CGDS	Directive Statement
6. DRU	16. CGRU	Reflective Utterance
7. DH	17. CGH	Hesitation Phenomena
8. DRS	18. CGRS	Reflective Statement
10. DJ	20. CGJ	Joking
11. DS	21. CGS	Silence

Table 1 (continued)

VERBAL CONTENT

22. DVC1	36. CGVC1	Ear, Nose & Throat
23. DVC2	37. CGVC2	Respiratory System
24. DVC7	38. CGVC7	Skeletal System
25. DVC8	39. CGVC8	Skin & Soft Tissue
26. DVC12	40. CGVC12	Psychological/Behavioral Skills
27. DVC13	41. CGVC13	Immunological System
28. DVC14	42. CGVC14	Nutrition
29. DVC17	43. CGVC17	Social Amenities
30. DVC18	44. CGVC18	Open-Ended, Misc.

FORM (FUNCTION)

31. DF1	45. CGF1	Accelerated Function
32. DF2	46. CGF2	Static Function
33. DF3	47. CGF3	Potential Function
34. DF5	48. CGF5	Static Dysfunction
35. DF6	49. CGF6	Potential Dysfunction

NONVERBAL CLASSIFICATION

50. DNV11	61. CGNV11	Eye Gaze at Patient
51. DNV12	62. CGNV12	Mutual Eye Gaze
54. DNV4c	65. CGNV4c	Position Shift to Standing
55. DNV4h	66. CGNV4h	Position Shift to Sitting
56. DNV64	67. CGNV64	Manipulation (Instrumental)
57. DNV65	68. CGNV65	Manipulation (Non-Instrumental)
58. DNV66	69. CGNV66	Manipulation (Tactile)
59. DNV77	70. CGNV77	Notetaking Activity

INFORMATION

60. DAI	71. CGAI	Amount of Information

DESCRIPTION OF VARIABLES

Variables 2-21 are classified as vocal structures for either the physician or the patient (caregiver). A question is characterized as a request for information or clarification based on another's experience. It may be posed with such interrogative words as who, what, where, when, why and how; by tonal inflection; by inverting subject-verb order; or the use of litotes (use of an opposite to express the intended).

Variable 2 & Variable 12 (OEQ)

An open ended question is an interrogative which is free to be argued or developed further, where the extent of the answer will be determined by the respondent; one which is open to a wider range of responses (more than just a yes/no) than such questions which have a specific correct answer.

Variable 3 & Variable 13 (DQ)

A direct question is an interrogative requiring a relatively straightforward response, one which limits the respondent to a minimal number of appropriate responses. It may appear as a litote or inflection.

Variable 4 & Variable 14 (EX)

An explanatory statement reveals information concerning objective knowledge or subjective perceptions. It may be

elicited in response to a question or freely offered with the intention of disclosing or describing matters previously unknown to other communicants.

Variable 5 & Variable 15 (DS)

A directive statement expresses the intent of the speaker to create an alteration in the behavior of another by means of either an imperative or in the giving of permission. It may occur as a command, a staqement or in the form of a rhetorical question or advisement.

Variable 6 & Variable 16 (RU)

A reflective utterance is a vocalized expression on the part of the speaker which connotes an abbreviated request for, or conveyance of information. It may appear in the form of an acknowledgement or facilitation. Its content is reflected in the immediately prior utterance by another speaker.

Variable 7 & Variable 17 (H)

Hesitation phenomenon is characterized by a break in the temporal continuity of the expression of a unified thought or idea.

Variable 8 & Variable 18 (RS)

A reflective statement by the speaker which tends to restate or clarify a previous utterance made by another person, mainly for the speakers own benefit. It may attempt

to put another's thoughts into one's own words.

Variable 9 & Variable 19 (C)

A visual and audible act usually associated with facial distortion and tearing of the lacrimal glands. Behvior included in this category include episodes of whining or sobbing.

Variable 10 & Variable 20 (J)

The joking format includes comments of a light-hearted or comic nature which may relate information gathering, line of questioning, or establishing and maintaining rapport.

Variable 11 & Variable 21 (S)

Silence is the sustained refraining from speaking which occurs when encouraging further conversation by another or while listening, when not necessarily focusing on the conversation, and while engaged at turn-taking points.

VOCAL VERBAL CONTENT ENCODES

The content of the medical interview is divided into four major encodes: Body systems, Form, Socioecologic system, and personal referent. The latter three encodes are each nested within body systems such that each content code represents a system by form, by environment and by referent.

Variable 22 & Variable 36 (VC1)

Includes any discussion on the Ears, Eyes, Nose, Throat, and Head (ENT) this includes: Gums, tongue, goiter, glaucoma, double vision, eyelids, vertigo, hayfever, headache, colds, sinuses, cataracts, strep throat, meningitis, teeth, or lips.

Variable 23 & Variable 37 (VC2)

The respiratory system includes any discussion on or about shortness of breath, edema, bronchial congestion, cough, lungs, emphysema, pleurisy, chest pain, tuberculosis, sleeping activity and asthma.

Variable 24 & Variable 38 (VC7)

The skeletal system system includes any discussion on or about "joint" pains, swelling, inflammation, arithitis, deformaities, lameness, fractures, bursitis or rheumatoid arthritis.

Variable 25 & Variable 39 (VC8)

The Skin and Soft tissue concerns any discussion on or about peritonitis, epidermal pathology including skin, nails, hair or acne. Any addition discussion about contact allergy, eczema, skin color change, psoriasis, dry skin, diseases of the scalp, discoloration of nails, growths, warts, scaling, lesions, scars, tumors and moles.

Variable 26 & Variable 40 (VC12)

Psychological & behavioral skills include any discussion

of motor skills, cognitive development, speech, oculomotor coordination and depending on the age of the patient may lead to an inquiry of various body systems.

Variable 27 & Variable 41 (VC13)

The immunologic variable includes any discussion of pathologies or concerns about malaria, immunizations, transfusions, vaccinations, infectious diseases, lupus, allergies, lymph nodes, fever, tonsillitis, medications and insect bites or stings.

Variable 28 & Variable 42 (VC14)

Nutritional concerns include discussions about appetite, including anorexic conditions, food idiosyncracies, diet and vitamin supplements.

Variable 29 & Variable 43 (VC17)

Social amenities include humor and other pleasantries, including greeting or departing comments, social non-health conversation and directive/facilitative remarks.

Variable 30 & Variable 44 (VC18)

Open ended (misc.) discussion includes comments on previous hospitilizations, vaccination history, age/sex, health of family members, general health inquiries including medical forms or rules and regulations.

Variable 31 & Variable 45 (F1)

The Form variable:"Accelerated Function" includes statements pertaining to improved or increased health status including normal developmental processes.

Variable 32 & Variable 46 (F2)

The Form variable:"Static Function" includes statements referring to status quo systems or conditions. Includes the state of particular instance for an event.

Variable 33 & Variable 47 (F3)

The Form variable: "Potential Function" includes statements of possible or impending emotional or physical problem that may not have occurred.

Variable 34 & Variable 48 (F5)

The Form: "Static Dysfunction" includes all statements about the status quo of a system diorder, or other perturbation of normal activities or occurences.

Variable 35 & Variable 49 (F6)

The Form: "Potential Dysfunction" includes the discussion on a possible disturbance or degeneration of health or system functioning as yet not known to be present or having occured at the time of making a statement.

Variables 50 & 61 (NV11)

These variables involve the non-verbal visual aspect of the communication encounter and directly describe the

behavior which reflects the eye gaze toward the patient.

Variables 51 & 62 (NV12)

These variables involve the mutual gaze of both communicants with one another.

Variables 54 & 65 (NV4c)

These variables involve the change in the physical position of the communicants to a vertical stance.

Variables 55 & 66 (NV4h)

These variables involve the change in the physical position of the communicants to a sitting position.

Variables 56 & 67 (NV64)

These variables describe the act of manipulating instruments required for the collection of information or useful in identifying the information when not readily available to the unaided sensual systems.

Variables 57 & 68 (NV65)

These variables describe the act of manipulating instruments which are not required for the collection of information and are not useful in identifying the medical information sought in the encounter between communicants.

Variables 58 & 69 (NV66)

These variables involve the act of actually touching,

which may not be the patient, and is useful in obtaining a description or specifying the location of a unique condition or pathological complaint by the communicants.

Variables 59 & 70 (NV77)

These variables are self-explanatory and involve the act of writing information for later recall. The written information is not analyzed and is kept confidential.

Variables 60 & 71 (AI)

The amount of information communicated is measured by the frequency of thematic units that occur during the communicative episode. A thematic unit is a word, phrase or sentence which connotes its own intact message by means of one complete thought; a phrase or word with an implied subject; a part of an associated chain of words or phrases which indicate a time or place. It appears that redundancy will not provide any additional clarification. In general all non-verbal variables are coded as discrete occurrences except eyegazes, manipulations and note-taking, which are considered as continuous due to their extended duration. For convenience, several discrete items have been included in the continuous category.

Each of these measured variables are described further in table 2, a listing of the mean activity levels for each pair of variables along with the deviations of each set of variables for comparisons are shown.

TABLE 2

DESCRIPTIVE STATISTICS
FOR BEHAVIORAL & CLINICAL VARIABLES ACTIVE
IN THE CODED HIP4 COMMUNICATION VECTORS

VERBAL CLASSIFICATION

PHYSICIAN			PATIENT		
VECTOR	M	SD	VECTOR	M	SD
2. DOEQ	0.180	0.640	12. CGOEQ	0.055	0.503
3. DDQ	0.465	1.032	13. CGDQ	0.080	0.366
4. DEX	1.340	1.895	14. CGEX	1.025	1.621
5. DDS	0.030	0.360	15. CGDS	0.135	0.624
6. DRU	0.490	1.061	16. CGRU	0.470	1.169
7. DH	0.015	0.122	17. CGH	0.030	0.299
8. DRS	0.075	0.413	18. CGRS	*	*
10. DJ	0.270	0.769	20. CGJ	0.010	0.141
11. DS	2.145	1.831	21. CGS	3.190	1.766

VERBAL CONTENT

22. DVC1	0.050	0.457	36. CGVC1	0.005	0.071
23. DVC2	1.170	2.082	37. CGVC2	0.950	1.912
24. DVC7	0.280	1.131	38. CGVC7	0.430	1.351
25. DVC8	1.215	2.112	39. CGVC8	0.790	1.842
26. DVC12	0.255	1.094	40. CGVC12	0.255	1.094
27. DVC13	0.110	0.656	41. CGVC13	0.135	0.794
28. DVC14	0.730	1.756	42. CGVC14	1.150	2.083
29. DVC17	0.190	0.899	43. CGVC17	0.520	1.432
30. DVC18	0.860	1.857	44. CGVC18	0.705	1.674

* NO ACTIVITY

FORM (FUNCTION)

31. DF1	0.235	1.012	45. CGF1	0.025	0.354
32. DF2	2.025	2.388	46. CGF2	2.215	2.425
33. DF3	0.595	1.531	47. CGF3	0.665	1.660
34. DF5	1.615	2.276	48. CGF5	1.685	2.307
35. DF6	0.380	1.278	49. CGF6	0.260	1.090

NONVERBAL CLASSIFICATION

50. DNV11	0.295	1.120	61. CGNV11	0.890	1.318
51. DNV12	0.210	0.975	62. CGNV12	2.315	2.399
52. DNV13	0.895	1.755	63. CGNV13	0.740	1.752
54. DNV4c	0.165	0.794	65. CGNV4c	0.150	0.855
55. DNV4h	0.035	0.290	66. CGNV4h	1.245	2.128
56. DNV64	0.520	1.463	67. CGNV64	0.105	0.645
57. DNV65	0.480	1.414	68. CGNV65	*	*
58. DNV66	0.140	0.770	69. CGNV66	*	*
59. DNV77	1.110	2.000	70. CGNV77	0.005	0.071

INFORMATION

60. DAI	0.515	0.951	71. CGAI	0.662	0.721

* NO ACTIVITY

The summarized Descriptive Statistics (Table 2) measuring the activities (mean and standard deviation) of each pair of communication vectors supports the analytical notion that each active variable, or vector, fails to minimally demonstrate stoichastic properties in the evolving patterns to be found in the network of communication activities across time. This table (2) serves only to provide a summative evaluation for the comparison of the behaviors of the physician and the patient or caregiver. Several variables were not active for both communicants. The caregiver had no behavior in Variables numbered as 18 (CGRS), 68 (CGNV65), 69 (CGNV66) which was not the case with the physician. The greatest activity was found in the amount of time in which the patient or caregiver was silent which was compared with the activity scores of the physician and was shown to significantly different ($P < 0.05$).

The greatest verbal activity of the patient or caregiver

involved the amount of time spent providing an explanation to the physician. The amount of time spent providing an explanation by the patient or caregiver (Variable 14) to the physician was found to be negatively correlated with the amount of time spent by the physician in asking a direct question (Variable 3), table 48. No significant differences were found the amount of time spent by the physician in Joking with the patient or caregiver and in asking open ended questions ($P < 0.05$). In addition, no significant differences were found in the comparison of mean activity times for the physicians behavior when asking direct questions (Variable 3) and making a reflective utterance (Variable 6). The content of the comparative verbal behaviors for the physician and the patient or caregiver demonstrates that the physician spent most of the interview time discussing skin and soft tissue problems (Variable 25) while the patient spent most of the time on issues related to the nutritional requirements (Variable 42) of maintaining a healthy state.

No significant differences were demonstrated in the mean activity scores of these two variables ($P < 0.05$), while the index of correlation between these variables was found to be -0.13, a slightly negative correlation of association. It should be noted that the greatest correlation (.93) was found between the mean activity scores for the discussion of the patient's cognitive development and other related motor skills (Table 64). This is interpreted as indicating a large amount of harmony in the communication issues which are

associated with the psychological and/or behavioral skills of concern to the communicants. No signifiant differences were found in the amount of time spent dissussing ailments of the Ear, Nose and Throat, Respiratory system, skeletal system, or the immunological system. While a significant difference ($P < 0.05$) was noted in the amount of time the physician spent in the discusion of social ammenities (Variable 29) and the nutritional issues (Variable 42) of the patient.

Testing for Differences

The Tukey procedure (HSD test) is used because this method is designed to make all pair wise comparisons of mean activity levels for the communication vectors active between the physician and the patient, or caregiver, while maintaining the experimental error rate (alpha level) at the prestablished level of 0.05, as set in the hypotheses. Tables 3 through 46 contains the matrices of the calculated Q statistic, which uses the studentized range distibution rather than the t-distributions as the underlying test statistic. The comparisons which failed to be rejected as being significantly different ($P < 0.05$) are indicated with an asterisk (*). Table 5 provides summary comparisons for the physician's verbal vectors (Variable 2 - Variable 11) vs the physician's verbal content vectors (Variable 22 - Variable 30). No significant differences are noted in a comparison of the level of activity in Variable 4 (DEX) vs Variable 23

(DVC2), the communication channels most frequently used by the physician to transmit or obtain information. Variable 4 also had an index of activity which was shown to be nonsignifcant ($P < 0.05$) with Variable 25 (DVC8).

The comparison of the patient's Verbal vectors (Variable 12 - Variable 21) vs. the patient's Verbal content vectors (Variable 36 - Variable 44) in Table 14 demonstrates that the variables found to be most active (Variable 14 & Variable 42) had activity scores which were not found to be significantly different, the amount of time spent asking opened-ended questions was significantly different than the amount of time silent. The correlation of these active variables is summarized in table 47 through table 90. It can be seen that most of the Pearson product moment correlations were found to be negligible according to Best's criteria. However, certain exceptions are to be noted.

Moderate positive correlations were found in Table 49 between variable 10 (DJ) and variables 25 (DVC8); in Table 51, between variable 10 (DJ) and variable 39 (CGVC8); in Table 53, between variable 10 (DJ) and variable 56 (DNV64); Table 54, between variable 10 (DJ) and Variable 66 (CGNV4h); in Table 63, between variable 23 (DVC2) and variable 37 (CGVC2), in Table 69, variable 31 (DF1) and variable 40 (CGVC12); in Table 70, between variable 32 (DF2) and variable 46 (CGF2); between variable 34 (DF5) and variable 48 (CGF5); in Table 72, between variable 63 (CGNV13) and variables 34 (DF5) & 35 (DF6); in Table 74, between variable 37 (CGVC12)

and variable 48 (CGF5); in Table 75, between variable 39 (CGVC8) and variable 56 (DNV64) and between variable 41 (CGVC13) and variable 58 (DNV66);

Moderate negative correlations are found in table 55, between variable 16 (CGRU) and variable 21 (CGS) as well as between variable 14 (CGEX) and variable 21 (CGS); in Table 68, between variable 32 (DF2) and variable 34 (DF5); in Table 72, between variable 32 (DF2) and variable 48 (CGF5); in Table 74, between variable 37 (CGVC2) with variable 46 (CGF2); in Table 77, between variable 46 (CGF2) and variable 48 (CGF5); while substantial positive pearson product moment correlations were noted between variable 10 (DJ) and variable 56 (DNV65); in Table 64, between variable 22 (DVC1) and variable 36 (CGVC1).

The amount of verbal information transmitted was found to be negligibly correlated with most variables with the following exceptions. Table 84 indicates that Variable 71 (CGAI) and variable 14 (CGEX) demonstrated a moderately positive correlation coefficient of 0.46. While a negative correlation was found between Variable 71 (CGAI) and variable 21 (CGS).

Was the silence of the patient an indication of an important property of communication events ? This question could not be answered by merely comparing the summed activities of the active HIP4 variables. A search for the patterns in the communication events which could direct an investigator to an understanding of the deterministic, or

stochastic properties of clinical commmunication, as captured with the HIP4, could be realized by examining the vectors along a non-reductionistic time continuum which could provide a measure of the spectral coefficients of any cyclic or periodic functions of the communicative signals.

TABLE 3

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN VERBAL CATEGORY VARIABLES

	V2	V3	V4	V5	V6	V7	V8	V10	V11
V2	-	3.2	7.8	2.9	3.4	3.8	1.9*	1.4*	13.8
V3		-	5.4	5.5	.22*	6.1	4.8	2.0	10.9
V4			-	9.5	4.9	9.8	8.9	7.4	3.4
V5				-	5.7	.56*	1.2*	16.	.56*
V6					-	6.3	5.1	2.3	10.7
V7						-	1.9*	4.6	16.4
V8							-	3.5	15.3
V10								-	11.7
V11									-

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 4

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) VERBAL CATEGORY VARIABLES

	V12	V13	V14	V15	V16	V17	V18	V20	V21
V2	2.14	1.9*	.69*	3.2	2.97	3.98	3.98	23.2	2.3
V3	4.96	4.88	4.0	3.8	.04*	5.7	6.40	6.30	19.8
V4	9.5	9.6	1.6	8.4	5.6	9.7	10.0	9.9	11.3
V5	.57*	1.4*	8.4	2.1	5.0	0*	1.2*	.73*	25.0
V6	5.1	5.0	4.4	4.1	.19*	5.8	6.5	6.3	17.1
V7	1.1*	2.4	8.8	2.7	5.4	.66*	1.7*	.38*	25.0
V8	.43*	.12*	8.2	1.1*	4.4	1.2*	2.6	2.1	24.0
V10	3.7	3.2	5.9	1.9*	1.9*	4.1	4.9	4.7	22.0
V11	15.	15.	7.6	15.	11.	16.1	16.6	16.5	5.2

* NOT SIGNIFICANT

[$P < 0.05$]

TABLE 5

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DVC) VERBAL CONTENT VARIABLES

	V22	V23	V24	V25	V26	V27	V28	V29	V30
V2	2.3	6.5	1.1*	6.8	.85	1.1*	4.1	.13*	4.8
V3	5.3	4.2	1.7*	4.4	2.1	4.8	1.9*	2.9	2.5
V4	9.2	.84*	7.2	.62*	6.6	8.6	3.2	7.7	3.0
V5	.48*	7.8	3.0	7.8	2.7	1.5*	5.5	2.3	6.2
V6	5.4	4.0	1.9*	4.3	2.2	4.2	1.7*	3.1	2.6
V7	25.	1.0*	7.8	3.3	8.0	3.1	2.0	2.7	6.4
V8	.57*	7.5	2.4	7.5	2.1	.63*	5.1	1.6*	5.9
V9	1.5*	7.9	3.5	8.1	3.3	2.4	5.9	3.0	6.6
V10	3.4	5.7	.09*	7.0	.15*	2.2	3.2	.92*	3.9
V11	16.	5.0	12.1	4.5	13.1	14.6	8.4	13.7	6.5

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 6

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V2	.65*	10.7	3.4	8.6	2.0
V3	2.6	8.7	.93*	6.4	.72*
V4	6.8	3.0	4.8	1.3*	6.2
V5	2.7	11.6	5.0	9.9	3.7
V6	2.4	8.7	.76*	6.5	.88*
V7	3.1	12.	5.3	9.9	4.1
V8	2.0	11.2	4.6	9.6	3.3
V9	3.3	12.0	5.5	10.0	4.2
V10	.37*	9.4	2.5	8.6	1.1*
V11	13.5	.57*	9.4	2.4	10.8

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 7

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V2	3.8	5.3	2.3	4.5	.85*	.61*	6.3	3.0	4.2
V3	6.2	3.1	.30*	2.1	2.2	3.7	4.2	.43*	1.7*
V4	9.9	2.2	5.6	2.8	6.6	8.5	.94*	4.9	3.6
V5	.96*	6.6	4.0	5.7	2.7	1.7*	7.5	5.0	5.5
V6	6.4	3.0	.48*	2.0	2.2	3.7	4.0	.23*	1.6
V7	1.0*	6.9	4.4	6.0	3.1	2.1	7.7	5.0	5.8
V8	2.4	6.3	3.5	5.4	2.1	.94*	7.1	4.2	5.3
V9	1.0*	7.0	4.5	6.1	3.3	2.4	7.8	5.1	6.0
V10	4.8	4.5	1.5*	4.3	.15*	1.7*	5.4	2.1	3.4
V11	16.6	6.2	10.7	7.0	13.0	14.2	5.2	10.1	8.0

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 8

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CG) VERBAL FORM VARIABLES

	V45	V46	V47	V48	V49
V2	3.0	11.9	3.7	8.8	.86*
V3	5.7	9.4	1.4*	6.8	2.0
V4	9.7	3.8	4.5	1.6*	6.9
V5	.14*	12.8	5.2	9.9	2.8
V6	5.8	9.3	1.2*	6.8	2.2
V7	.38*	13.0	5.5	10.2	3.2
V8	1.3*	12.4	4.8	9.7	2.2
V9	1.0*	13.0	5.7	10.3	3.4
V10	4.1	11.3	2.9	8.0	.11*
V11	16.2	.32*	8.0	2.3	12.3

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 9

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V54	V55	V56	V57	V58	V59
V2	1.31*	.37*	.21*	2.8	3.1	2.6	.55*	6.6
V3	1.5*	2.5	3.4	5.6	.41*	.12*	3.6	4.3
V4	7.1	7.2	8.1	9.6	5.2	5.4	8.3	1.0*
V5	3.2	2.4	2.2	.15*	4.8	4.3	1.8*	7.5
V6	1.8*	3.0	3.4	5.8	.22*	.08*	3.7	4.0
V7	3.5	2.9	2.6	.89*	4.8	4.6	2.3	7.7
V8	2.6	1.9*	1.5*	1.1*	4.3	3.8	1.0*	7.2
V10	.31*	.66*	1.3*	4.0	3.0	1.8*	1.6*	5.2
V11	11.3	13.6	14.0	16.4	8.4	10.1	14.4	6.3

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 10

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V65	V66	V67	V68	V69	V70
V2	7.0	12.3	.39*	6.8	1.1*	3.9	3.9	3.8
V3	3.5	10.8	3.2	4.4	4.1	6.4	6.4	6.3
V4	3.1	3.9	7.8	.54*	9.4	10.0	10.0	9.9
V5	8.8	5.6	8.1	1.4*	1.2*	1.2*	.96*	11.2
V6	3.1	10.6	3.6	4.2	4.2	6.5	6.5	6.6
V7	9.4	13.5	8.1	1.9*	1.7*	1.7*	1.0*	12.4
V8	8.3	13.1	1.1*	7.8	.55*	2.6	2.6	2.4
V10	5.8	10.8	1.4*	7.1	2.6	5.0	5.0	4.8
V11	7.3	.94*	15.0	3.9	14.0	16.6	16.6	16.5

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 11

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CG) VERBAL CATEGORY VARIABLES

	V12	V13	V14	V15	V16	V17	V20	V21
V12	-	.56*	7.9	1.3*	4.5	.60*	1.2*	23.0
V13		-	7.8	1.1*	4.4	1.5*	2.5	24.3
V14			-	7.0	3.5	8.4	8.9	9.8
V15				-	3.5	2.1	2.8	21.9
V16					-	5.1	5.5	15.6
V17						-	.85*	24.7
V20							-	25.1
V21								-

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 12

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DVC) VERBAL CONTENT VARIABLES

	V22	V23	V24	V25	V26	V27	V28	V29	V30
V12	.10*	7.3	2.5	7.9	2.3	.93*	5.2	1.8*	5.8
V13	.72*	7.2	2.3	7.5	2.2	.56*	5.1	1.5*	5.9
V14	8.2	.76*	5.5	1.1*	5.7	7.4	1.8*	6.0	.91*
V15	1.5*	6.7	1.6*	6.7	1.3*	.38*	4.9	.70*	5.3
V16	4.7	4.3	1.6*	4.3	2.0	3.7	1.8*	2.6	2.5
V17	.52*	7.6	3.0	7.8	2.8	1.6*	5.7	2.4	6.3
V20	1.2*	7.8	3.3	8.0	3.1	2.4	5.8	2.8	6.5
V21	25.0	11.0	19.4	9.7	19.0	23.0	13.0	23.0	13.0

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 13

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V12	2.2	11.2	4.7	9.8	3.3
V13	2.0	11.3	4.7	9.3	3.3
V14	6.2	4.7	2.6	3.1	4.3
V15	1.2*	11.3	4.0	8.5	2.4
V16	2.1	8.7	.91*	6.1	.75*
V17	2.7	11.8	5.2	9.7	3.7
V20	3.1	11.9	5.4	9.9	4.1
V21	20.1	5.4	16.0	7.8	18.4

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 14

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V12	1.4*	6.3	4.2	5.4	2.3	1.2*	7.1	4.3	5.2
V13	2.8	6.2	3.6	5.3	2.2	.88*	7.2	4.2	5.2
V14	8.9	.39*	4.1	1.5*	5.8	6.9	.67*	3.2	2.0
V15	2.9	5.7	2.8	4.7	1.3*	0*	7.0	3.4	4.5
V16	5.7	3.1	.32*	1.9*	2.0	3.4	4.0	.38*	1.6*
V17	1.1*	6.7	4.1	5.7	2.8	1.7*	7.6	4.7	5.7
V20	.45*	6.9	4.4	6.0	3.1	2.4	7.7	5.0	5.9
V21	25.4	12.7	16.3	13.0	19.0	22.3	10.3	17.8	14.2

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 15

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGF) VERBAL FORM VARIABLES

	V45	V46	V47	V48	V49
V12	.69*	12.1	4.9	10.1	2.4
V13	1.5*	12.1	5.1	9.6	2.3
V14	8.4	5.6	2.1	3.5	5.8
V15	2.2	12.1	4.2	9.0	1.3*
V16	5.3	9.3	1.3*	6.6	1.8*
V17	.15*	12.7	5.4	9.9	2.9
V20	.56*	12.8	5.5	10.2	3.4
V21	24.8	4.7	15.2	7.0	19.3

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 16

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V54	V55	V56	V57	V58	V59
V12	2.8	1.9*	6.8	1.6*	.48*	4.2	3.9	1.3*	7.1
V13	2.6	1.7*	6.4	1.4*	1.3*	4.1	4.1	.98*	7.1
V14	5.2	6.7	.77*	6.8	8.4	3.1	3.6	6.9	.50*
V15	1.8*	.90*	5.8	.41*	2.3	3.3	3.2	0.7*	6.7
V16	1.5*	2.3	2.8	3.0	5.2	.38*	.07*	3.2	4.0
V17	3.2	2.5	6.8	2.2	.17*	4.6	4.5	1.9*	7.6
V18	3.7	3.1	7.2	2.9	1.7*	5.0	4.8	2.6	7.9
V19	3.7	3.0	7.2	2.9	1.7*	5.0	4.8	2.6	7.9
V20	3.6	2.9	7.1	2.7	1.1*	4.9	4.7	2.3	7.7
V21	20.3	20.1	12.8	22.1	24.8	17.9	16.9	23.3	10.2

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 17

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67	V70
V12	8.4	12.7	5.3	1.3*	7.7	1.3*	1.4*
V13	8.3	12.7	5.4	1.0*	7.7	.47*	2.8
V14	.85*	7.5	1.6*	6.5	1.1*	7.5	8.9
V15	7.1	12.7	4.5	.20*	7.1	.46*	2.9
V16	3.3	9.6	2.0	3.1	4.4	3.8	5.6
V17	8.9	13.4	5.7	1.9*	7.9	1.5*	1.1*
V20	9.3	13.5	5.9	2.3	8.3	2.0	.45*
V21	16.3	3.8	13.9	23.1	11.2	22.3	25.5

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 18

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DVC) VERBAL CONTENT VARIABLES

	V22	V23	V24	V25	V26	V27	V28	V29	V30
V22	-	7.4	2.6	7.5	2.4	1.0*	5.2	1.9*	6.0
V23		-	5.0	.19*	5.2	6.7	2.1	5.9	1.4*
V24			-	5.2	.22*	1.8*	2.9	.89*	3.6
V25				-	5.4	6.9	2.2	6.1	1.6*
V26					-	1.6*	3.1	.63*	3.8
V27						-	4.6	1.0*	5.5
V28							-	3.8	.66*
V29								-	4.4
V30									-

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 19

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V22	2.3	11.3	4.8	9.8	3.4
V23	6.1	3.2	3.4	2.6	4.6
V24	.41*	10.7	2.2	7.0	.80*
V25	5.6	3.2	3.4	2.4	4.5
V26	.27*	9.7	2.5	7.1	1.0*
V27	1.4*	11.2	4.1	8.7	2.6
V28	3.3	6.8	.76*	3.8	3.1
V29	.46*	11.1	3.1	7.9	1.7*
V30	4.0	6.5	1.7*	3.2	2.8

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 20

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V22	1.6*	6.4	3.7	5.5	2.4	1.3*	7.2	4.8	5.3
V23	7.9	1.9*	4.0	1.7*	5.2	6.4	.09*	3.6	2.6
V24	3.4	4.1	1.5*	3.2	.22*	1.5*	4.9	2.2	2.9
V25	8.1	1.2*	5.1	4.0	5.5	6.9	.28*	3.6	2.4
V26	3.2	4.3	1.3*	3.4	0*	1.2*	5.2	2.0	2.1
V27	2.2	5.7	2.9	4.8	1.6*	.57*	6.7	3.7	4.8
V28	5.8	1.1*	1.8*	.31*	3.1	4.2	4.5	1.2*	.13*
V29	2.9	4.9	2.0	4.0	.63*	.63*	6.3	3.1	3.7
V30	6.5	.48*	2.5	.35*	3.8	5.2	1.4*	2.1	1.2*

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 21

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGF) VERBAL FORM VARIABLES

	V45	V46	V47	V48	V49
V22	.61*	12.2	5.0	10.1	2.5
V23	7.6	4.2	2.6	2.8	5.2
V24	3.3	11.3	2.6	7.2	.17*
V25	7.8	4.5	2.6	2.3	5.7
V26	2.8	10.3	3.1	7.9	.04*
V27	1.6*	12.2	4.3	9.0	1.7*
V28	5.5	6.9	.42*	4.2	3.7
V29	2.4	11.9	3.4	8.1	.68*
V30	6.2	6.4	1.2*	3.7	3.9

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 22

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V54	V55	V56	V57	V58	V59
V22	2.8	2.1	6.5	1.8*	.39*	4.3	4.0	1.4*	7.2
V23	5.0	5.9	1.4*	6.2	7.6	3.8	3.7	6.4	.31*
V24	.13*	.65*	4.1	1.6*	2.9	1.8*	1.6*	1.5*	4.9
V25	6.3	5.9	1.6*	6.3	7.8	4.5	3.9	6.7	.48*
V26	.35*	.42*	4.2	.92*	2.7	1.9*	1.7*	1.2*	6.1
V27	2.0	1.2*	5.8	.78*	1.5*	3.5	3.3	.51*	6.7
V28	2.8	3.5	.98*	4.0	5.6	1.2*	1.6*	4.3	2.3
V29	1.1*	.21*	5.1	.30*	2.4	2.7	2.4	.75*	5.7
V30	3.5	5.1	.21*	4.9	6.2	1.9*	2.7	4.9	1.2*

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 23

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CBNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67	V70
V22	8.7	13.2	5.3	1.4*	7.7	.98*	1.5*
V23	1.6*	5.5	2.0	6.2	.37*	6.7	7.9
V24	4.9	10.5	3.0	1.4*	5.8	2.2	3.5
V25	2.0	4.7	2.3	6.4	.15*	8.1	8.1
V26	5.0	12.1	3.2	1.0*	5.6	1.6*	3.2
V27	7.5	12.2	4.9	.52*	7.3	.08*	2.2
V28	.96*	8.2	.06*	4.1	2.4	4.6	5.9
V29	6.5	11.8	3.8	.45*	6.7	1.1*	2.9
V30	.18*	6.2	.84*	4.7	2.0	5.3	6.5

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 24

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V31	-	9.2	2.7	7.5	1.2*
V32		-	6.3	1.4*	7.9
V33			-	4.8	1.5*
V34				-	6.2
V35					-

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 25

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V31	3.2	5.0	1.6*	3.6	.27*	1.1*	5.3	2.2	3.3
V32	11.9	4.5	8.8	5.2	9.6	10.6	4.4	8.3	6.3
V33	5.4	2.2	1.1*	1.1*	2.5	4.1	2.8	.56*	.76*
V34	10.0	3.5	6.3	5.0	7.3	8.4	1.9*	5.6	4.4
V35	4.1	3.3	.37*	2.4	1.0*	2.3	5.4	.98*	2.2

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 26

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGF) VERBAL FORM VARIABLES

	V45	V46	V47	V48	V49
V31	2.8	9.9	3.2	8.8	.23*
V32	11.9	1.2*	6.2	1.2*	9.6
V33	5.1	7.3	.51*	5.8	2.4
V34	9.7	2.3	4.5	.40*	7.5
V35	3.8	8.9	2.2	6.9	1.0*

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 27

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V54	V55	V56	V57	V58	V59
V31	.55*	.25*	4.4	.75*	2.7	2.2	1.9*	1.0*	6.3
V32	8.8	10.3	5.2	11.2	11.8	7.2	8.3	11.2	4.2
V33	2.2	3.1	1.8*	3.4	5.1	.47*	.78*	3.8	3.1
V34	8.2	7.9	3.6	9.6	6.5	5.6	8.4	2.2	6.2
V35	.68*	1.5*	3.7	2.0	3.7	1.1*	.80*	2.2	4.2

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 28

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67	V70
V31	5.3	12.4	3.5	.89*	5.8	1.5*	3.2
V32	5.6	1.2*	6.3	10.3	3.5	11.0	12.0
V33	2.2	8.3	.96*	3.5	3.4	4.1	5.5
V34	4.2	3.1	3.8	8.2	1.8*	9.2	10.0
V35	3.9	9.4	3.0	2.1	4.9	2.7	4.2

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 29

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V36	-	7.0	4.4	6.0	3.2	2.3	7.8	5.1	5.9
V37		-	2.9	.77*	4.3	5.4	.90*	2.4	0.3*
V38			-	2.1	1.4*	2.6	3.8	.63*	1.7*
V39				-	3.4	4.5	1.6*	1.5*	.45*
V40					-	1.2*	5.1	1.9*	3.0
V41						-	6.2	3.3	4.4
V42							-	3.2	2.1
V43								-	1.1*
V44									-

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 30

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGF) VERBAL FORM VARIABLES

	V45	V46	V47	V48	V49
V36	.78*	12.9	5.6	10.3	3.3
V37	6.9	4.9	1.6*	4.9	4.2
V38	4.1	9.7	1.5*	6.5	1.4*
V39	5.7	6.5	.66*	4.7	3.6
V40	2.8	10.1	3.1	8.0	.04*
V41	1.8*	12.0	4.0	8.7	1.4*
V42	7.5	5.0	2.7	2.2	5.8
V43	4.7	10.0	.88*	5.7	2.0
V44	5.6	7.6	.28*	4.4	3.1

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 31

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V54	V55	V56	V57	V58	V59
V36	3.7	2.9	7.2	2.8	1.4*	5.0	4.7	2.5	7.8
V37	4.1	5.1	.29*	5.2	6.6	2.5	2.8	5.4	.84*
V38	1.2*	1.8*	3.0	2.6	4.0	.61*	.38*	2.6	3.7
V39	3.4	3.8	.56	4.3	5.6	2.1	1.9*	4.5	1.6*
V40	.35*	.42*	4.3	.92*	2.7	1.9*	1.7*	1.2*	5.9
V41	1.6*	.88*	5.4	.37*	1.7*	3.2	3.1	.09*	6.2
V42	5.3	5.7	1.4*	6.1	7.6	3.2	3.7	6.4	.22*
V43	1.6*	2.4	2.4	3.3	4.7	0*	.27*	3.5	3.3
V44	2.8	4.1	1.2*	4.2	5.5	1.2*	1.5*	4.2	2.0

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 32

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67	V70
V36	9.5	13.6	5.9	2.4	8.2	2.2	1.0*
V37	.37*	6.7	1.1*	5.4	1.5*	5.8	7.0
V38	3.4	9.4	1.9*	2.5	4.8	3.4	4.5
V39	.67*	.67*	.26*	4.3	2.6	4.9	6.1
V40	5.0	12.1	3.2	1.0*	5.6	1.6*	3.2
V41	6.9	11.6	5.1	.18*	6.9	.41*	2.3
V42	1.4*	6.0	2.4	6.1*	.40*	6.6	7.8
V43	2.9	8.4	1.4*	3.1	4.3	4.0	5.1
V44	1.2*	7.5	.22*	4.1	3.0	4.6	6.0

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 33

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGF) VERBAL FORM VARIABLES

	V45	V46	V47	V48	V49
V45	-	12.5	5.3	10.0	2.9
V46		-	6.5	1.8*	9.7
V47			-	4.5	2.8
V48				-	7.4
V49					-

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 34

MULTIPLE TEST STATISITC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V54	V55	V56	V57	V58	V59
V45	3.2	2.5	6.8	2.3	.31*	4.6	4.4	1.9*	7.6
V46	10.1	11.1	6.1	12.1	12.8	9.4	8.4	12.3	4.7
V47	2.6	3.3	1.4*	3.7	5.2	.91*	1.4*	3.9	2.3
V48	7.9	8.3	3.9	8.5	9.9	5.5	6.2	8.6	2.9
V49	.31*	.47*	4.2	.97*	2.8	2.1	1.6*	1.2*	5.7

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 35

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V64	V65	V66	V67	V70
V45	8.9	13.2	5.6	1.0*	2.3	7.9	1.5*	.78*
V46	6.7	.41*	6.7	12.9	11.2	4.8	11.9	12.9
V47	1.5*	7.4	.55*	5.7	3.8	3.1	4.4	5.6
V48	4.4	3.0	4.4	10.3	8.5	1.8*	9.5	10.3
V49	5.1	11.2	3.2	3.4	1.1*	6.0	1.7*	3.4

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 36

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V54	V55	V56	V57	V58	V59
V50	-	.79*	3.9	1.3*	3.2	1.7*	1.4*	1.6*	4.7
V51		-	4.6	.50*	2.4	2.4	2.2	.80*	5.5
V52			-	.5.2	6.8	2.1	2.4	5.4	1.0*
V54				-	2.2	2.9	2.7	.31*	6.0
V55					-	4.6	4.3	1.9*	7.4
V56						-	.26*	3.2	3.1
V57							-	2.9	3.4
V58								-	6.2
V59									-

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 37

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V64	V65	V66	V67	V70
V50	5.1	11.1	2.9	3.7	1.4*	5.7	2.2	3.6
V51	5.6	12.1	3.7	3.0	.64*	6.1	1.3*	2.9
V52	.35*	6.5	1.0*	7.2	5.2	1.7*	6.0	7.1
V53	.57*	8.0	.37*	7.3	5.2	2.3	5.8	7.2
V54	6.4	11.8	4.1	2.9	.18*	7.2	.85*	2.8
V55	8.9	13.4	5.7	1.7*	1.8*	7.9	1.4*	1.4*
V56	2.8	7.9	1.3*	5.0	3.0	6.2	3.6	4.9
V57	2.9	8.5	2.0	4.0	2.9	4.3	3.3	4.7
V58	7.0	11.9	4.7	2.6	.12*	6.9	.49*	2.5
V59	1.3*	6.9	1.7*	7.9	6.1	.57*	6.6	7.7

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 38

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V64	V65	V66	V67	V70
V61	-	6.3	.99*	9.6	6.3	2.1	7.6	9.5
V62		-	6.4	13.6	11.4	3.8	12.2	13.6
V63			-	6.0	4.2	2.3	4.7	5.9
V64				-	2.5	8.3	2.3	1.0*
V65					-	6.5	.59*	2.4
V66						-	7.1	8.2
V67							-	2.1
V70								-

* NOT SIGNIFICANT

[P < 0.05]

TABLE 39

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DVC) VERBAL CONTENT VARIABLES

	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
V60	4.1	.56*	5.4	6.6	.25*	7.4	5.9	7.7	2.6	11.4
V71	6.5	2.1	4.4	11.1	2.3	12.4	9.8	12.9	5.0	11.9

* NOT SIGNIFICANT

[p < 0.05]

TABLE 40

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V12	V13	V14	V15	V16	V17	V20	V21
V60	5.9	5.8	3.9	4.6	.45*	6.8	7.5	19.6
V71	9.9	10.1	3.6	7.9	1.9*	11.3	12.3	16.5

* NOT SIGNIFICANT

[p < 0.05]

TABLE 41

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DVC) VERBAL CONTENT VARIABLES

	V22	V23	V24	V25	V26	V27	V28	V29	V30
V60	6.1	4.2	2.5	4.3	2.6	5.0	1.5*	3.4	2.2
V71	10.1	3.3	4.6	3.6	4.4	7.7	.58*	5.5	1.4*

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 42

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V60	2.7	8.6	.62*	6.2	1.2*
V71	5.1	7.5	.54*	5.6	2.7

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 43

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V60	7.5	2.9	.81*	1.8*	2.5	4.2	3.8	.04*	1.4*
V71	12.8	1.9*	2.4	.99*	4.4	6.9	3.2	1.1*	.39*

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 44

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGF) VERBAL FORM VARIABLES

	V45	V46	V47	V48	V49
V60	6.7	9.4	1.1*	6.8	2.5
V71	12.9	8.3	.08*	6.3	4.4

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 45

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59	V60
V60	2.0	3.2	2.7	2.3	4.3	6.7	.04*	.27*	4.1	3.9	-
V71	3.7	5.6	1.8*	1.0*	6.5	11.1	1.1*	1.9*	6.7	3.2	1.6

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 46

MULTIPLE TEST STATISTIC FOR SIGNIFICANT DIFFERENCES

(t - RATIOS FOR MEAN COMPARISON)

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V64	V65	V66	V67	V70
V60	3.1	10.9	1.5*	7.7	3.9	4.1	5.7	7.5
V71	2.0	10.1	.65*	12.9	7.4	3.5	7.9	12.9

* NOT SIGNIFICANT

[$p < 0.05$]

TABLE 47

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN VERBAL CATEGORY VARIABLES

	V2	V3	V4	V5	V6	V7	V8	V10	V11
V2	1.0	-.1	-.2	-.02	-.1	.35	.05	.2	-.13
V3		1.0	-.3	-.04	-.1	-.1	-.1	-.14	-.10
V4			1.0	-.06	-.3	-.1	-.1	-.01	-.61
V5				1.0	-.04	-.01	-.1	-.03	-.10
V6					1.0	-.1	-.1	-.05	-.10
V7						1.0	-.02	-.04	-.01
V8							1.0	.22	-.08
V10								1.0	-.42
V11									1.0

TABLE 48

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CG) VERBAL CATEGORY VARIABLES

	V12	V13	V14	V15	V16	V17	V20	V21
V2	-.03	-.04	-.07	-.06	.07	-.03	-.02	.07
V3	-.05	-.06	-.06	-.03	.03	.01	.11	.12
V4	.11	.20	-.31	-.07	.03	.04	-.05	.21
V5	-.01	-.02	-.04	.04	-.03	.01	-.01	.06
V6	-.05	-.07	.23	-.01	.09	-.05	-.03	-.22
V7	-.01	-.03	-.01	-.03	-.05	-.01	-.01	.06
V8	-.02	-.04	.11	-.04	-.07	-.02	-.01	-.02
V10	.22	.03	-.02	-.08	-.09	-.04	-.03	.04
V11	-.03	-.12	.28	.14	-.13	.02	.03	-.24

TABLE 49

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DV) VERBAL CONTENT VARIABLES

	V22	V23	V24	V25	V26	V27	V28	V29	V30
V2	-.03	.06	-.06	.07	.04	0	-.05	.08	-.09
V3	.04	-.03	-.01	-.07	.15	.28	.09	.02	-.12
V4	-.08	-.04	.13	-.02	-.17	-.04	-.02	-.02	.26
V5	-.01	.12	-.02	-.05	-.02	-.01	.01	-.02	-.04
V6	.01	-.05	-.06	-.03	.05	.08	.02	.01	.13
V7	-.01	.01	-.03	.03	-.03	-.02	-.05	-.03	-.05
V8	-.02	.16	-.05	-.02	-.04	-.03	-.08	-.04	.01
V10	-.04	.01	-.08	.43	-.08	-.06	-.15	-.08	-.17
V11	.09	.01	-.03	-.12	.10	-.04	.13	.03	-.16

TABLE 50

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V2	.01	.05	-.07	.01	.01
V3	.24	.09	-.15	-.03	-.05
V4	-.17	-.06	.19	0	.10
V5	-.02	-.04	-.03	.09	-.03
V6	-.02	.12	-.09	.05	-.12
V7	.01	-.02	-.02	.01	.09
V8	-.04	-.08	-.07	.14	.05
V10	-.08	-.16	-.14	.26	.11
V11	.09	.03	.04	-.12	-.07

TABLE 51

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CG) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V2	-.02	-.05	-.09	.09	.04	-.05	.04	-.02	.01
V3	-.03	-.04	.04	-.09	.18	.08	.04	-.08	-.04
V4	-.05	.15	.04	-.08	-.17	.06	-.03	.02	.03
V5	-.01	-.04	-.03	-.04	-.02	-.01	-.01	.21	-.04
V6	-.03	.02	-.11	.05	.03	-.08	0	-.03	.07
V7	-.01	.05	.12	.06	-.03	-.02	-.07	-.05	-.05
V8	-.01	-.01	-.06	.02	-.04	-.03	-.01	-.03	.13
V10	-.03	-.14	.04	.38	-.08	-.06	-.13	-.10	.04
V11	.11	-.07	.01	-.13	.09	-.01	.06	.04	-.05

TABLE 52

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CG) VERBAL FORM VARIABLES

	V46	V47	V48	V49
V2	.13	-.12	-.01	-.07
V3	0	-.05	-.02	.09
V4	-.12	.30	-.04	-.02
V5	.10	-.03	-.06	-.02
V6	-.01	-.09	.08	.04
V7	-.11	-.05	.09	.16
V8	.07	-.03	-.02	-.04
V10	.17	-.11	-.08	-.02
V11	-.01	-.13	.04	-.04

TABLE 53

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DNV) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59
V2	.09	.02	-.1	-.09	0	-.03	.09	-.09	-.06	.16
V3	-.12	-.05	-.06	.13	.08	-.06	-.13	-.08	.07	.13
V4	.13	-.09	.26	-.04	.01	-.01	.13	.11	.01	-.34
V5	-.02	-.02	-.04	-.04	-.01	-.01	.21	-.03	-.02	-.01
V6	-.01	.17	-.06	.06	-.04	-.06	-.10	0	-.02	-.08
V7	-.03	.18	.05	-.06	-.03	-.02	-.04	-.04	-.03	.03
V8	-.05	.05	-.09	-.05	.05	-.02	.18	-.06	-.03	.01
V10	.3	-.08	-.13	-.06	-.07	-.04	.39	-.12	-.06	-.20
V11	-.19	.08	-.09	.02	0	.10	-.37	0	.02	.26

TABLE 54

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGNV) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V2	.03	.03	.12	-.04	.04	-.04
V3	-.04	.19	-.11	-.07	-.13	-.08
V4	.24	-.37	.30	-.10	.25	.21
V5	-.06	-.06	-.04	-.01	.11	-.01
V6	-.12	.21	-.05	-.07	-.16	-.08
V7	.04	-.03	.07	-.02	-.07	-.02
V8	-.04	.03	-.08	-.03	.09	-.03
V10	.02	-.22	-.15	-.05	.40	.20
V11	-.17	.27	-.10	.22	-.34	-.19

TABLE 55

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CG) VERBAL CATEGORY VARIABLES

	V12	V13	V14	V15	V16	V17	V20	V21
V12	1.0	-.02	-.07	-.02	-.04	-.01	-.01	-.18
V13		1.0	-.13	-.15	-.09	-.12	-.02	-.01
V14			1.0	-.12	-.24	-.06	.09	-.87
V15				1.0	-.06	-.02	-.02	-.18
V16					1.0	-.04	-.03	-.38
V17						1.0	-.01	-.07
V20							1.0	-.13
V21								1.0

TABLE 56

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DVC) VERBAL CONTENT VARIABLES

	V22	V23	V24	V25	V26	V27	V28	V29	V30
V12	-.01	-.06	-.02	.20	-.03	-.02	-.05	-.02	-.05
V13	-.02	-.11	-.15	.02	.07	-.04	.03	-.05	.12
V14	.03	-.06	.10	.14	.06	0	.03	-.14	-.09
V15	-.02	-.05	-.05	-.13	-.06	-.04	.26	-.02	.05
V16	-.04	.07	-.03	-.06	.10	-.04	.04	-.08	0
V17	-.01	-.06	-.02	-.06	-.02	-.02	.10	-.12	.09
V20	-.01	-.04	-.02	-.04	-.02	.53	-.03	-.02	.16
V21	.02	.08	-.05	-.09	-.11	.02	-.16	.21	.03

TABLE 57

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V12	-.03	-.09	-.04	.16	-.03
V13	-.05	-.01	.03	-.02	.09
V14	.13	-.05	-.06	.08	-.02
V15	.03	.16	.05	-.16	-.06
V16	-.09	.13	-.01	-.09	.03
V17	-.02	.02	.13	-.07	-.03
V20	-.02	-.06	-.03	-.05	-.02
V21	-.05	-.06	.03	.01	.02

TABLE 58

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V12	-.01	-.05	.38	-.05	-.03	-.02	-.06	-.04	-.05
V13	-.02	-.09	.04	-.01	.07	-.04	.04	-.04	.05
V14	.09	-.12	.06	.16	.07	-.01	-.01	-.09	.04
V15	-.02	.01	-.03	-.02	-.05	-.03	.19	-.05	-.02
V16	-.03	.09	.03	-.11	.10	.02	.01	-.03	-.05
V17	-.01	-.05	-.03	-.04	-.02	-.02	.06	.04	.11
V20	-.01	-.04	-.02	-.03	-.02	.44	-.04	-.03	.18
V21	-.05	.09	-.18	-.04	-.12	-.01	-.06	.14	-.03

TABLE 59

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGF) VERBAL FORM VARIABLES

	V46	V47	V48	V49
V12	-.10	-.04	.16	-.03
V13	-.11	.21	-.06	.07
V14	-.05	-.1	.13	.08
V15	.11	.01	-.06	-.05
V16	.05	-.02	-.01	-.02
V17	.01	.11	-.07	-.02
V20	-.07	-.03	.05	.31
V21	.03	.06	-.10	-.07

TABLE 60

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DNV) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59
V12	.03	-.02	.05	.02	-.02	.01	-.04	-.04	-.02	-.17
V13	.06	-.05	-.03	-.06	-.05	-.03	-.04	.28	-.04	-.02
V14	-.03	.20	.01	-.07	.04	-.08	-.13	-.01	-.04	.12
V15	-.01	-.05	.03	.03	-.05	.23	-.08	.05	-.02	.04
V16	-.11	-.09	-.01	.06	-.03	.04	.03	.08	.06	.07
V17	-.03	-.02	-.05	-.02	-.02	-.01	-.03	.11	-.02	.07
V20	-.02	-.02	-.04	-.04	-.01	-.01	-.03	-.02	-.01	-.04
V21	.09	-.08	-.03	.03	.01	-.02	.16	-.02	.11	-.16

TABLE 61

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGNV) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V12	.02	-.11	-.15	-.02	-.01	.60
V13	-.02	-.13	.20	-.03	.05	-.04
V14	-.16	.30	-.13	-.07	-.20	0
V15	-.08	.09	-.09	-.03	0	-.04
V16	-.03	-.05	.18	-.06	-.06	-.04
V17	-.03	0	.1	-.01	-.06	-.01
V20	-.05	-.07	-.03	-.01	.13	-.01
V21	.19	-.22	-.01	.13	.22	-.13

TABLE 62

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DVC) VERBAL CONTENT VARIABLES

	V22	V23	V24	V25	V26	V27	V28	V29	V30
V22	1.0	-.04	-.03	-.06	-.03	-.02	-.05	-.02	-.03
V23		1.0	-.13	-.31	-.13	-.10	-.24	-.10	-.26
V24			1.0	-.13	-.05	-.04	-.09	-.04	-.09
V25				1.0	-.13	-.18	-.24	-.12	-.26
V26					1.0	-.04	-.10	-.05	-.01
V27						1.0	-.07	.02	.07
V28							1.0	-.07	.02
V29								1.0	-.10
V30									1.0

TABLE 63

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V22	-.03	-.09	-.01	.14	-.03
V23	.14	-.44	.14	.37	.01
V24	-.05	.29	-.09	-.16	-.07
V25	-.14	-.24	0	.44	-.17
V26	.49	.06	-.09	-.16	-.07
V27	-.04	.09	-.01	-.12	-.15
V28	-.09	.20	-.16	-.30	.49
V29	-.05	.25	-.08	-.14	-.06
V30	-.11	.32	.17	-.32	-.14

TABLE 64

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V22	.77	-.03	-.03	-.05	-.03	-.02	-.06	.27	-.05
V23	-.04	.67	-.14	-.24	-.13	-.10	-.21	-.04	.10
V24	-.02	-.11	.33	-.10	-.05	-.04	-.13	.32	-.08
V25	-.04	-.29	.27	.72	-.09	.05	-.23	-.15	-.20
V26	-.02	-.12	-.07	-.10	.93	-.04	-.09	-.09	-.10
V27	-.01	-.08	-.05	-.07	-.04	.65	-.01	0	.06
V28	-.03	-.21	-.13	-.18	-.10	-.07	.77	-.15	-.18
V29	-.02	-.11	-.07	-.09	-.05	-.04	.12	.24	-.09
V30	-.03	.03	-.10	-.14	-.11	.06	-.13	.04	.50

TABLE 65

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGF) VERBAL FORM VARIABLES

	V46	V47	V48	V49
V22	-.10	-.05	.16	-.03
V23	-.20	-.03	.32	-.09
V24	.26	-.09	-.17	-.05
V25	.03	-.24	.17	.02
V26	-.04	.14	-.01	-.06
V27	.12	-.07	-.12	.14
V28	-.03	.18	-.19	.27
V29	.20	-.09	-.16	-.05
V30	.03	.21	-.13	-.05

TABLE 66

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59
V22	-.03	-.02	-.06	.30	-.02	-.01	-.04	-.04	-.02	-.06
V23	-.10	-.01	-.03	.21	-.07	-.07	.12	-.14	-.10	.11
V24	-.06	-.05	-.01	-.02	.53	-.03	-.08	-.06	-.08	-.13
V25	.30	-.08	-.05	-.08	-.08	.01	.30	-.08	-.04	-.11
V26	-.06	-.05	-.09	.07	-.05	-.03	-.08	-.07	-.04	.28
V27	-.05	-.04	-.09	-.09	-.07	-.02	-.06	-.01	.34	0
V28	-.11	-.19	.09	-.10	-.09	.11	-.15	.10	-.06	.26
V29	.17	-.05	.02	-.07	.02	.15	-.04	-.04	.37	-.12
V30	-.10	.30	.11	-.04	.02	-.06	-.07	.29	-.08	-.22

TABLE 67

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V22	.08	.04	-.05	.02	.06	.02
V23	0	.13	-.21	-.08	.06	.09
V24	-.03	-.05	-.10	-.03	.09	.34
V25	.19	-.06	-.16	-.08	.11	.11
V26	-.09	.22	-.10	-.03	-.14	-.04
V27	0	-.12	.13	-.02	.05	-.03
V28	-.16	.17	.12	-.06	-.26	-.07
V29	.08	0	-.09	-.03	.08	-.03
V30	-.02	-.23	.37	-.07	.10	-.08

TABLE 68

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V31	1.0	-.18	-.07	-.11	-.05
V32		1.0	-.31	-.58	-.23
V33			1.0	-.23	-.11
V34				1.0	-.20
V35					1.0

TABLE 69

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V31	-.02	.17	-.05	-.10	.49	-.04	-.13	-.09	-.10
V32	-.06	-.24	.15	-.21	.03	-.02	.24	.17	-.02
V33	-.03	.17	-.11	-.02	-.09	.19	-.20	-.04	.18
V34	.11	.19	-.01	.38	-.13	-.12	-.22	-.07	-.09
V35	-.02	-.04	-.03	-.13	-.07	-.05	.36	-.11	-.05

TABLE 70

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGF) VERBAL FORM VARIABLES

	V46	V47	V48	V49
V31	-.21	.07	.21	-.03
V32	.57	-.17	-.46	.03
V33	-.21	.26	.10	-.08
V34	-.24	-.16	.42	-.03
V35	-.15	.26	-.05	.07

TABLE 71

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59
V31	-.06	-.05	-.09	.06	-.05	-.03	-.08	-.08	-.04	.29
V32	-.14	.09	-.06	-.19	.22	.09	-.13	.11	.17	.04
V33	-.03	.05	-.01	.04	-.08	.04	-.13	.01	.03	.14
V34	.25	-.05	.03	.22	-.11	-.09	.24	-.15	-.13	-.15
V35	-.18	-.07	.20	-.07	-.06	-.04	-.08	.04	-.05	-.10

TABLE 72

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V31	-.13	.23	-.09	-.04	-.14	-.04
V32	-.12	.07	.04	-.12	.03	.03
V33	.13	-.07	.17	-.06	-.08	-.06
V34	.13	-.18	.39	-.04	-.03	-.04
V35	0	-.18	.39	-.04	-.03	-.05

TABLE 73

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V36	1.0	-.04	-.02	-.03	-.02	-.01	-.04	.18	-.03
V37		1.0	-.15	-.21	-.12	-.09	-.24	-.15	-.17
V38			1.0	-.09	-.07	-.05	-.07	-.05	-.12
V39				1.0	-.10	-.07	-.23	-.13	-.17
V40					1.0	-.04	-.12	-.09	-.10
V41						1.0	-.10	-.04	-.02
V42							1.0	-.20	-.23
V43								1.0	-.15
V44									1.0

TABLE 74

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGF) VERBAL FORM VARIABLES

	V46	V47	V48	V49
V36	-.07	-.03	.10	-.02
V37	-.42	.01	.52	-.12
V38	.12	-.13	-.02	.01
V39	-.05	-.17	.17	.07
V40	-.08	.14	.03	-.06
V41	.13	-.07	-.13	.10
V42	.10	.07	-.20	.18
V43	.32	-.14	-.17	-.09
V44	.11	.27	-.27	-.03

TABLE 75

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59
V36	-.02	-.02	-.04	.20	-.01	-.01	-.03	-.02	-.01	-.04
V37	-.07	.09	-.09	.25	-.10	-.06	-.03	.05	-.09	.05
V38	.14	-.07	.01	-.02	.20	-.04	-.01	.06	-.02	-.17
V39	.08	-.09	-.09	.05	.09	-.05	.42	-.02	-.08	-.03
V40	-.07	-.05	-.05	.09	.05	-.03	-.08	-.07	-.04	.24
V41	-.04	.09	-.07	-.09	-.04	.07	-.06	-.03	.46	-.10
V42	.10	-.06	.12	-.18	-.08	.14	-.20	-.02	-.01	.24
V43	-.10	-.18	-.13	.02	.19	.03	-.03	-.09	.10	-.12
V44	-.09	.28	.07	-.01	.05	-.05	.02	.10	-.18	-.17

TABLE 76

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V36	.11	-.01	-.03	-.01	-.04	-.01
V37	0	.12	-.13	-.08	.02	-.08
V38	-.05	-.07	-.08	-.05	.12	.23
V39	.15	-.13	-.18	-.06	.12	-.01
V40	.09	.22	-.10	-.03	-.14	-.04
V41	-.01	-.17	.33	-.02	-.03	-.03
V42	-.09	.25	.21	-.08	-.31	-.09
V43	.13	-.20	-.03	-.07	.13	.17
V44	-.10	-.18	.10	-.06	.13	-.07

TABLE 77

PEARSON PRODUCT MOMENT CORELLATION COEFFICIENTS

PATIENT (CGF) VERBAL FORM VARIABLES

	V46	V47	V48	V49
V46	1.0	-.35	-.63	-.20
V47		1.0	-.28	-.10
V48			1.0	-.18
V49				1.0

TABLE 78

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59
V46	-.03	.06	-.03	-.25	.21	.14	.22	-.13	.21	-.10
V47	-.01	-.02	.04	.09	-.08	-.05	-.05	.31	-.07	-.12
V48	.09	0	.05	.27	-.12	-.09	-.21	-.03	-.03	-.14
V49	-.06	-.05	-.06	-.08	-.05	-.03	.03	-.08	-.04	.20

TABLE 79

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT

PATIENT (CGVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V46	-.03	-.03	-.08	-.06	.21	.01
V47	-.03	-.19	.36	-.06	.05	-.06
V48	.08	.21	-.13	-.11	-.25	.07
V49	-.07	.04	-.04	-.04	.06	-.04

TABLE 80

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59
V50	1.0	-.06	-.12	-.07	-.06	-.03	-.09	-.09	-.05	-.15
V51		1.0	-.11	-.10	-.05	-.03	-.08	-.06	-.01	-.12
V52			1.0	-.16	-.06	0	-.16	-.16	-.19	-.26
V53				1.0	-.11	.01	-.12	-.12	-.07	-.21
V54					1.0	-.02	-.08	-.05	-.04	-.10
V55						1.0	-.04	-.04	.11	-.07
V56							1.0	-.12	-.07	-.20
V57								1.0	-.04	-.18
V58									1.0	-.18
V59										1.0

TABLE 81

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V50	.08	.08	-.11	-.04	.03	.10
V51	-.10	.16	-.03	-.03	-.08	-.04
V52	.15	-.08	.26	-.07	-.13	-.03
V53	-.06	.17	-.10	-.07	-.04	-.03
V54	-.09	-.08	-.09	-.03	.20	.05
V55	-.06	.06	.05	-.02	-.07	.02
V56	.10	-.35	-.15	-.05	.63	-.06
V57	-.06	-.21	.37	-.05	.03	-.05
V58	.03	-.08	.15	-.03	.03	-.03
V59	0	.38	-.24	-.08	-.33	-.09

TABLE B2

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V61	1.0	-.44	.06	-.10	.07	.01
V62		1.0	-.40	-.14	-.57	-.11
V63			1.0	-.06	-.24	-.07
V65				1.0	-.08	-.02
V66					1.0	-.07
V67						1.0

TABLE 83

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENT

PHYSICIAN (DV) VERBAL CONTENT VARIABLES

	V2	V3	V4	V5	V6	V7	V8	V10	V11
V60	-.03	.18	-.05	-.05	-.06	.06	-.05	-.19	-.03
V71	-.16	-.08	-.23	-.04	.16	0	-.02	-.07	.30

TABLE 84

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V12	V13	V14	V15	V16	V17	V18	V19	V20	V21
V60	-.06	-.11	.03	-.05	.11	-.06	0	0	0	0
V71	.04	.01	.46	.05	-.09	-.02	0	0	.07	-.39

TABLE 85

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DVC) VERBAL CONTENT VARIABLES

	V22	V23	V24	V25	V26	V27	V28	V29	V30
V60	-.06	.08	.20	.01	.02	.01	-.03	-.05	-.11
V71	.01	0	-.03	.05	.04	-.07	.09	-.09	-.02

TABLE 86

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DF) VERBAL FORM VARIABLES

	V31	V32	V33	V34	V35
V60	.01	.10	-.05	-.03	-.04
V71	.13	-.06	.18	-.05	.02

TABLE 87

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGVC) VERBAL CONTENT VARIABLES

	V36	V37	V38	V39	V40	V41	V42	V43	V44
V60	-.04	.07	.23	-.10	0	-.06	-.07	.02	-.01
V71	.03	-.02	.04	.06	.04	.02	.03	-.14	.02

TABLE 88

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CGVC) VERBAL FORM VARIABLES

	V46	V47	V48	V49
V60	.06	-.13	.06	-.02
V71	-.13	-.01	.16	.05

TABLE 89

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PHYSICIAN (DNVC) NONVERBAL CONTENT VARIABLES

	V50	V51	V52	V53	V54	V55	V56	V57	V58	V59
V60	-.15	.02	.03	.03	.15	-.06	-.20	-.17	-.10	.08
V71	-.06	.16	-.05	-.07	0	-.06	-.11	.12	-.06	.19

TABLE 90

PEARSON PRODUCT MOMENT CORRELATION COEFFICIENTS

PATIENT (CBNVC) NONVERBAL CONTENT VARIABLES

	V61	V62	V63	V65	V66	V67
V60	-.10	.28	-.20	-.08	-.21	.24
V71	-.22	.25	.04	-.13	-.20	-.04

Results of Spectral Analysis

The areas useful for the application of the HIP4 methodology and spectral analysis include model construction, creating advanced time series experimental designs as well as frequency, and signal response studies. The variance of a sequential network or average power of a communication signal can be decomposed into contributions at various harmonic intervals (Priestly, 1981). The calculation of the variance was completed using the following algorithm:

$$X_m = 1/T \int_{-T/2}^{T/2} x(t)\ e^{-j2mt} d(t)$$

This algorithm demonstrates that it is possible for the harmonic behavior of each signal to exist at fm = m/T of the fundamental frequency f1 = 1/T. The term Xm represents the complex amplitude at the harmonic frequency fm = m/T and measures the amplitude of the sine and cosine terms at frequency fm in the time series X(t). The amplitude of the function may be computed from:

$$\Gamma_{(f)} = \text{Lim}\ T(X_m)^2$$

Any time series data will consist of values of the cosine function if discrete times are considered. If X(t) consists of a mixture of several cosine waves with frequencies, Fi, and amplitudes Ai, then the variance is C(o) = sum 1/2 a^2. Indicating that if X(t) can be regarded as a mixture of waves, its variance can be decomposed into various components having an average power or variance at different frequencies (Jenkins, 1968). In this investigation of physician and patient communication, a stationary time series, the variance of the hypothesized stochastic processes can be decomposed into contributions at a continous range of frequencies according to the following algorithm :

$$\sigma^2 = \gamma_{(0)} = \int_{-\infty}^{\infty} \Gamma(f)df$$

I(f) is the power spectrum of a static process. And assuming, the recorded behavior of the interactants is a time series X(t) which has a well behaved fourier transform, the limit of I(f) is zero. This is due to fact that X(t) must tend to zero as t tends to +/- infinity, if its fourier transform is to exist (Priestly, 1981). For signals found to be deterministic, the convergence of the spectral frequencies to I(f) will be smooth and any increase in the length of the recorded signals of the HIP4 would increase the smoothness of the function based on the length of time

in which the behavior or communication signals exist.

$$\sigma^2 = \lim_{T \to \infty} 1/T \int_{-T/2}^{T/2} x^2(t)dt = \lim_{t \to \infty} \sum_{m=-\infty}^{\infty} (T[X_m]^2)1/T = \int_{-\infty}^{\infty} \Gamma(f)df$$

The amplitude of any harmonic communicative process for a distributed set of signals can be measured in terms of the frequency of a mixture of sine and cosine properties for the wave function. This fact allows the amplitude to be found by manipulation techniques to yield the following relationship:

$$X_t = \mu + \left[\alpha \operatorname{Cos} \omega t + \beta \operatorname{Sin} \omega t\right] + Z_t$$

the fourier decomposition of X(t) then becomes possible:

$$e^{-J2\pi mt/T} = \operatorname{Cos} 2\pi mt/T - J \operatorname{Cos} 2\pi mt/T$$

$$X_{(t)} = \sum_{m=-\infty}^{\infty} X_m e^{J2\pi mt/T}$$

and if the average power is to be further investigated it may be decomposed into contributions at a finite number of harmonic frequencies.

$$f_{(\tau)} = \frac{a_0}{2} + \sum_{r=1}^{K} \left(a_r \cos r\tau + b_r \sin r\tau\right)$$

The contibution of $[Xm]^2$ to the average power at frequency fm is known as the intensity at the specified frequency and a plot of $[Xm]^2$ vs m is a fourier line spectrum which provides evidence about the association of the communication signal produced by physician or patient (caregiver), across time, with the other signals generated in the informational exchange episode of the clinical environment.

The power spectrum for each signal identified with the HIP4 should theoretically tend towards asymtotic dimensions approaching infinity, if the signal sources, as indicated in the hypotheses, continue their associated relationships along stochastic dimensions. If, on the otherhand the signals are found to be deterministic, the power spectrum should remain constant, with minimal fluctuations in the power spectrum across the analytical frequencies up to and including the Nyquist frequency. This is the essential difference between the stochastic signal vs the deterministic signal as identified with the HIP4. For an infinite size record of behavior, the variance in the signal may be associated with the power spectrum:

$$\sigma_t^{\,2} = 1/T \int_{-T/2}^{T/2} x^2(t)dt = \sum_{m=-\infty}^{\infty} [X_m]^2$$

the term is known as a fourier power spectrum and may be

conceived as:

$$X_m = 1/N \sum_{t=-n}^{n-1} x_t e^{-j2\pi mt/T} = 1/N \sum_{t=-n}^{n-1} x_t e$$

Cxx(f) is defined for a continous range of frequencies and is known as the spectrum of the sample. And if X(t) has a "well-behaved" fourier transform, the line for !(f) will tend towards zero as t tends toward infinity. But if X(t) does not dissipate, Cxx(f) will tend to a well defined limit. For deterministic signals, the convergence of Cxx(f) to !(f) is smooth in the sense that the function Cxx(f) obtained by increasing the length of any recorded signal would fail to reflect any erratic and unconventional behavior. But, when a stochastic signal is plotted from its record, frequent changes in the plot is a reflection of noise and multiple perturbations will be found in the spectral plot. This roughness will be an indicator that the function fails to converge in any statistical way to a limiting value, regardless of any increase in the record approximating infinity.

When it is necessary to compare time series data having different scales of measurement, the spectral density function is the most parsimonious relationship to contrast any hypothesized differences. This requires a transformation of the autocorrelation function. This investigation of the

communication signals between a physician and patient (caregiver) employees an identical scale of measurement for each variable recorded although differences exist in the metric utilized. A spectrum for each vector active in the HIP4 was completed. This procedure allows a direct comparison of the variance to be found in the signal frequencies used to exchange informationand allows the signal to be evaluated and classified as a stochastic or deterministic function in time. The fourier analysis employed in this study approximates the behavior by utilizing an integral function of sine and cosine functions.

The time series vectors for the physician and the patient (caregiver) in this investigation were made with the continuous observations collapsed to equal unit time intervals. These time intervals are hypothesized to contain deterministic sinusoidal components with an associated error term. This assumption is provided in the mathematical model given as:

$$f_d(\omega) = \sum_{S=0}^{\infty}\left\{f_c(\omega) + f_c\left[2\pi S \div \delta\tau\right]\right\} + \ldots$$

$$\ldots \sum_{S=1}^{\infty}\left\{f_c(-\omega) + f_c\left[2\pi S \div \delta\tau\right]\right\}$$

The observations of the clinical encounter sum to an even integer as required (Jenkins, 1968) and can extended to any dimension of N. This restriction allows the opportunity to detect the Nyquist frequency (Pocock, 1974). This

frequency reflects the highest oscillatory harmonics which can be associated with the communicational signal being investigated.

The ANOVA, analysis of variance techniques, allow the TSS to be partitioned into a minimum of two components, the residual sum of squares and the explained sum of squares. This procedure is extended in the spectral analyses of communication signals to allow the explained sum of squares of the signal to be represented by any periodic components in the TSS at any component frequency. Each of the communication variables investigated was be partitiioned across a minimum of 100 frequencies, from zero, to the calculated Nyquist frequency. The total effect of a fourier analysis of these signals is to partition the variability of the series into components at multiple harmonics.

Periodogram Analysis

The periodogram ordinate and the autocovariance coefficient are both quadratic transformations of the data obtained with the HIP4. They are associated in each spectrum as the finite fourier transform of the autocovariance coefficient. These periodograms may fluctuate wildly and lack any patterns of consistency.

The F test

The F statistic was applied to each physician variable and patient (caregiver) variable whose levels are described by empirical distributions that do not violate two assumptions which underly its use:

1. A normal distribution fits the data except for chance variation.
2. The normal distributions approximating the levels within a specific time interval possess the property of homoscedascity.

Three additional assumptions for the F-test are believed to hold and to further validate use of this statistic:

1. The observations between cases (time units) were independent of each other.
2. The variables were measured on at least an interval scale; it is likely a ratio scale on which just two considerations are being made: The signal is active or the signal is inactive.

Results for relevant statistical computations are presented. Standard tabular formats are employed for the Kolmogorov-Smirnov Probability test for "White Noise" available from the Statistical Research Laboratory of the Michigan Terminal System (MTS) through Wayne State University.

Table 91 and table 92 represent a summary of figures 1 through 30, the plots of the spectral density functions vs. frequency, in which sample spectral coefficients are summarized for each of the HIP4 vectors found to be active in measuring the communication between the physician and the patient. The variance of each communication signal is represented as the sum of the contributions made at each

frequency of the spectrum. The F(1) represents a frequency of 0.0, F(2) is a frequency of 0.25, F(3) is 0.50, F(4) is 0.75 and F(5) is 1.0 , which when summed will equal 100% of the total vaiance of the signal. The frequencies containing the density maximums will also contribute the greatest variance for the communication signals. The comparative plots of the Densities are shown in Figures 1 through 30.

TABLE 91

COMPARISON OF VARIANCE (PERCENT) DISTIBUTION BY FREQUENCY

PHYSICIAN VECTORS

SPECTRAL DENSITY COEFFICIENTS IN SPECTRUM					
VARIABLE	F(1)	F(2)	F(3)	F(4)	F(5)
2. DDEQ	0.8	22.8	51.2	77.2	100
3. DDQ	3.4	34.2	61.8	83.4	100
4. DEX	11.5	74.8	86.9	95.6	100
5. DDS	0.3	25.2	50.2	75.1	100
6. DRU	4.0	33.8	57.0	75.4	100
7. DH	2.4	40.7	70.6	90.1	100
8. DRS	0.0	27.6	51.8	74.7	100
10. DJ	1.3	69.6	82.5	92.8	100
11. DS	2.6	55.8	73.3	86.2	100
22. DVC1	1.3	55.5	88.2	98.8	100
23. DVC2	2.1	93.5	98.2	99.3	100
24. DVC7	0.3	88.9	96.1	98.6	100
25. DVC8	3.3	92.6	97.1	99.3	100
26. DVC12	0.0	92.4	97.6	99.2	100
27. DVC13	0.1	41.2	64.0	81.5	100
28. DVC14	6.2	97.6	99.0	99.7	100
29. DVC17	1.9	63.8	81.9	91.2	100
30. DVC18	5.6	87.4	93.3	98.3	100

Table 91 (Continued)

31. DF1	1.8	85.9	95.5	98.9	100
32. DF2	6.8	89.8	95.9	98.5	100
33. DF3	1.9	78.9	92.3	97.5	100
34. DF5	7.1	84.7	95.1	97.5	100
35. DF6	2.2	87.6	96.5	98.4	100
50. DNV11	0.4	79.6	93.7	97.6	100
51. DNV12	2.6	70.0	79.6	92.3	100
52. DNV13	0.7	61.5	92.4	91.8	100
54. DNV4c	1.9	65.9	81.5	95.6	100
55. DNV4h	0.2	41.3	72.5	90.8	100
56. DNV64	2.9	91.4	97.5	99.6	100
57. DNV65	2.8	76.1	92.2	96.6	100
58. DNV66	2.1	51.1	93.9	96.4	100
59. DNV77	5.0	82.1	92.9	97.4	100
60. DAI	3.7	65.2	76.3	86.4	100

The inspection of table 91 allows one to note that variable 4 (DEX) shows that about 11.5% of the variance of the signal is accounted for at small frequencies has reached maximum densities before any of the other verbal signals. when the frequency reaches 0.25 nearly 75% of the signal's variance has been acounted for, a very strong indicator that this signal may not be stochastic or randomly determined but may have deterministic associations with the other communication signals active in the informational exchange between the physician and the patient (Caregiver). Variable 28 (DVC14) demonstrates the greatest deterministic property with about 98% of the variance being demonstrated in the lower frequencies of the spectrum. Other physician variables

which demonstrate strong tendencies on being nonstochastic are Variables 10 (DJ), Variable 24 (DVC7), Variable 25 (DVC8), Variable 26 (DVC12), Variable 29 (DVC17), and Variable 30 (DVC18).

The Form (function) used during the signal transmission allows the strength of the HIP4 to capture the essence of the dependence of the form variables on the dynamic states of the remaining HIP4 commmunication vectors. All form variables for the physician appear to have minimal stochastic components when contrasted with other signals of this study. But, the actual distribution of the spectral density function will reveal more about the specific contributions of each frequency to the total variance of the signal. Spectral analysis represents a modified Fourier analysis which allows for the investigation of stochastic functions of time.

TABLE 92

COMPARISON OF VARIANCE (PERCENT) DISTRIBUTION BY FREQUENCY

PATIENT (CAREGIVER) VECTORS

SPECTRAL DENSITY COEFFICIENTS IN SPECTRUM					
VARIABLE	(F1)	(F2)	(F3)	(F4)	(F5)
12. CGOEQ	0.1	55.0	87.7	98.4	100
13. CGDQ	0.5	36.1	66.4	86.8	100
14. CGEX	4.3	43.5	68.4	81.7	100
15. CGDS	0.2	48.3	74.2	91.0	100
16. CGRU	0.2	33.0	57.2	77.8	100
17. CGH	0.5	25.2	50.1	75.0	100
20. CGJ	0.7	25.4	50.1	75.0	100
21. CGS	1.3	34.2	58.1	75.4	100
36. CGVC1	0.5	25.2	50.1	75.1	100
37. CGVC2	0.7	82.7	91.6	97.1	100
38. CGVC7	1.2	76.2	90.4	95.4	100
39. CGVC8	3.0	82.9	91.5	96.1	100
40. CGVC12	0.1	92.4	97.6	99.2	100
41. CGVC13	2.0	73.8	85.9	93.8	100
42. CGVC14	5.5	92.7	97.2	98.8	100
43. CGVC17	0.0	69.4	93.2	98.9	100
44. CGVC18	0.2	75.9	90.5	97.8	100

Each of the variables shown in table 92 are hypothesized to have equivalent amounts of variance accounted for at the same frequency in the spectrum, if they are expected to have equivalent characteristic properties. Obviously differences are found in the distribution of the spectral densities leading one to further speculate that communication between the physician and patient have hidden periodicities which are revealed with the HIP4 and are

verified with subsequent analysis.

From a theoretical point of view, the spectral properties of the informational signals of the active HIP4 vectors are described by the integrated spectrum and it is logical to concentrate the analytical method on these spectra. If the communication process is represented as a continuous spectrum, its properties can be identified from use of the HIP4 spectra rather tan from an integration of the signals into a composite network of information. The use of the periodgram was initially used to detect hidden periodicities which are capable of masking the periodic trigonometric terms which can be represented as background noise and not heuristically explained by the process under investigation. The location of frequency peaks in the spectral distributions allow major contributions to the variance of a signal to be identified.

Table 92 (Continued)

45. CGF1	0.7	25.3	50.1	75.1	100
46. CGF2	1.4	83.2	95.1	98.6	100
47. CGF3	0.0	85.8	95.5	98.6	100
48. CGF5	10.4	85.5	94.0	98.2	100
49. CGF6	0.9	70.5	84.9	92.5	100
61. CGNV11	0.6	57.0	74.3	87.1	100
62. CGNV12	14.5	86.2	95.1	98.8	100
63. CGNV13	9.4	82.3	95.0	97.5	100
65. CGNV4c	1.5	62.7	74.3	92.1	100
66. CGNV4h	1.2	83.9	93.7	97.5	100
67. CGNV64	0.7	57.9	90.8	99.3	100
70. CGNV77	0.7	25.3	50.1	75.1	100
71. CGAI	2.6	38.3	59.7	83.6	100

The inspection of table 92 allows the differences in the communication signals of the patient to be viewed. Variable 20 (CGJ) appears to have the greatest stochastic characteristic when compared with the other communication signals of the patient as captured with the HIP4. Note That variable 12 (CGOEQ) has 55% of the variance isolated with the lowest frequencies allowing it to belong to that group of signals having deterministic associations with the other communication modalities. Variable 42 (CGVC14) has the majority of its variance (92.7%) isolated to the lower frequencies allowing it to be viewed as a variable with a weak stochastic component until further analysis supports or rejects such a hypothesis. The specific frequencies which contain the density maximums for comparison are shown in table 93 and 94. The range of density peaks for the

physician variables range from a high of 66.4 found in variable 28 (DVC14) to a low peak of 3.01 as found in variable 5 (DDS). The range of density maximums for the patient were distributed from a high of 64 found in variable 42 (CGVC14) to a low of 2.05 in variable 70 (CGNV77).

TABLE 93

DISTRIBUTIVE COMPARISONS OF DENSITY $_{MAX}$ AND ASSOCIATED VARIANCE

PHYSICIAN VECTORS

VARIABLE	DENSITY$_{MAX}$	FREQUENCY	%VARIANCE
2. DOEQ	9.5438	0.3350	4.7
3. DDQ	9.9997	0.3850	4.9
4. DEX	37.917	0.0050	17.9
5. DDS	3.0155	0.0150	1.5
6. DRU	8.1999	0.0000	4.0
7. DH	5.8740	0.0700	2.9
8. DRS	7.0038	0.3900	3.4
10. DJ	40.355	0.0100	20.0
11. DS	33.291	0.0050	17.0
22. DVC1	4.9633	0.0350	2.5
23. DVC2	41.725	0.0100	20.7
24. DVC7	13.724	0.0150	26.6
25. DVC8	54.022	0.0150	26.6
26. DVC12	24.485	0.0100	12.2
27. DVC13	5.3448	0.0250	2.7
28. DVC14	66.442	0.0050	21.9
29. DVC17	9.2381	0.0250	4.7
30. DVC18	40.772	0.0050	19.8

TABLE 93 (continued)

31. DF1	19.813	0.0350	9.8
32. DF2	43.332	0.0100	20.9
33. DF3	16.361	0.0050	4.5
34. DF5	56.899	0.0100	27.4
35. DF6	25.796	0.0250	13.0
50. DNV11	21.631	0.0100	10.9
51. DNV12	12.042	0.0050	6.0
52. DNV13	12.452	0.0600	6.3
54. DNV4c	10.062	0.0200	4.9
55. DNV4h	5.4834	0.0500	2.8
56. DNV64	46.348	0.0100	22.8
57. DNV65	17.123	0.0150	8.4
58. DNV66	11.517	0.0250	5.7
59. DNV77	63.626	0.0050	31.0
60. DAI	11.280	0.0150	5.5

The spectral peaks in the signals of the physician demonstrate that the change in the variance of the communication signals are not identical. The amount of variance accounted for ranges from a low of 1.5% of the variance, as found in variable 5 (DDS) to a high of 31% for the notetaking activity of the physician, variable 59 (DNV77). Additional comparisons of table 93 with table 94 allows the differences in the amount of information of variable 4 (DEX) to show that a greater amount of variance exists in the physician's behavior than that of the patient, variable 14 (CGEX), at identical frequencies.

TABLE 94

DISTRIBUTIVE COMPARISONS OF DENSITY $_{MAX}$ AND ASSOCIATED VARIANCE

PATIENT (CAREGIVER) VECTORS

VARIABLE	DENSITY $_{MAX}$	FREQUENCY	%VARIANCE
12. CGDEQ	5.5236	0.0100	2.7
13. CGDQ	9.9909	0.1000	5.0
14. CGEX	8.9554	0.0050	4.3
15. CGDS	9.7128	0.0450	4.8
16. CGRU	6.8291	0.2550	3.4
17. CGH	4.0512	0.1250	2.0
20. CGJ	2.1886	0.0050	1.1
21. CGS	9.4348	0.1800	4.6
36. CGVC1	2.1108	0.0350	1.1
37. CGVC2	32.596	0.0050	14.9
38. CGVC7	19.995	0.0250	10.1
39. CGVC8	41.780	0.0150	20.5
40. CGVC12	24.480	0.0100	12.3
41. CGVC13	8.2829	0.0050	4.1
42. CGVC14	64.072	0.0050	22.0
43. CGVC17	15.988	0.0050	8.0
44. CGVC18	20.456	0.0250	10.2

It appears that the communication network between the physician and the patient is of such a complex nature that it becomes impossible to posit a single hypothesis which can appropriately describe its behavior in other than probabilistic terms.

TABLE 94 (continued)

45. CGF1	2.0890	0.0050	1.0
46. CGF2	34.457	0.0400	17.1
47. CGF3	36.220	0.0250	17.9
48. CGF5	32.786	0.0050	15.6
49. CGF6	12.466	0.0350	6.3
61. CGNV11	17.255	0.0150	8.6
62. CGNV12	45.959	0.0050	21.3
63. CGNV13	32.283	0.0100	15.4
65. CGNV4c	7.4926	0.0050	3.8
66. CGNV4h	57.615	0.0050	28.7
67. CGNV64	10.378	0.0250	5.2
70. CGNV77	2.0579	0.0750	1.1
71. CGAI	7.6807	0.0050	3.8

The spectral density peaks for the patient are shown in table 94. The range of the spectral density peaks range from a low of 1% at a frequency of 2.08 as shown in variable 45 (CGF1) to a high of 28.7% at a frequency of 0.005 as shown in variable 66 (CGNVh). This directs the investigation to test if the differences in these variables represent a degree of randomness in the behavior of the communication or if they are dependent on other signals active during the informational exchange.

To provide additional evidence of the nature of the communication patterns a Kolmogorov-Smirnov probability for white was calculated for each of the active HIP4 vectors in order to test the hypothesis that each signal transmitted was the result of random, unpredictable conditions. Table 95

contains the Kolmogorov-Smirnov probability coefficients for such a prediction.

Bartlett (1954,1955) proposed two tests designed to test the "goodness of fit" of the positive integrated spectrum. And the idea of relating the asymtotic distribution to the Komogorov-Smirnov statistic by considering white noise and replacing each of the integrals of the function with discrete sums over the frequency points.

TABLE 95

COMPARISON OF KOLMOGOROV-SMIRNOV PROBABILITIES FOR HIP4 VECTORS:
A WHITE NOISE TEST FOR SIGNALS IN STOCHASTIC PROCESSES

PHYSICIAN VECTORS		PATIENT (CAREGIVER) VECTORS	
2. DGEQ	0.03078	12. CGDEQ	0.37696
3. DDQ	0.12817	13. CGDQ	0.15874
4. DEX	0.51805	14. CGEX	0.18696
5. DDS	0.00370	15. CGDS	0.28060
6. DRU	0.11876	16. CGRU	0.10038
7. DH	0.21539	17. CGH	0.0
8. DRS	0.04233	18. CGRS	(S.N.A.)*
10. DJ	0.50489	20. CGJ	0.0
11. DS	0.31157	21. CGS	0.097834
22. DVC1	0.38248	36. CGVC1	0.0
23. DVC2	0.71740	37. CGVC2	0.60415
24. DVC7	0.63598	38. CGVC7	0.50996
25. DVC8	0.67787	39. CGVC8	0.58210
26. DVC12	0.74659	40. CGVC12	0.74674
27. DVC13	0.16901	41. CGVC13	0.48515
28. DVC14	0.81941	42. CGVC14	0.70786
29. DVC17	0.40253	43. CGVC17	0.48994
30. DVC18	0.65003	44. CGVC18	0.51622

Table 95 (Continued)

31. DF1	0.63173	45. CGF1	0.0
32. DF2	0.65187	46. CGF2	0.60228
33. DF3	0.53625	47. CGF3	0.60149
34. DF5	0.62878	48. CGF5	0.44905
35. DF6	0.64623	49. CGF6	0.44905
50. DNV11	0.56749	61. CGNV11	0.31438
51. DNV12	0.47365	62. CGNV12	0.67259
52. DNV13	0.37257	63. CGNV13	0.60631
54. DNV4c	0.40469	65. CGNV4c	0.37198
55. DNV4h	0.22436	66. CGNV4h	0.06465
56. DNV64	0.72827	67. CGNV64	0.42662
57. DNV65	0.51429	68. CGNV65	(S.N.A.)
58. DNV66	0.34509	69. CGNV66	(S.N.A.)
59. DNV77	0.58134	70. CGNV77	0.0
60. DAI	0.39537	71. CGAI	0.13980

* S.N.A. (SIGNAL NOT AVAILABLE FOR MEASUREMENT)

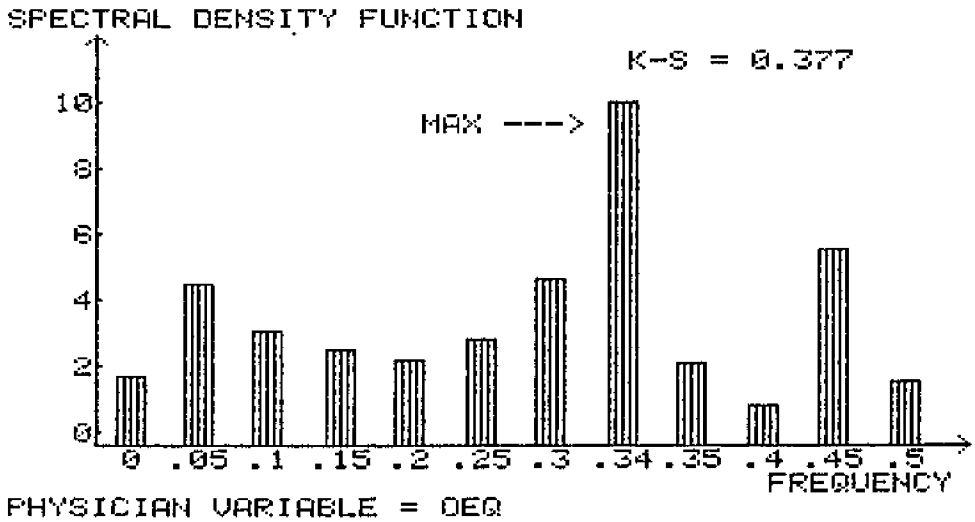
Table 95 allows a direct comparison of the stochastic nature of the communication signals as measured by the HIP4 vectors. Note that variables that approach zero probabilities are considered to be no different than that of random white noise processes. These signals are not shown to be related to the transmission of information in the clinical encounter. They have been shown to have high stochastic properties. Variable 2 (DOEQ), Variable 5 (DDS), and Variable (13) are the physician variable which have the greatest randomness. Fot the patient, variable 16 (CGRU), variable 17 (CGH), Variable 20 (CGJ), Variable 21 (CGS), Variable 45 (CGF1) variable 66 (CGNV4h) and variable 70 (CGNV77) have increased stochastic dimensions when compared

with the other variables having lesser amounts of randomness in their spectral distributions.

Figures 1 through 30 are graphical plots of the spectral density functions to allow comparison of all spectral coefficients accross the analytical frequencies. Figure 1 compares the spectral plots for both the patient (caregiver) and the physician. Note the existence of the spectral peak at low frequency when contrasted to the spectral maximum of the physician occurring at a high frequency, allowing the physican's behavior on this variable to be more random than that of the patient (caregiver). Figure 7 is a clear demonstration of the difference in the behavior of the physician which when compared with the identical variable of the patient allows the patient's behavior to be the random element in the exchange of information in the clinical environment. Figure 9 also demonstrates a significant difference in the nature of the communication signals as captured by the HIP4. The vocal content of the interview is compared and the physician appears to be using deterministic functions to control the content of his discussions while the patient is randomly sending signals to the physician. Figure 29 also portrays the great differences in the spectral behavior of the physician and the patient on the variable NV77 (notetaking).

FIGURE 1

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 2 (DOEQ): VAR 12 (CGOEQ)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



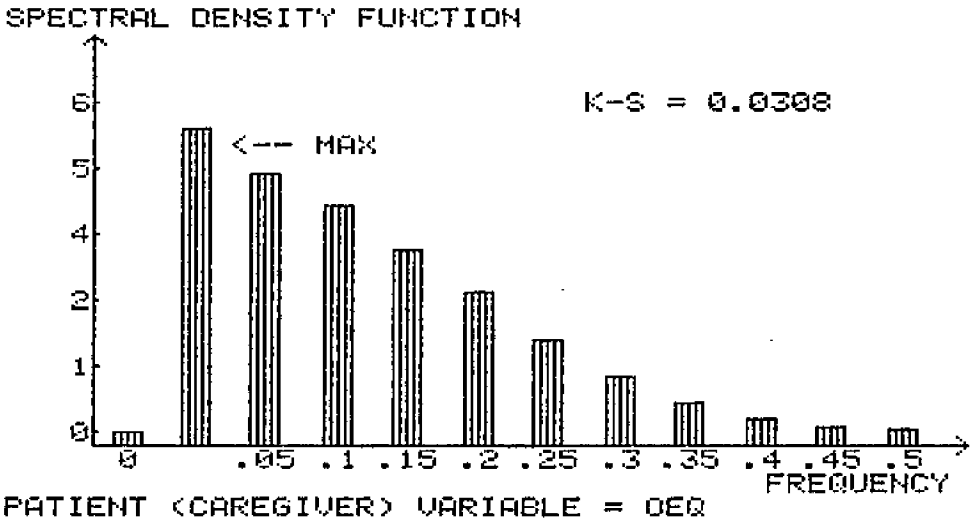
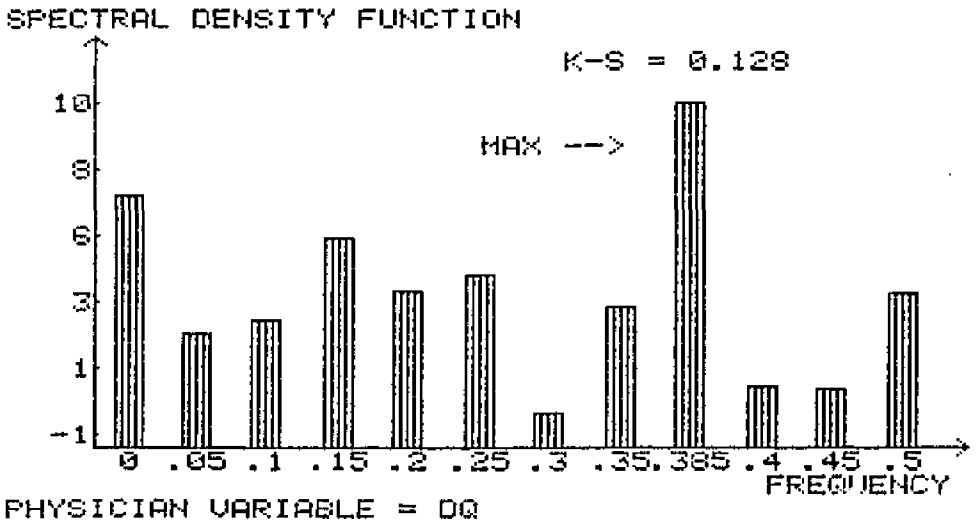


FIGURE 2

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 3 (DDQ): VAR 13 (CGDQ)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



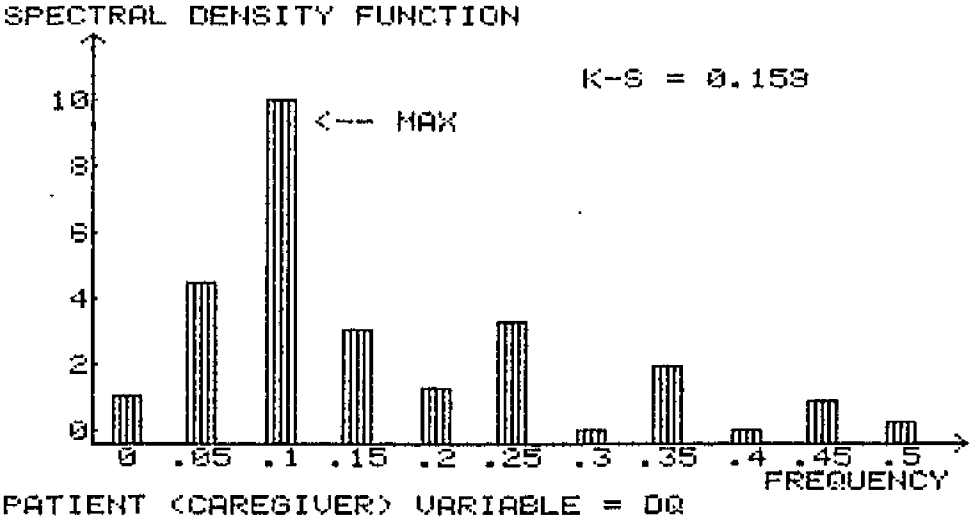
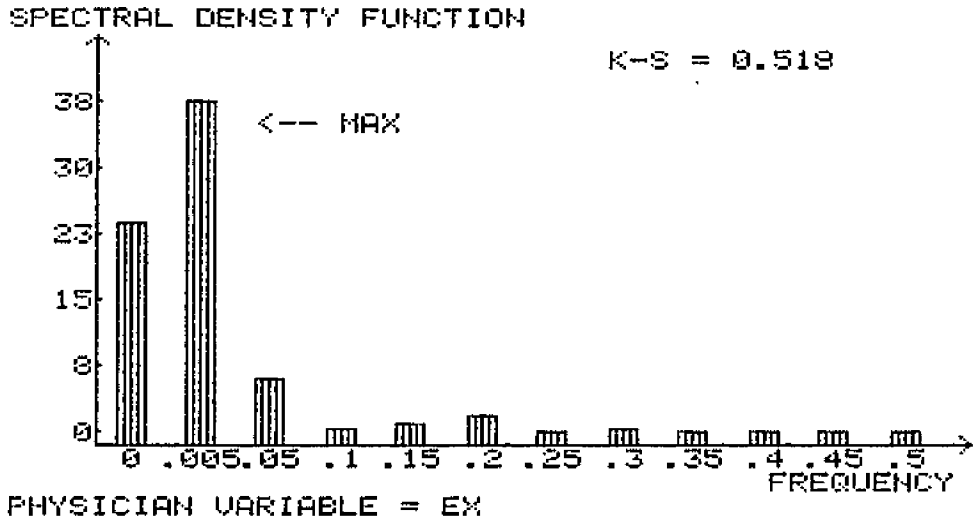


FIGURE 3

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 4 (DEX): VAR 12 (CGEX)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



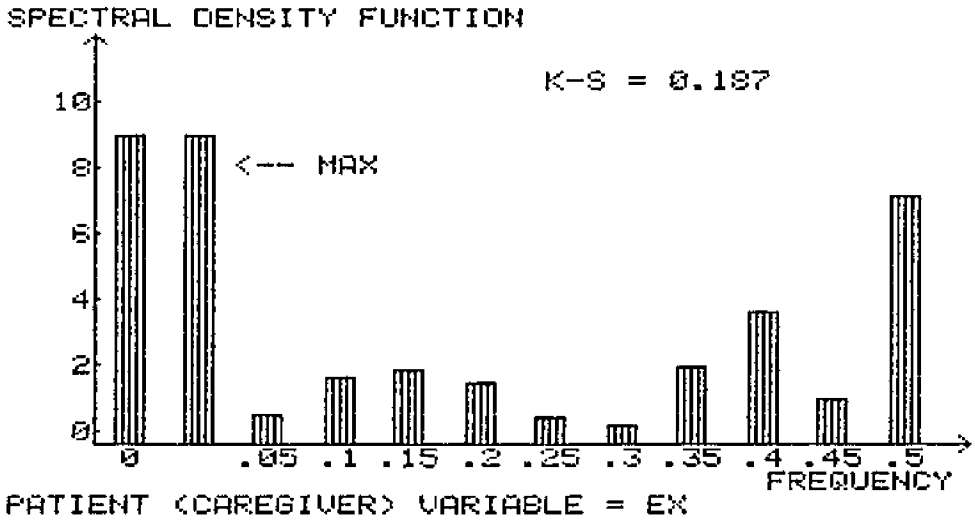
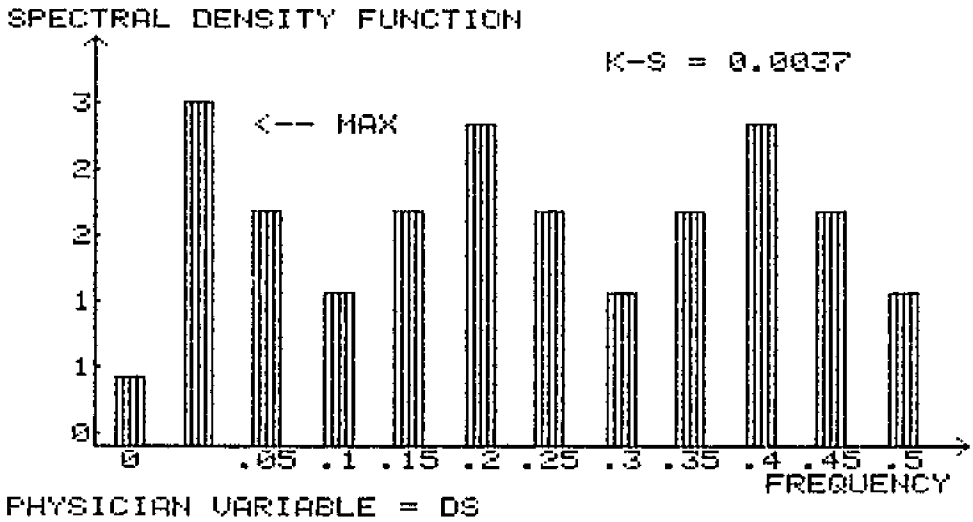


FIGURE 4

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 5 (DDS): VAR 15 (CGDS)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



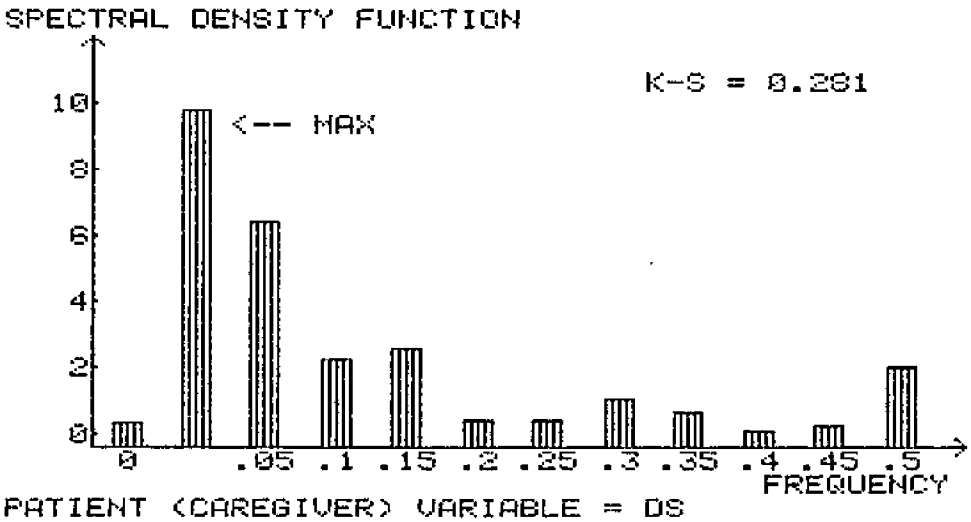
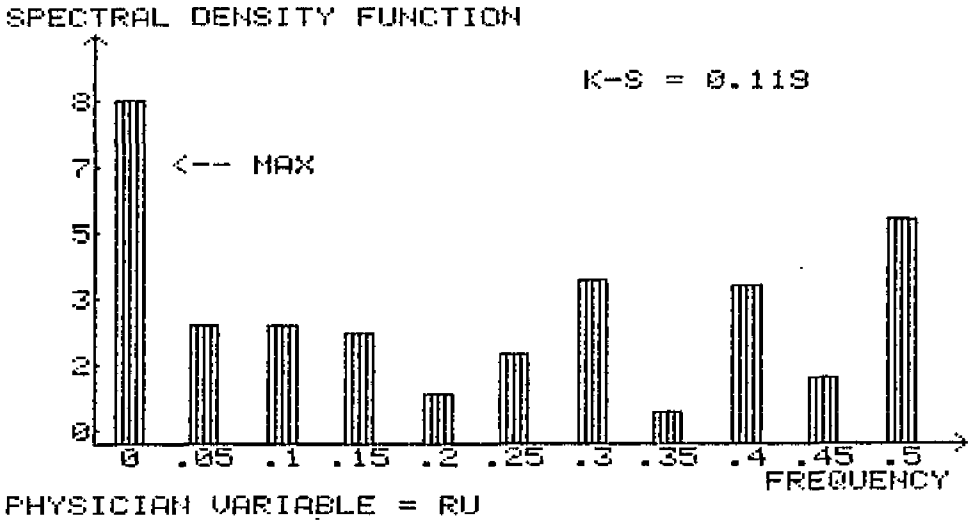


FIGURE 5

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 6 (DRU): VAR 12 (CGRU)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



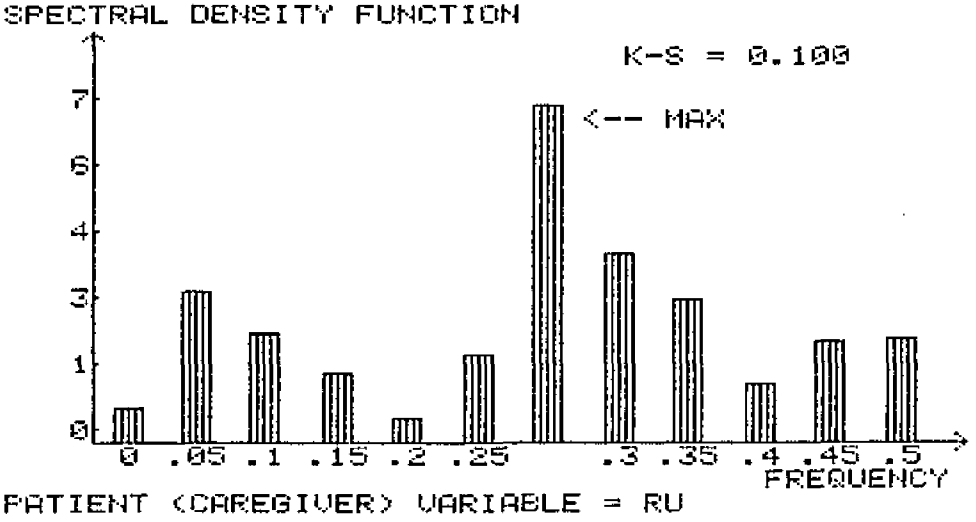
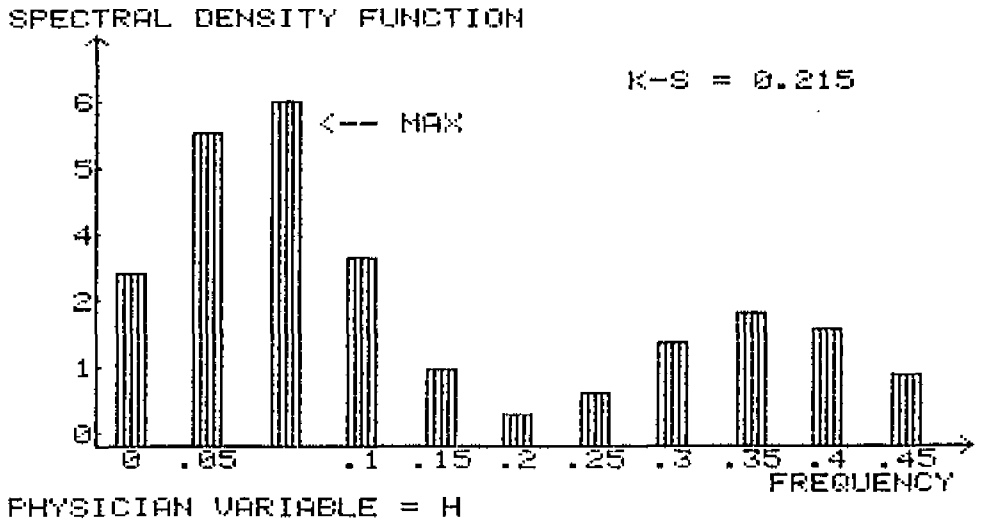


FIGURE 6

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 7 (DH): VAR 17 (CGH)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



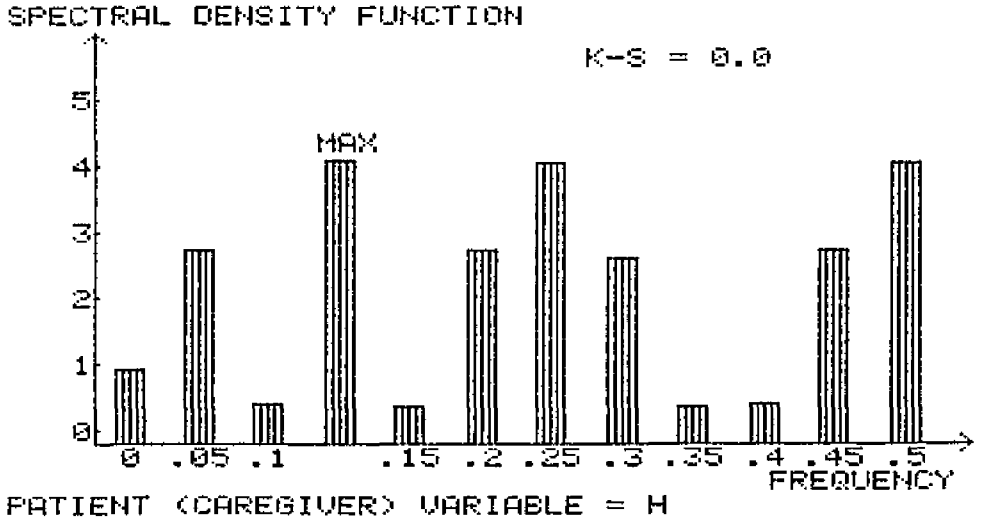
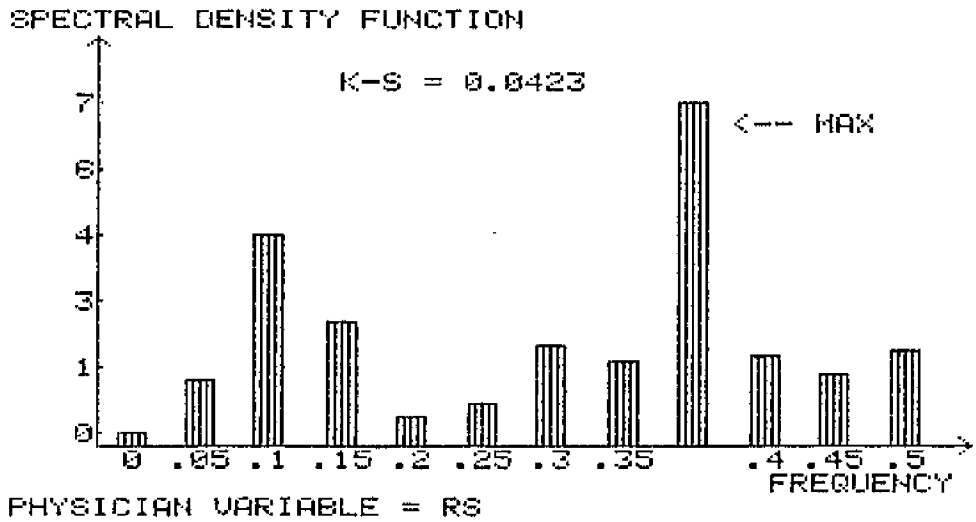


FIGURE 7

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 8 (DRS): VAR 18 (CGRS)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



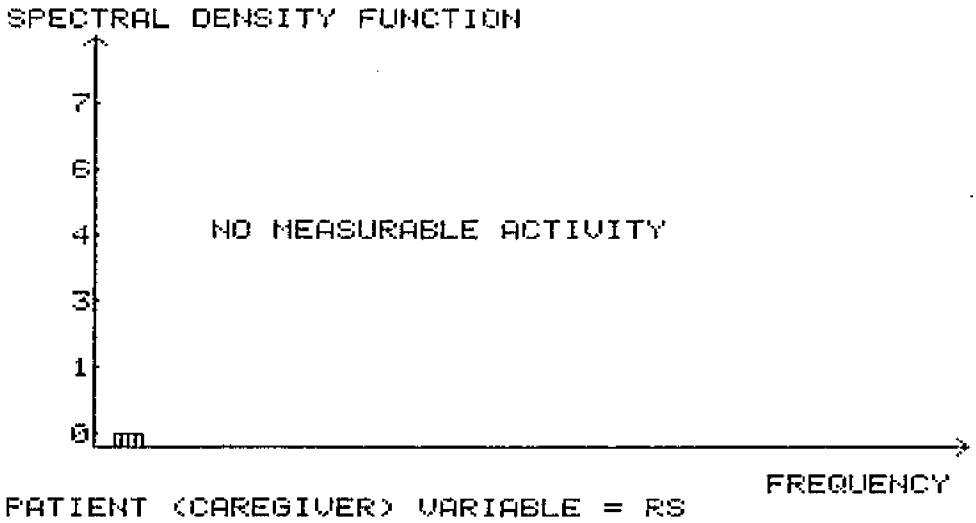
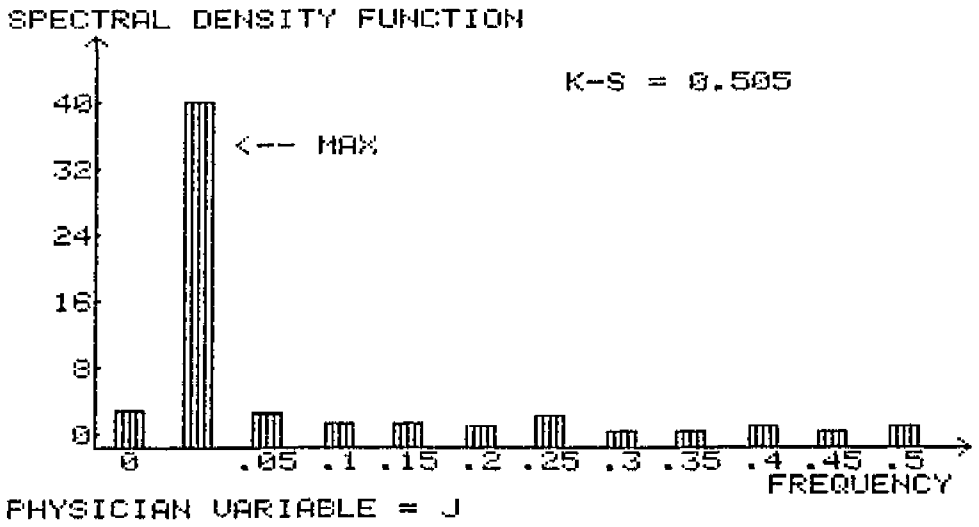


FIGURE 8

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 10 (DJ): VAR 20 (CGJ)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



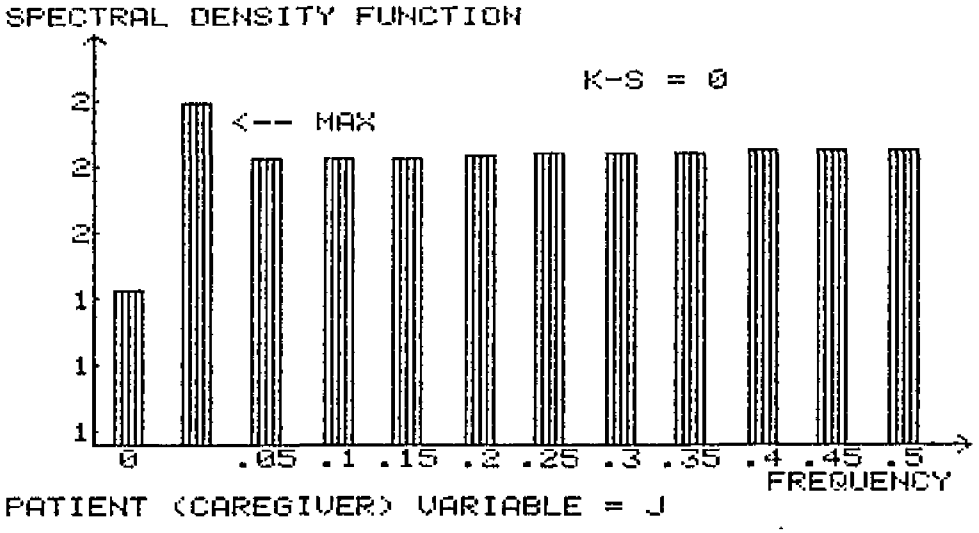
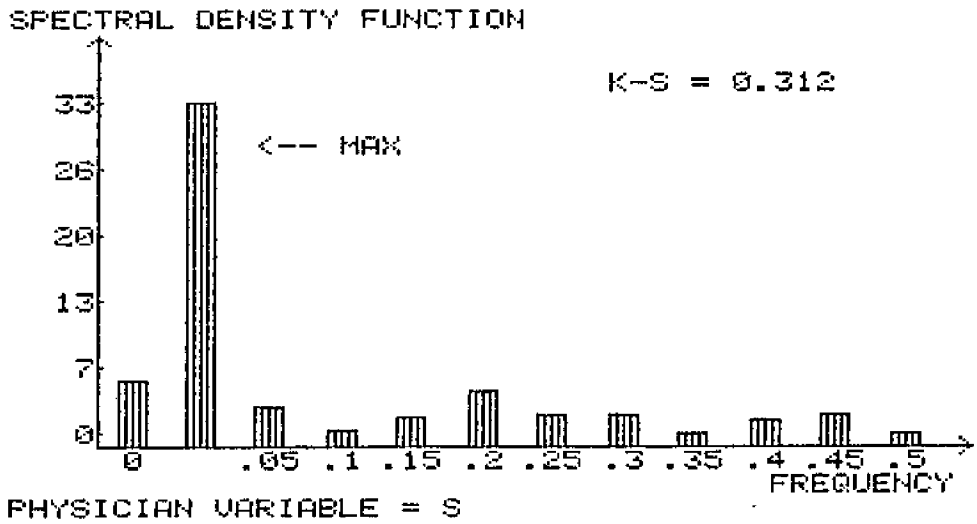


FIGURE 9

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 11 (DS): VAR 21 (CGS)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



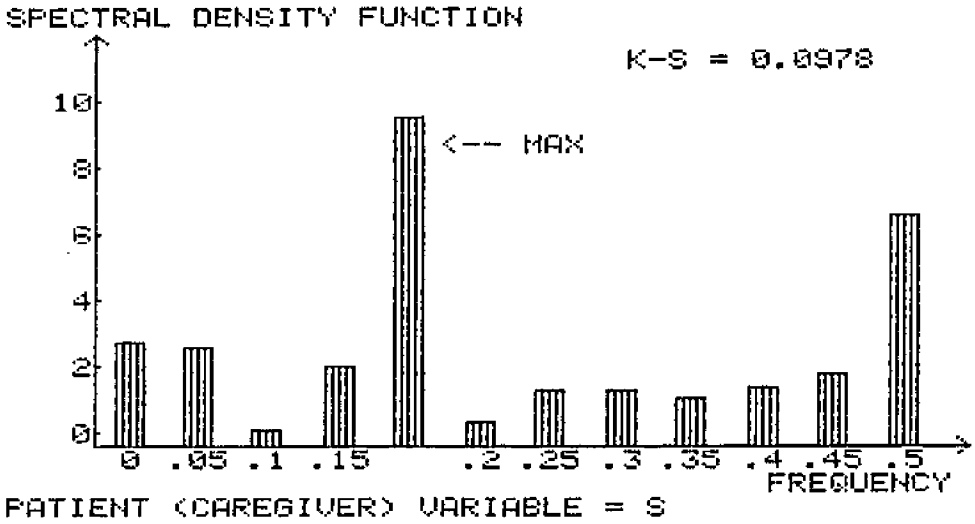
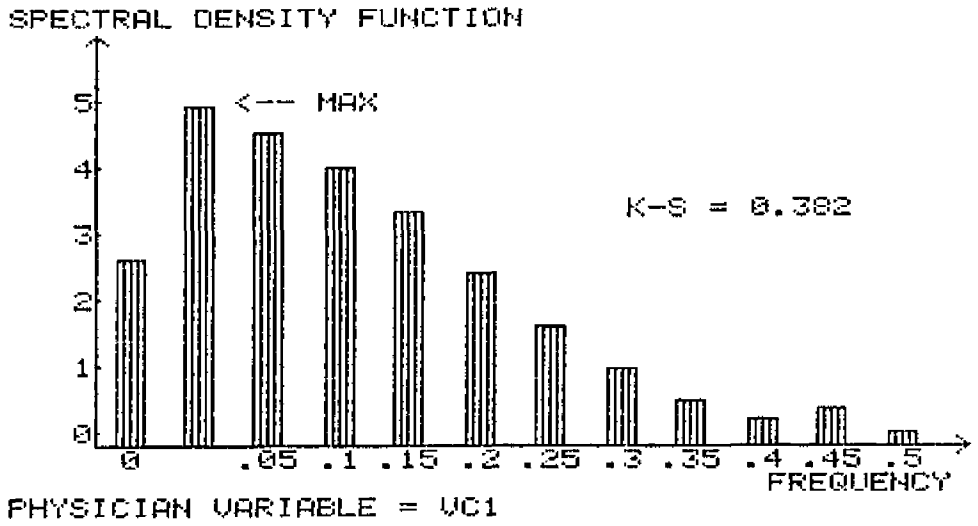


FIGURE 10

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 22 (DVC1): VAR 36 (CGVC1)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



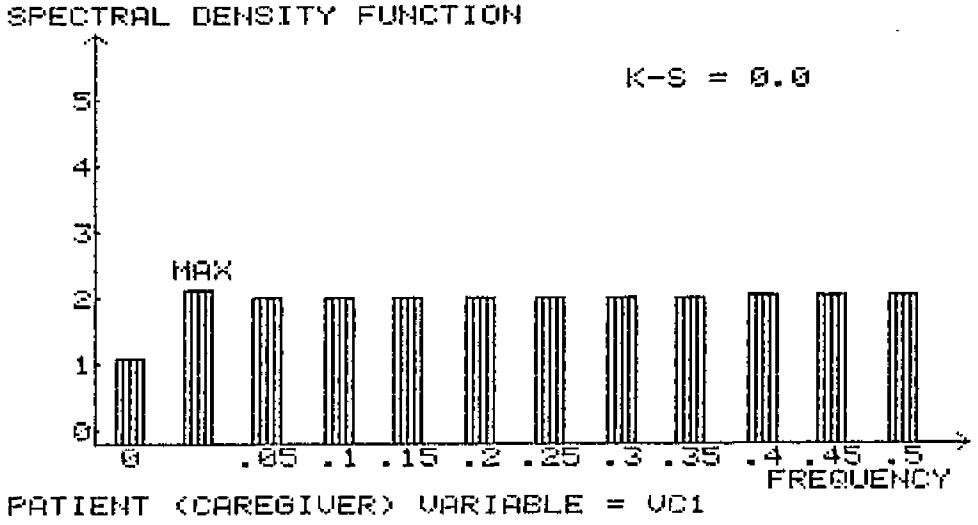
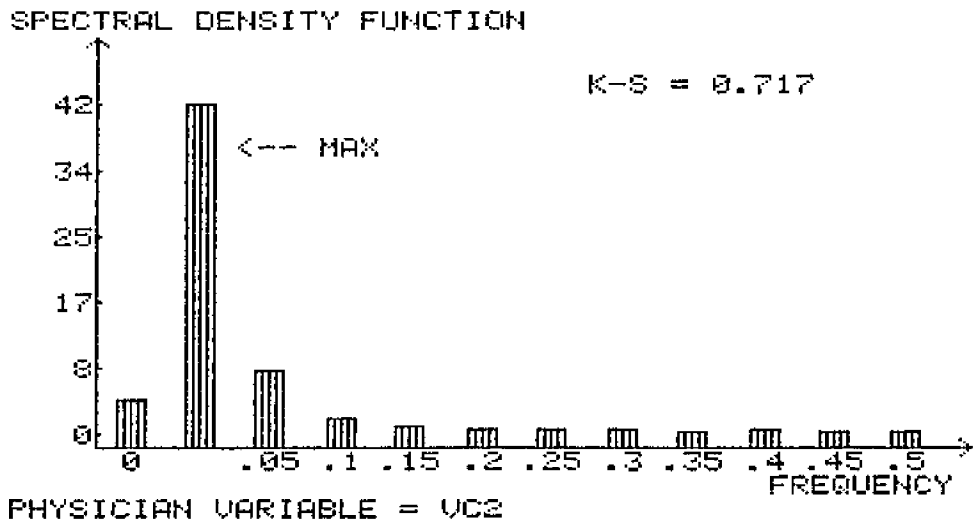


FIGURE 11

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 23 (DVC2): VAR 37 (CGVC2)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



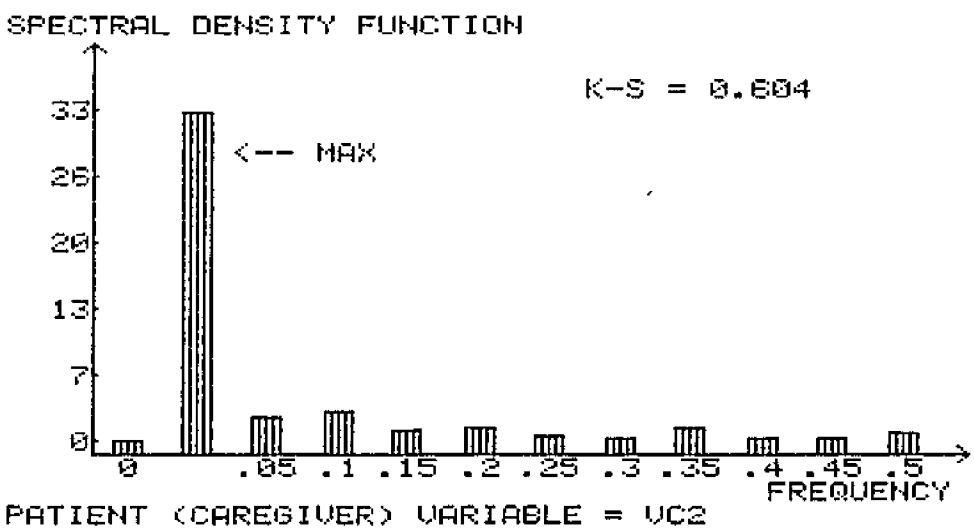
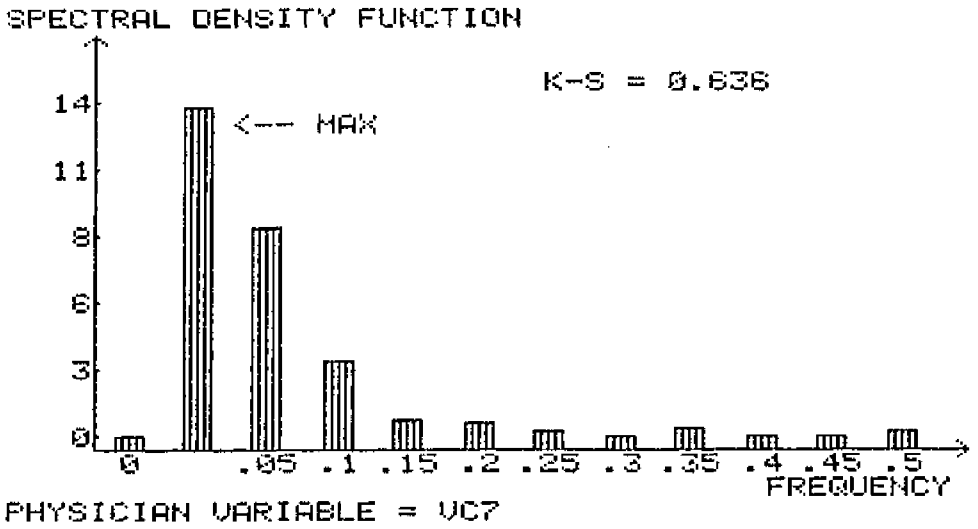


FIGURE 12

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 24 (DVC7): VAR 38 (CGVC7)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



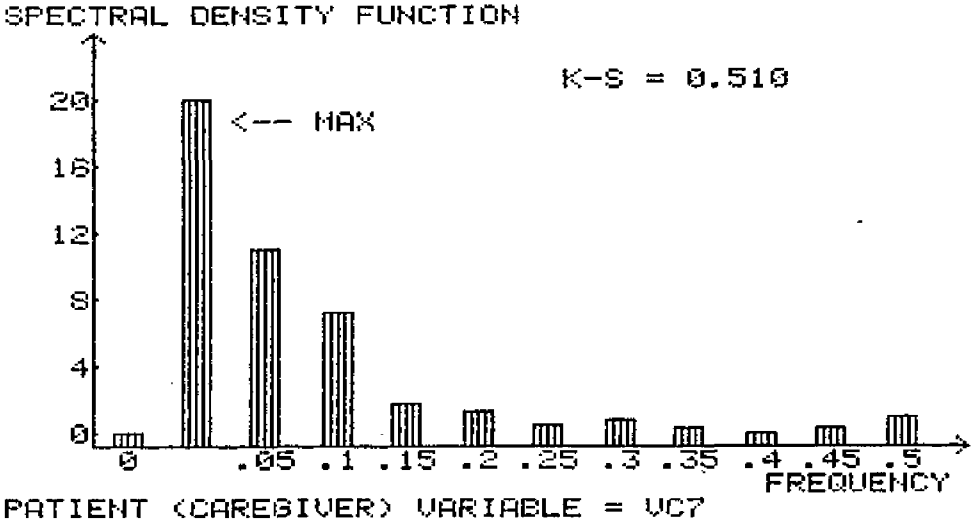
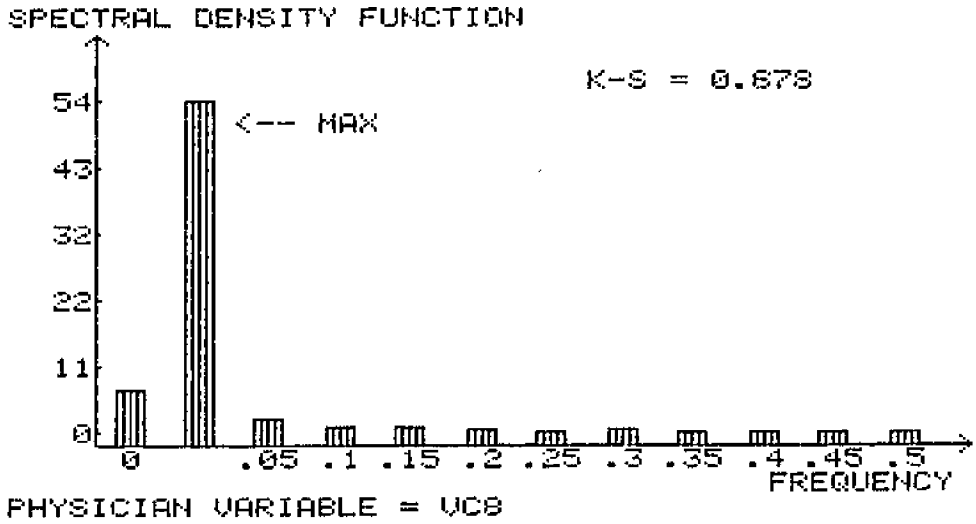


FIGURE 13

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 25 (DVC8): VAR 39 (CGVC8)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



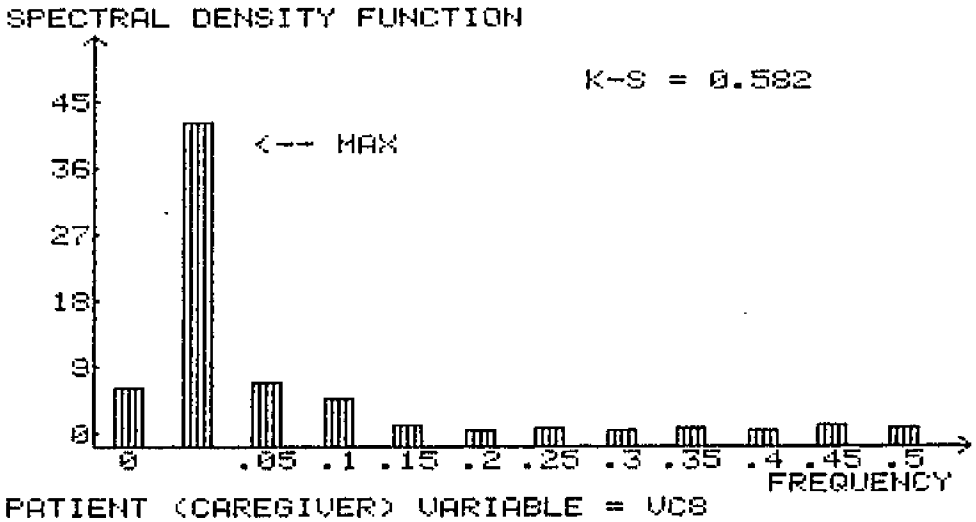
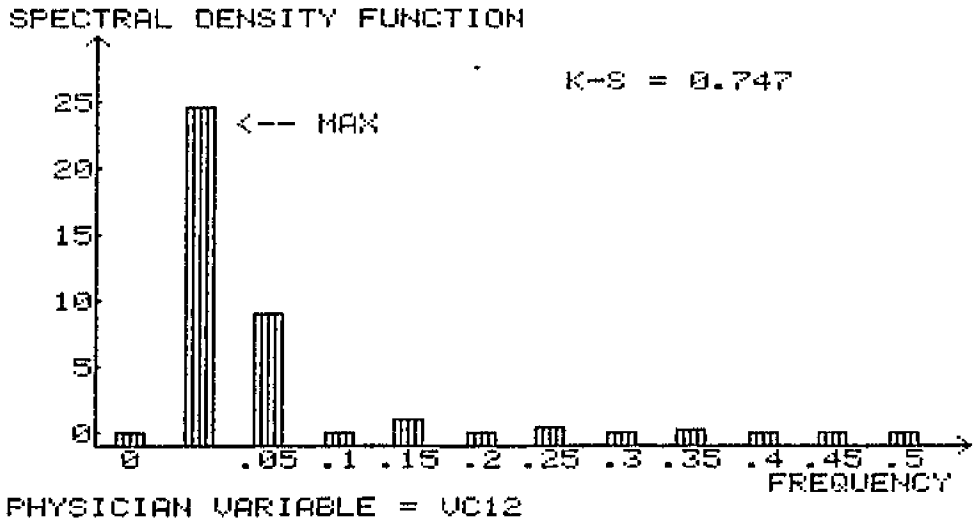


FIGURE 14

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 26 (DVC12): VAR 40 (CGVC12)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



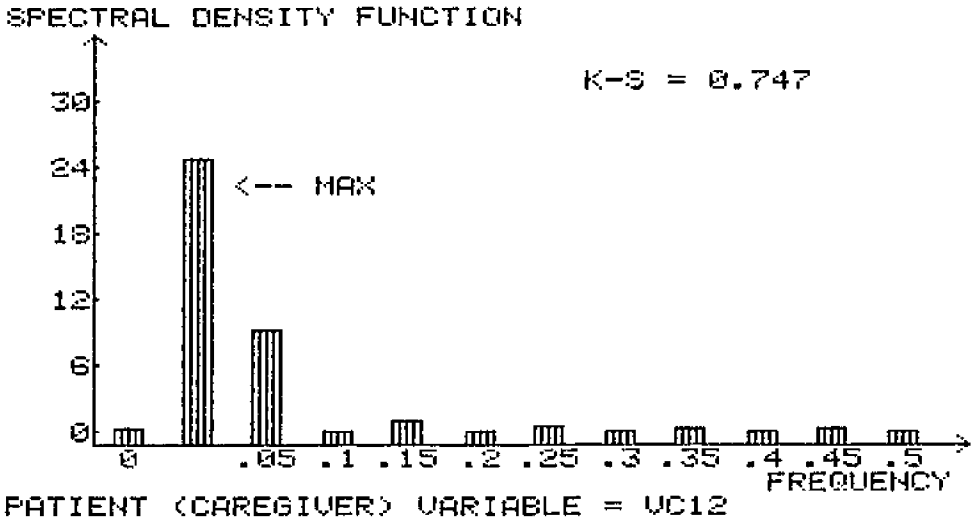
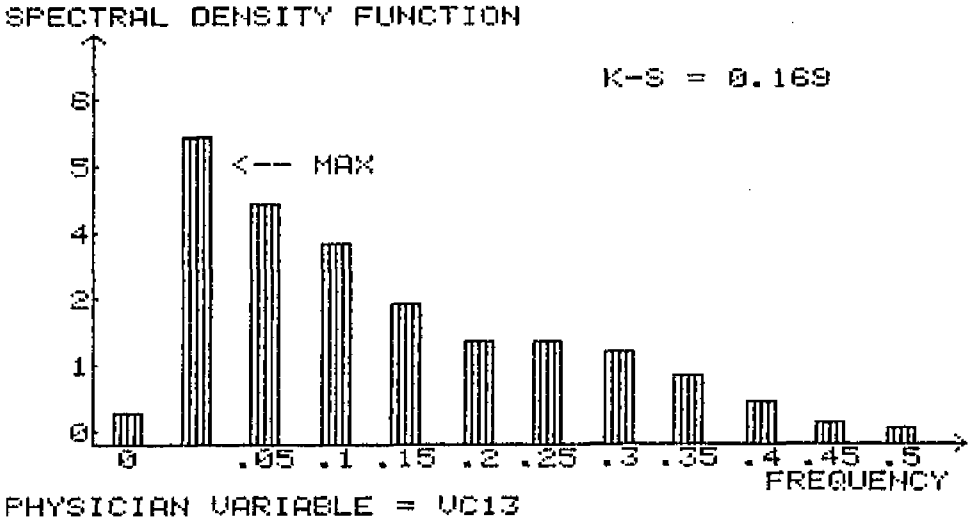


FIGURE 15

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 27 (DVC13): VAR 41 (CGVC13)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



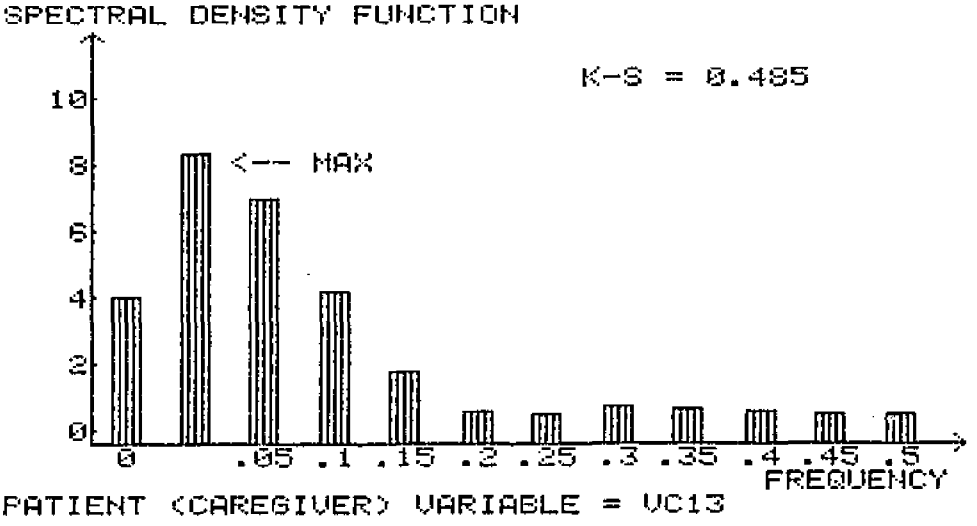
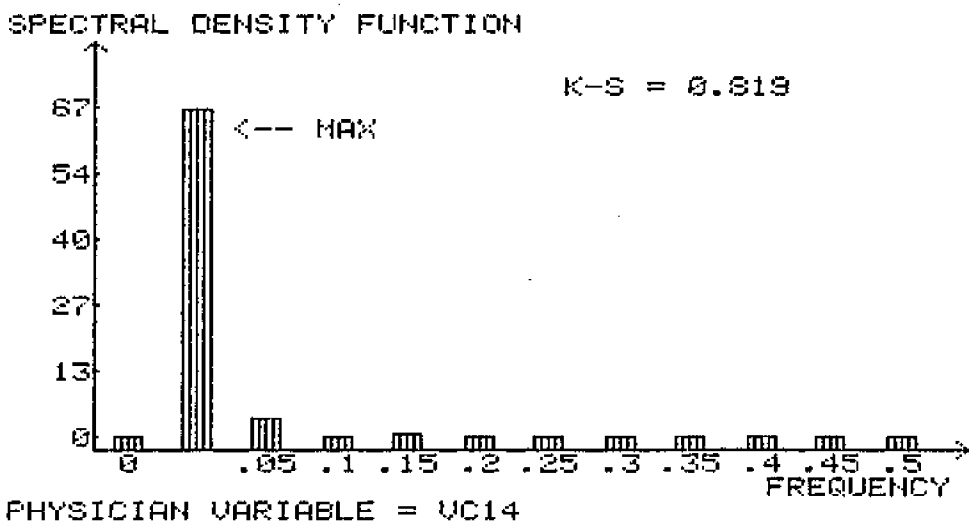


FIGURE 16

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 28 (DVC14): VAR 42 (CGVC14)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



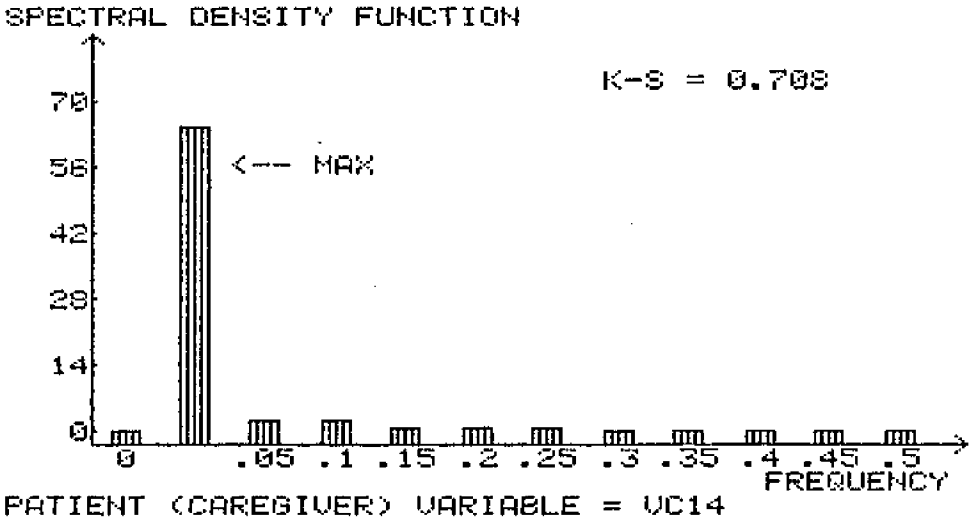
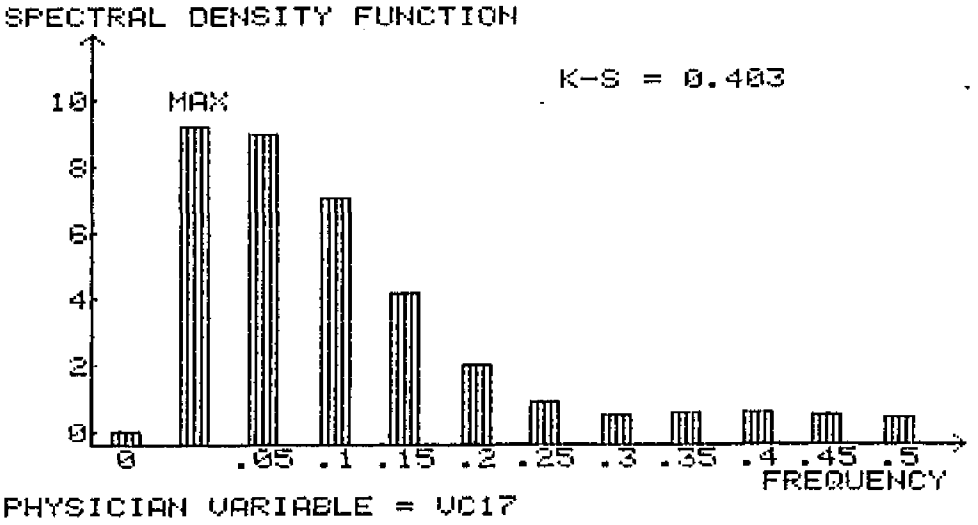


FIGURE 17

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 29 (DVC17): VAR 43 (CGVC17)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



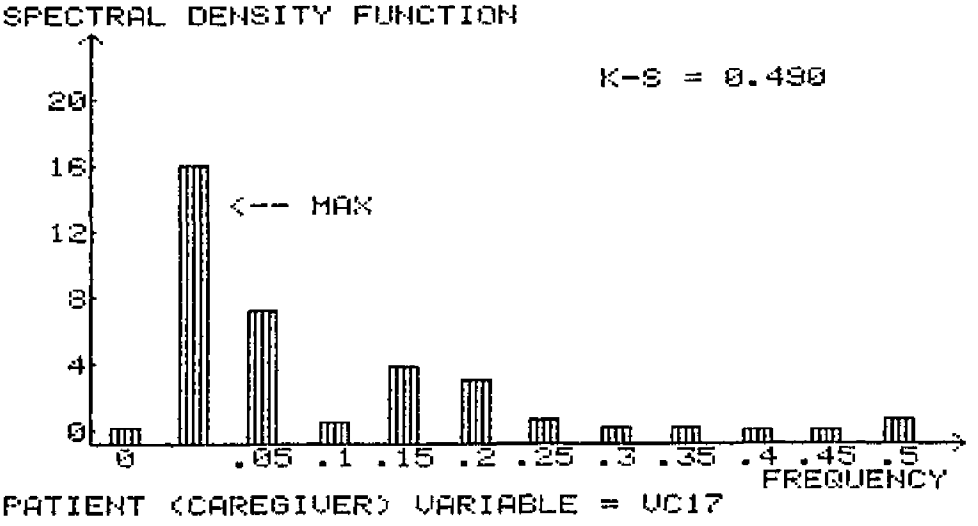
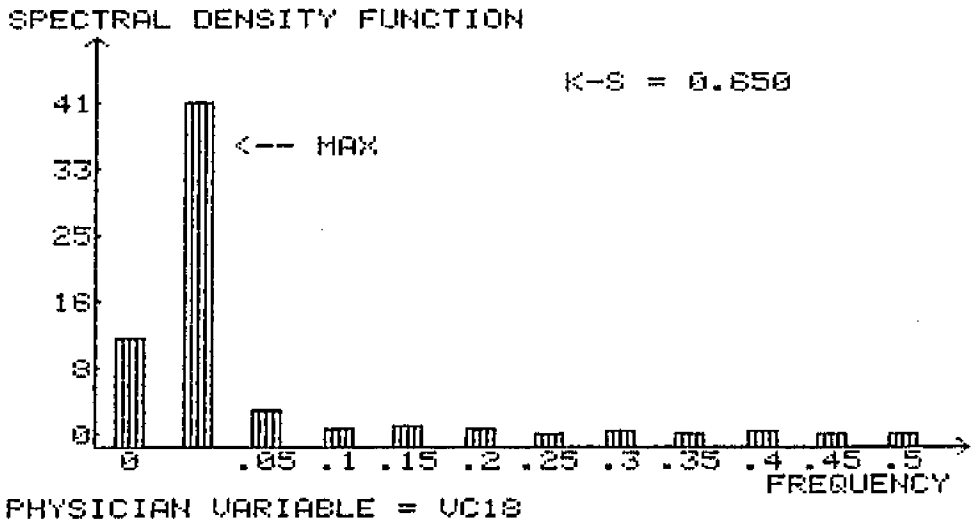


FIGURE 18

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 30 (DVC18): VAR 44 (CGVC18)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



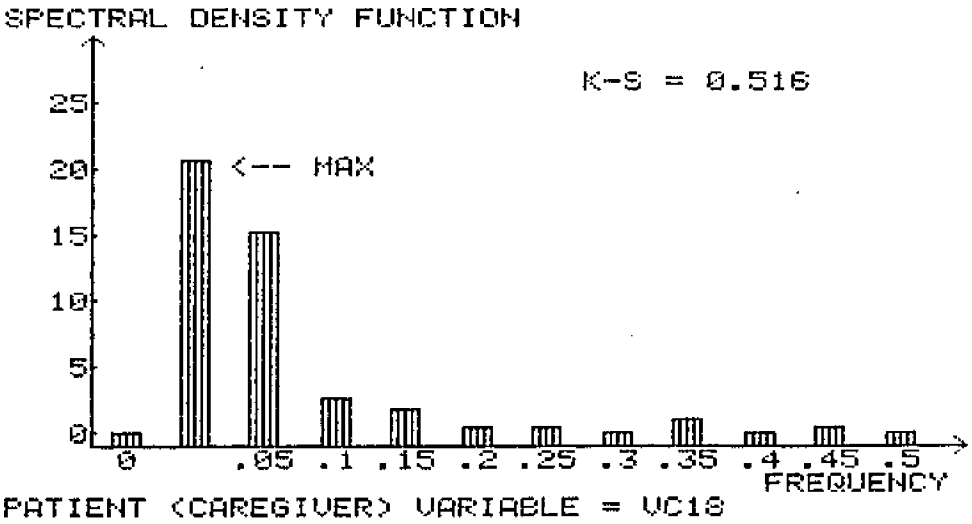
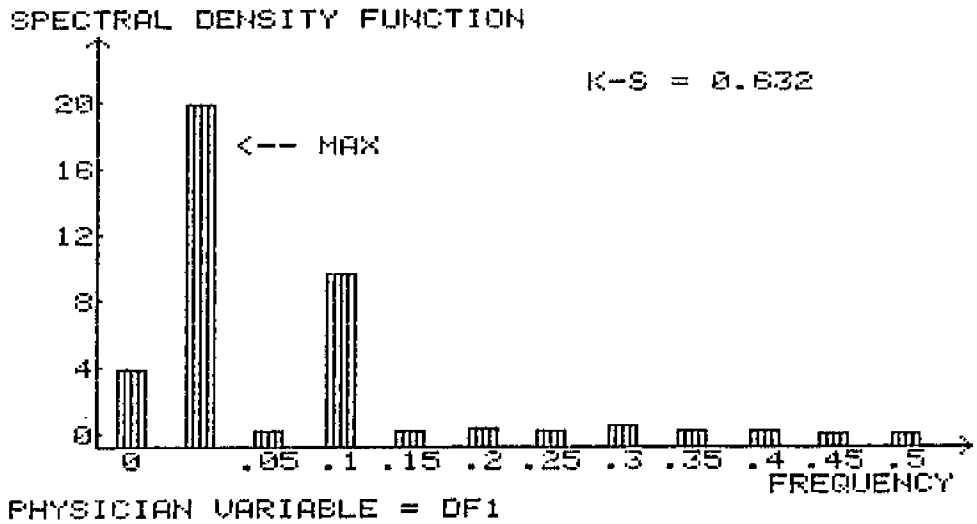


FIGURE 19

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 31 (DF1): VAR 45 (CGF1)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



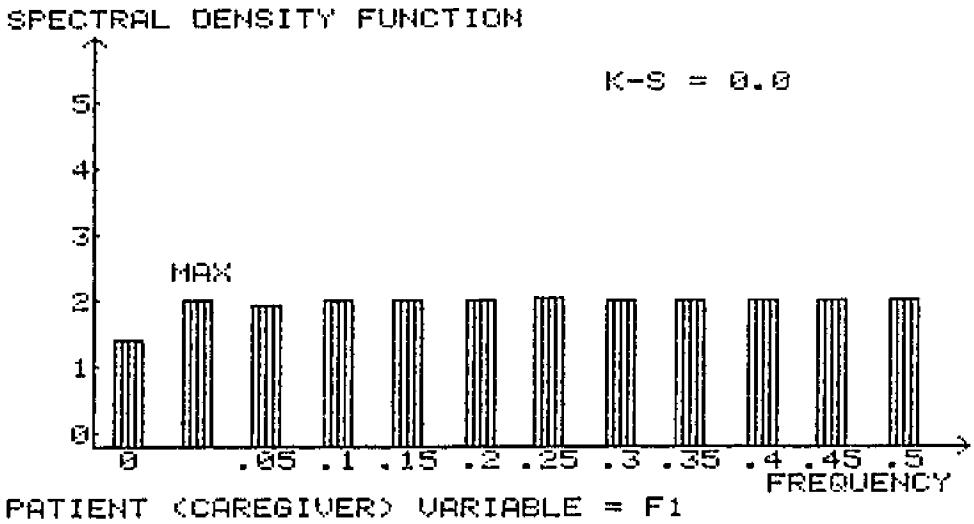
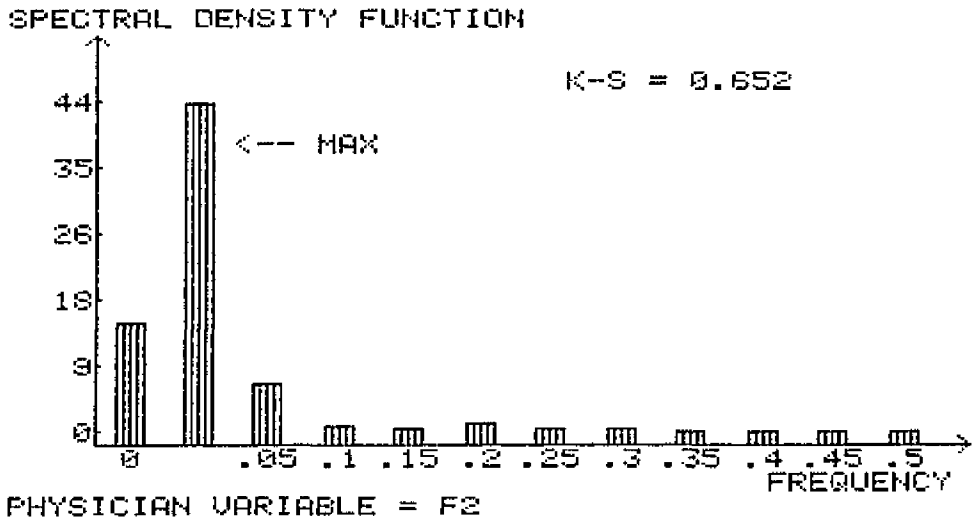


FIGURE 20

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 32 (DF2): VAR 46 (CGF2)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



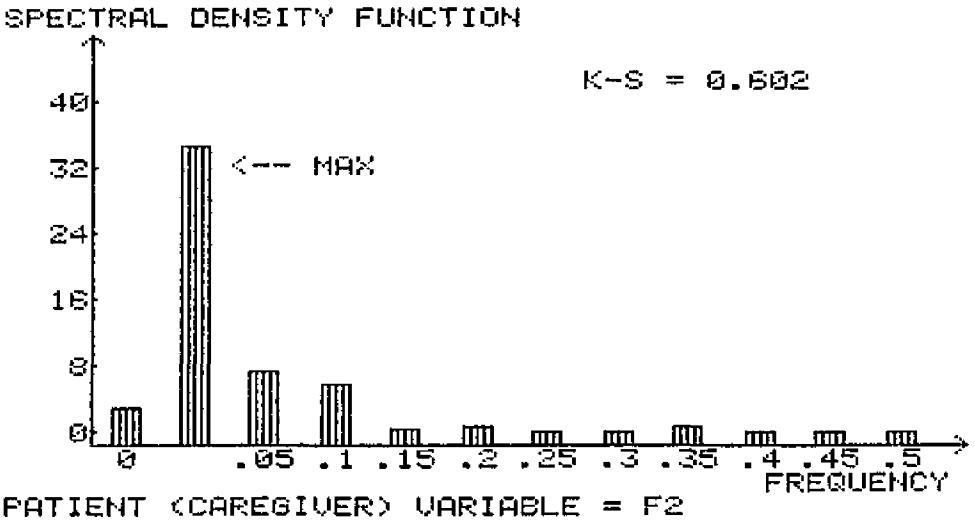
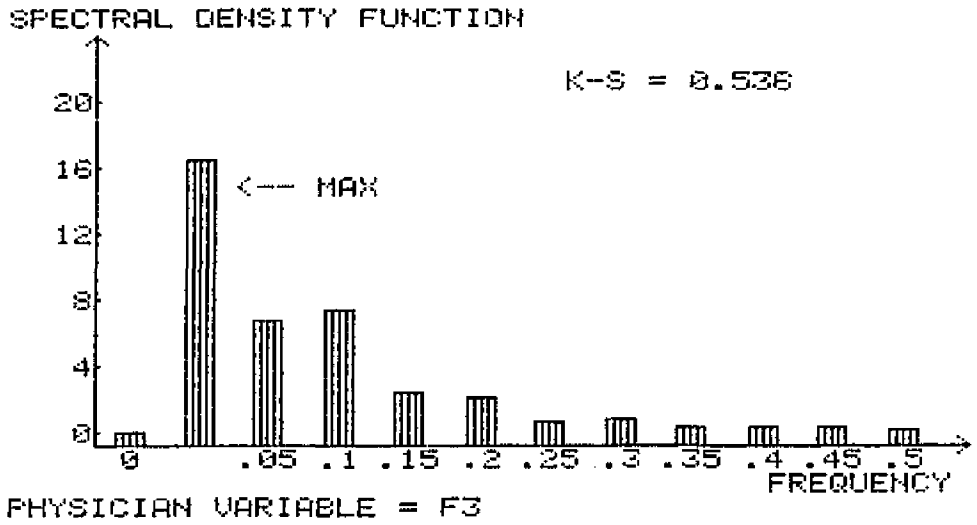


FIGURE 21

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 33 (DF3): VAR 47 (CGF3)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



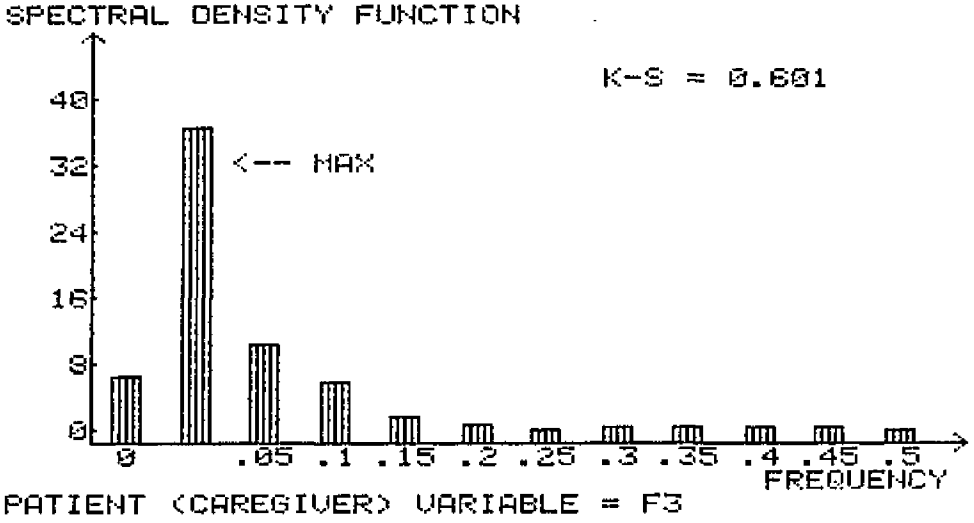
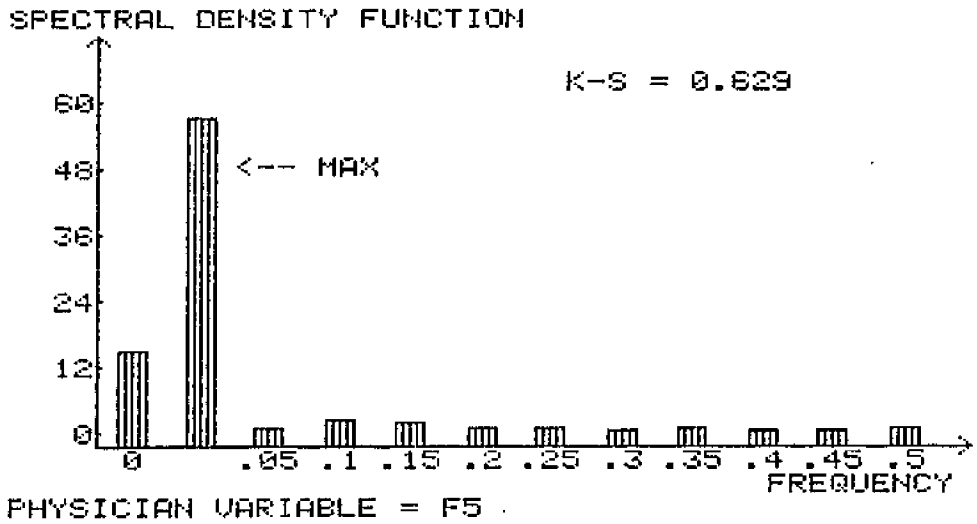


FIGURE 22

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 34 (DF5): VAR 48 (CGF5)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



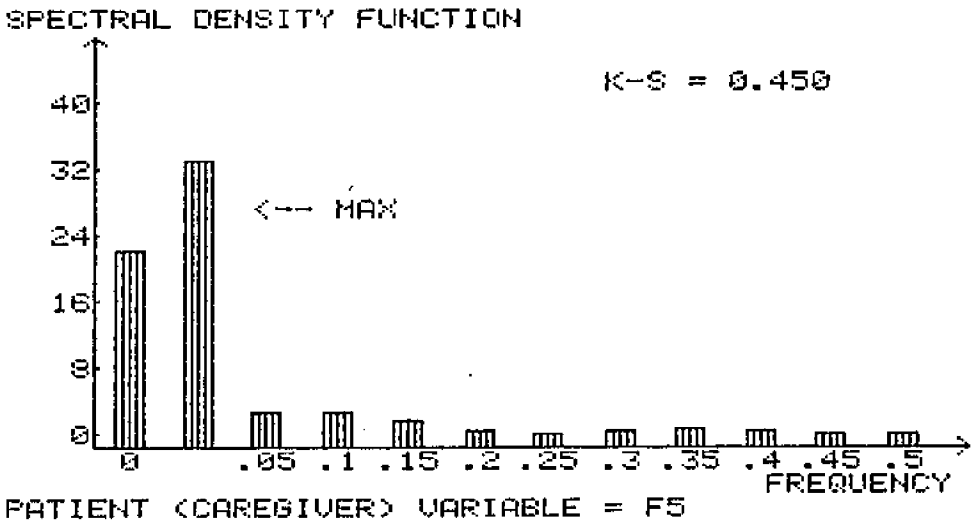
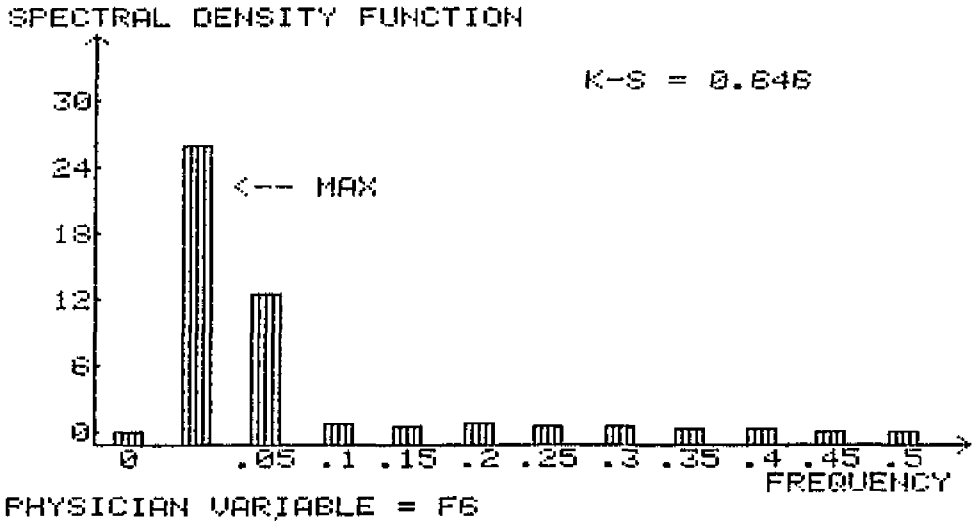


FIGURE 23

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 35 (DF6): VAR 49 (CGF6)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



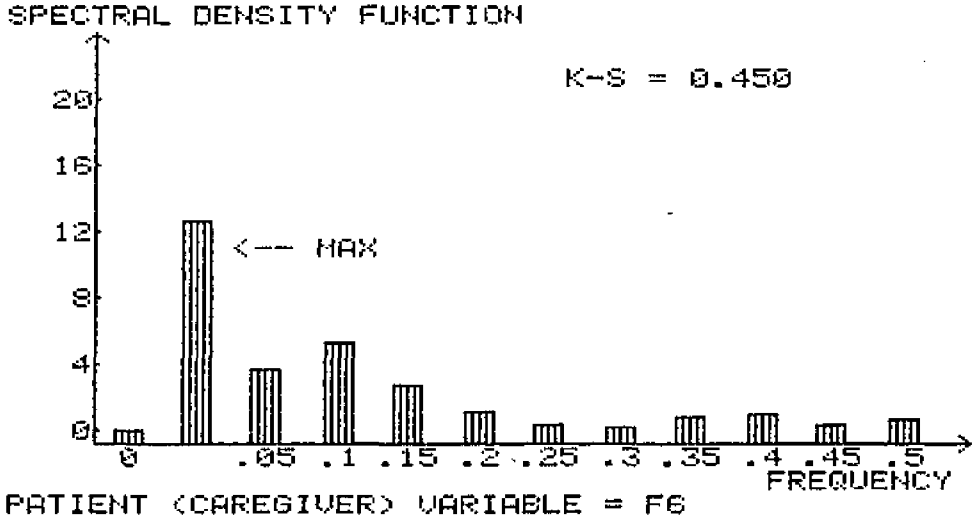
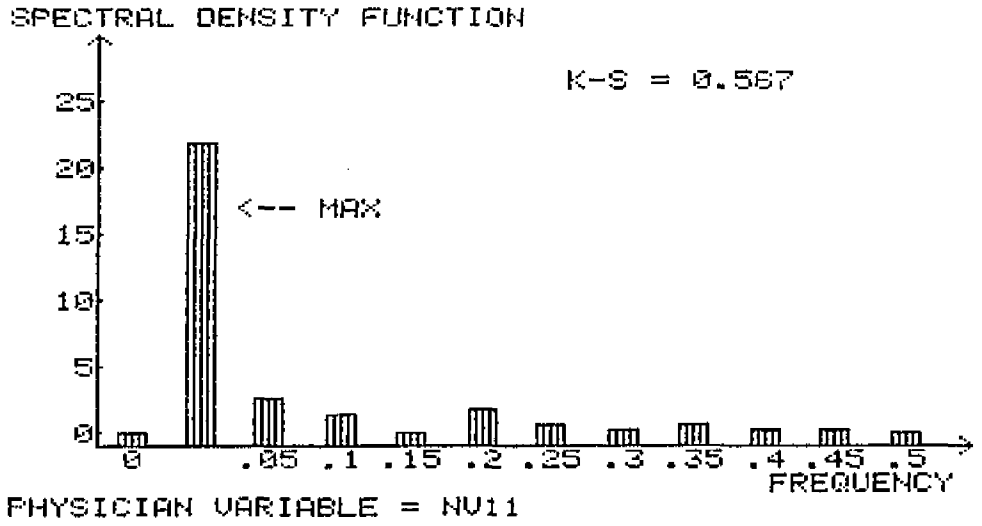


FIGURE 24

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 50 (DNV11): VAR 61 (CGNV11)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



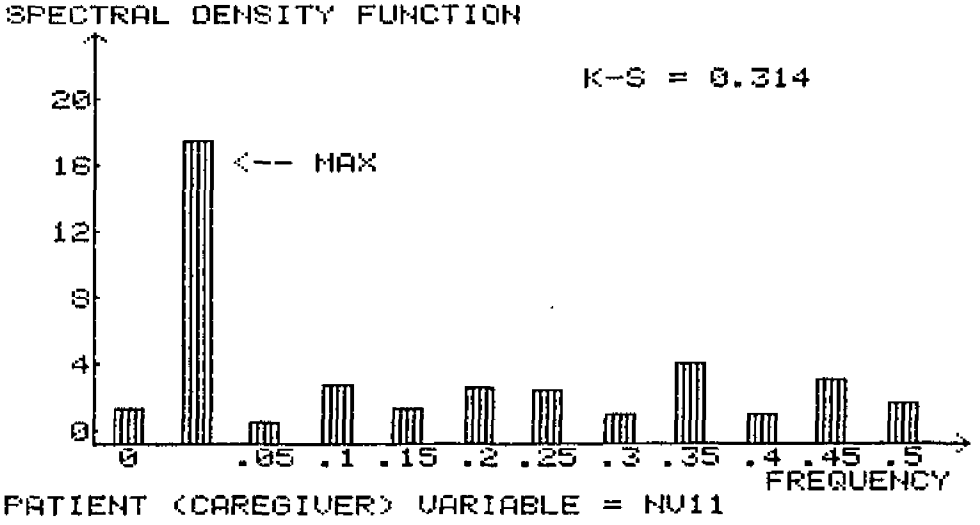
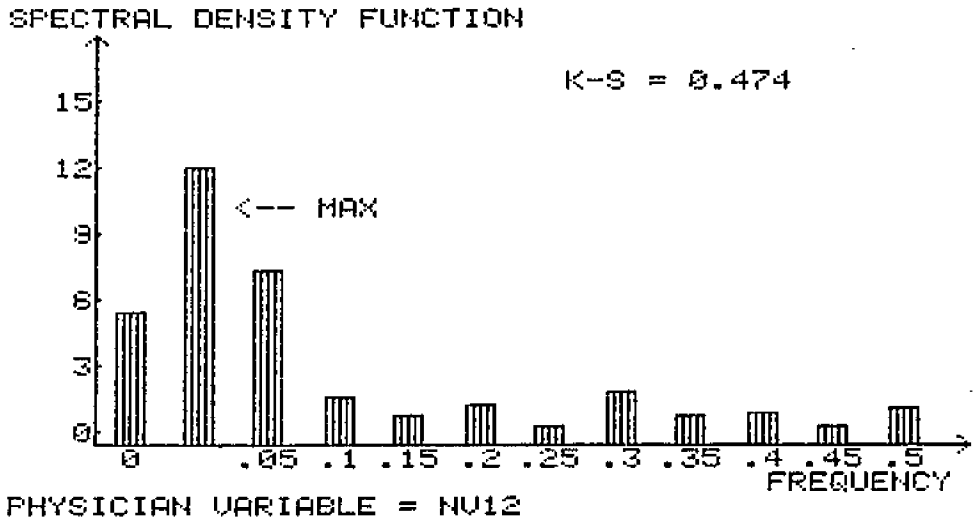


FIGURE 25

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 51 (DNV12): VAR 62 (CGNV12)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



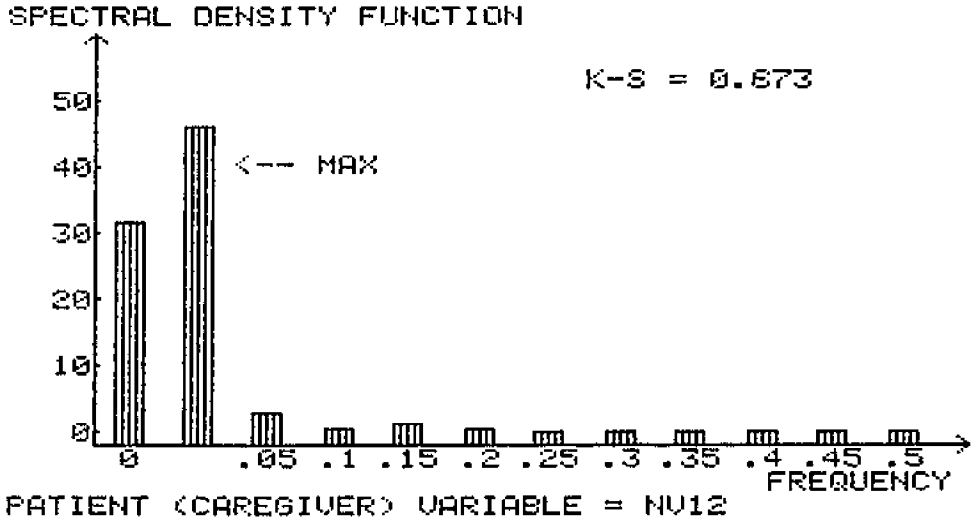
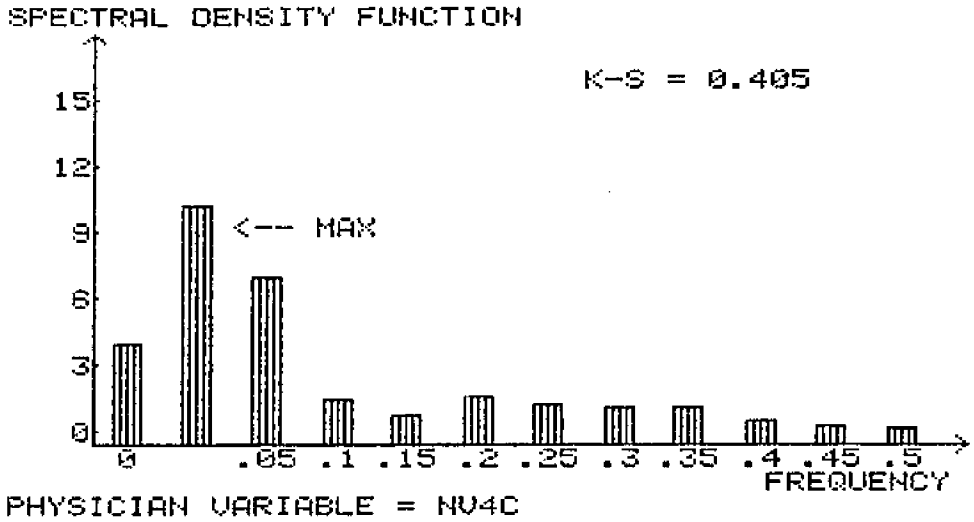


FIGURE 26

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 54 (DNV4c): VAR 65 (CGNV4c)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



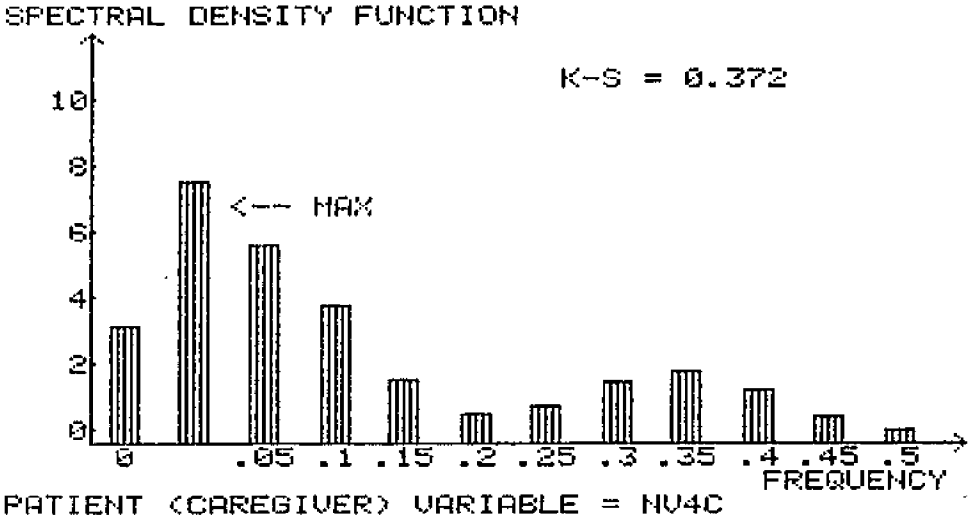
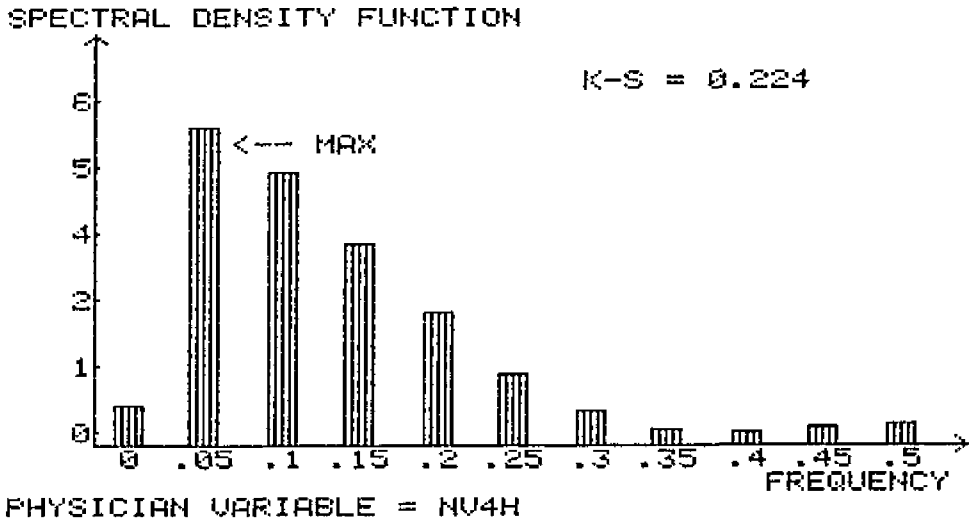


FIGURE 27

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 55 (DNV4h): VAR 66 (CGNV4h)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



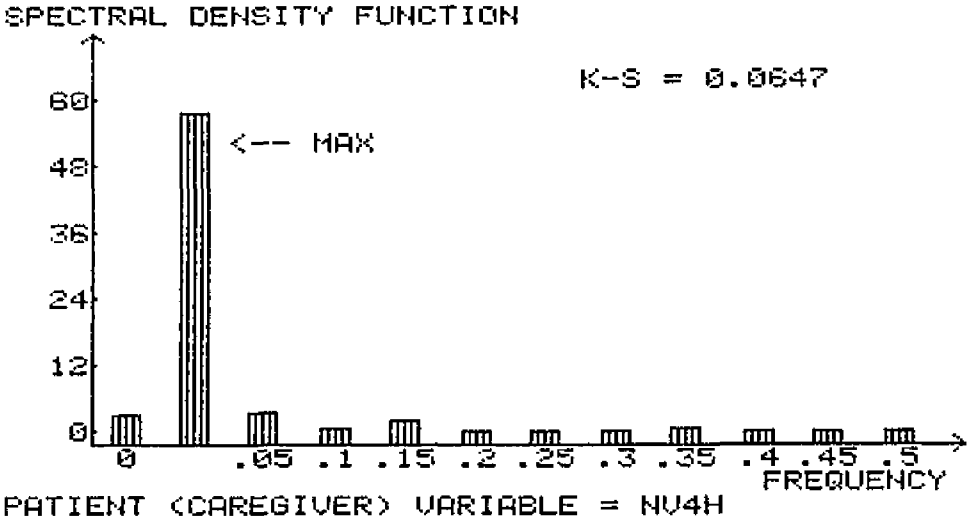
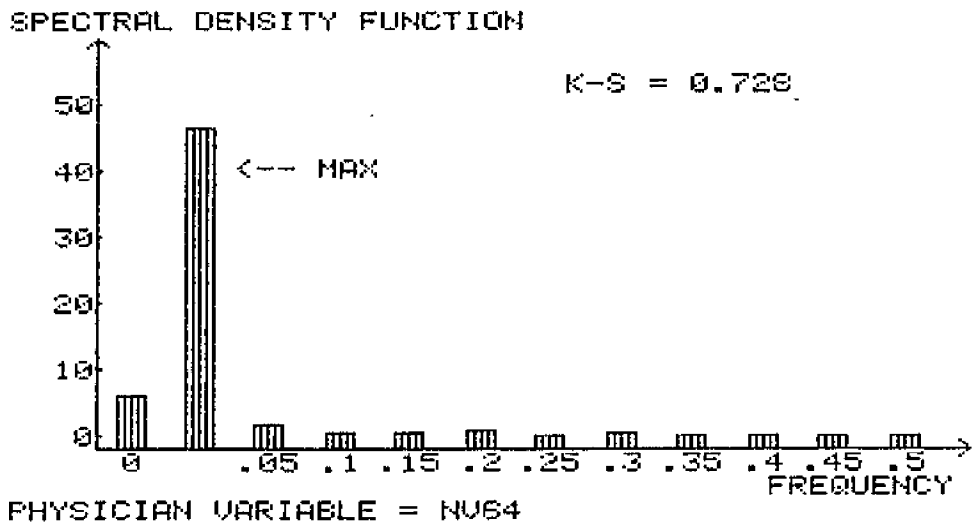


FIGURE 28

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 56 (DNV64): VAR 67 (CGNV64)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



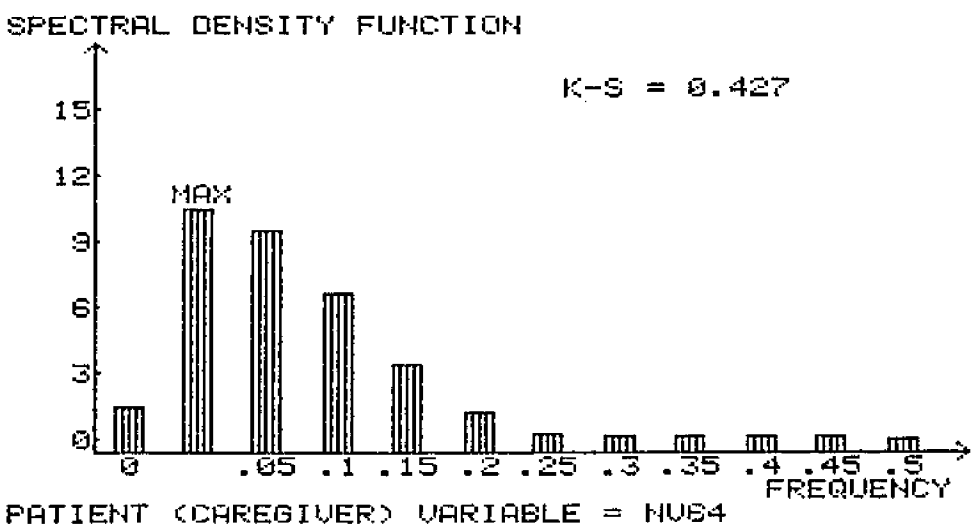
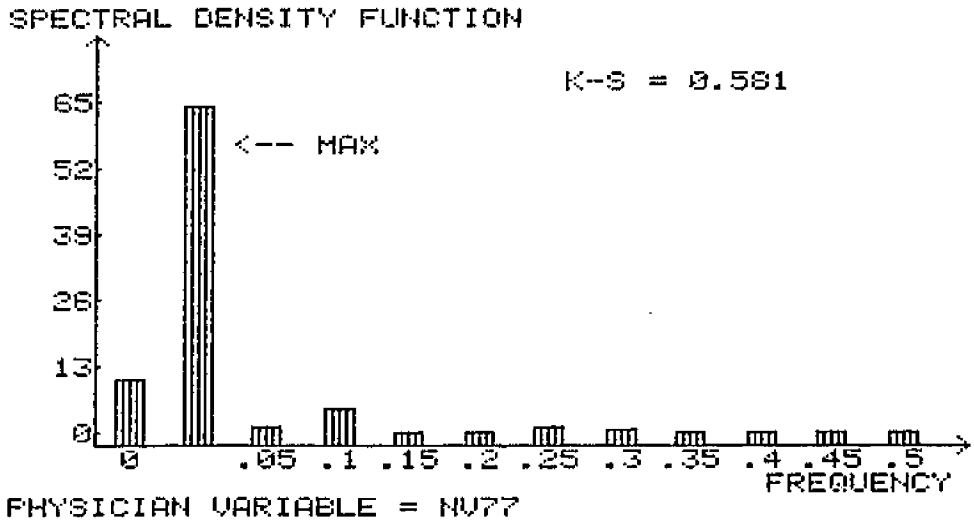


FIGURE 29

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 59 (DNV77): VAR 70 (CGNV77)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT



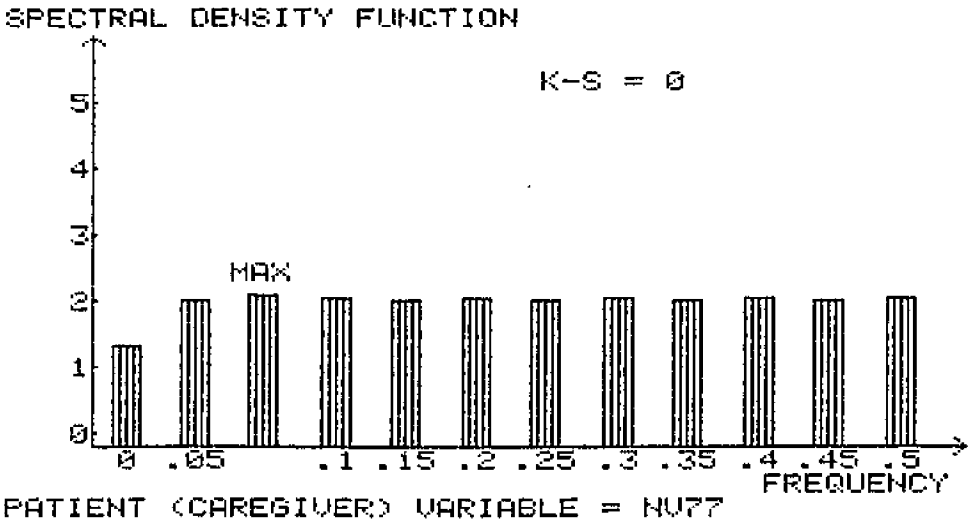
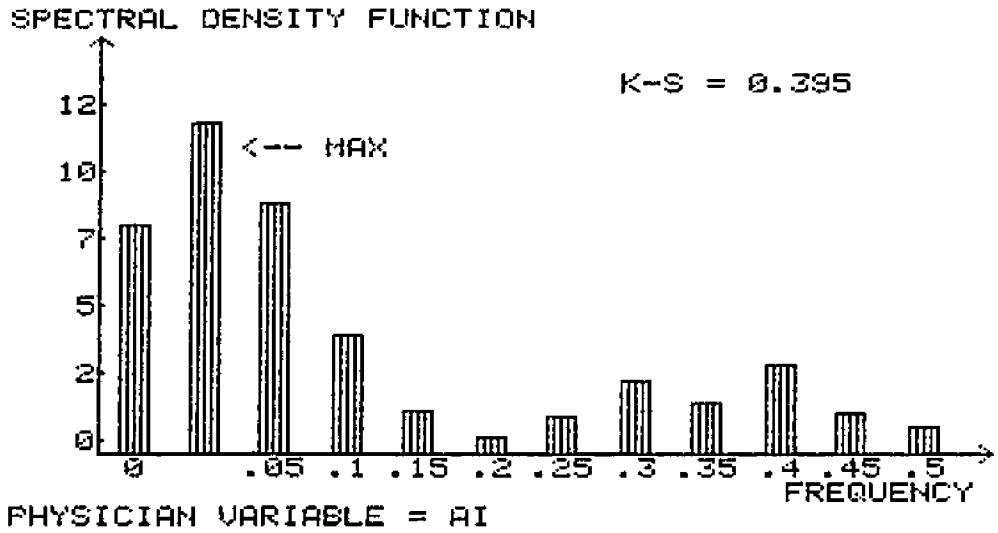
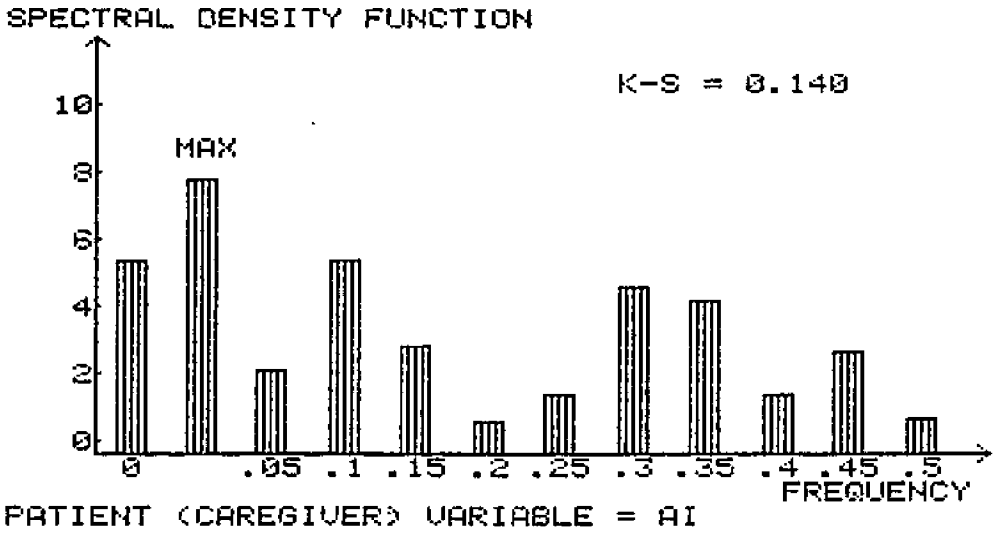


FIGURE 30

COMPARISON OF THE SPECTRAL DENSITY PLOTS OF
VAR 60 (DAI): VAR 71 (CGAI)
AND ASSOCIATED KOMOGOROV-SMIRNOV COEFFICIENT





CHAPTER 5

SUMMARY

Living organisms interact with each other. In interacting, the behavioral unit is not two separate individuals, but the whole single interaction (McBride, 1975). When two or more individuals gather together in some geographic location to accomplish a task they began to communicate. In this investigation, collective networks of communication signals were generated by a physician and a patient in order to keep a young infant child from experiencing medical difficulties. The complexity of interaction examined in this study supports the findings of Adler (1966) when he asserts that even irrelevant movements have the potential capacity to alter the communication signals of cooperating individuals. Of the many types of interactions possible, the physician-patient dyad represents "a stable system of individuals working together to achieve, through a hierarchy of ranks and divisions of labor, common goals" (Rogers & Agarwala, 1976, p.7). As this research study of clinical communication progressed, a system was needed to understand the subtle differences in the nature of the signals used by the subjects to share social and medical information with one another to meet with associated and mutually assumed tasks.

The specific purposes of this study were to:

1. Identify the relationships between the active communication vectors of physicians and patients as they communicate in the clinical environment.

2. Transform the qualitiative indices of the clinical interview to quantitative measures of communication in specific informational channels.

3. Utilize the "Hogan Interactional Profile of Physician-Patient Performance" (HIP4) to measure the time dependent topology of the clinical interview.

4. Compare the performance of the physician's utilization of the verbal channels of communication with the non-verbal channels of communication.

5. Compare the performance of the patient's utilization of the verbal channels of communication with the non-verbal channels of communication.

6. Test the hypothesis that no differences exist in the stochastic properties of the signals used to transmit and exchange information and white noise processes.

Research Findings

MAJOR HYPOTHESES

Analytical results providing support, or rejection of null hypotheses for this investigation are as follows:

1. Statistically significant differences (alpha = 0.05) between the mean activation times for the physician verbal communication signals and in patient (Caregiver) verbal commmunication signals in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of

Physician and Patient Performance" were found.

2. There are statistically significant differences (alpha = 0.05) between the mean activation times for the physician non-verbal communication signals and the patient (Caregiver) nonverbal communication signals in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance".

3. There is no statistically significant difference (alpha = 0.05) between the amount of information transmitted in the active verbal communication signals of the physician and the amount of information transmitted in the active verbal communication signals of the patient (caregiver) in a clinical environment as mapped by the topology of the "Hogan interactional Profile of Physician and Patient Performance".

4. The Pearson product-moment correlational coefficients between the amount of time required to transmit verbal signals by the physician and the amount of time required to transmit the verbal signals of the patient (caregiver) in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" was found to be "negligible" when evaluated according to Best's criteria.

5. The Pearson product-moment correlational coefficients between the amount of time required to transmit non-verbal signals by the physician and the amount of time to transmit non-verbal signals by the patient (caregiver) in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" was "negligible" when evaluated according to Best's criteria.

6. The Pearson Product-Moment Correlational Coefficients between the amount of information transmitted by the physician and the amount of information transmitted by the patient (caregiver) in a clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" are "negligible" when evaluated according to Best's criteria.

MAJOR SUB-HYPOTHESES

1. There are statistically significant differences in the distribution of the spectral coefficients in the active verbal communication signals for the physician and in the distribution of the spectral density coefficients of the active verbal communication signals for the patient (caregiver) in the clinical environment as identified with the "Hogan Interactional Profile of Physican and Patient Performance".

2. There are statistically significant differences in the distribution of the spectral density coefficients in the active non-verbal communication signals for the physician and in the distribution of the spectral density coefficients of the active non-verbal communication signals for the patient (caregiver) in the clinical environment as identified with the "Hogan Interactional Profile of Physician and Patient Performance".

3. There are statistically significant differences in the distribution of the spectral density coefficients in the amount of information transmitted by the physician and the spectral density coefficients in the amount of information transmitted by the patient as transmitted in the clinical environment as identified with the "Hogan Interactional Profile of Physician and Patient Performance".

MINOR HYPOTHESES

1. There are statistically significant differences in the spectral density coefficients across all analytical frequencies for the active verbal communication signals of the physician in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicated by the

Kolmogorov-Smirnov statistic.

2. There are statistically significant differences in the spectral density coefficients across all analytical frequencies for the active non-verbal communication signals of the physician in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicated by the Kolmogorov-Smirnov statistic.

3. There are statistically significant differences in the spectral density coefficients across all analytical frequencies for the amount of information transmitted by the physician in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicated by the Kolmogorov-Smirnov statistic.

4. There are statistically significant differences in the spectral density coefficients across all analytical frequencies for the active verbal communication signals of the patient (caregiver) as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicated by the kolmogorov-Smirnov statistic.

5. There are statistically significant differences in the spectral density coefficients across all analytical frequencies for the active non-verbal communication signals of the patient (caregiver) in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicted by the Kolmogorov-Smirnov statistic.

6. There are statistically significant differences in the spectral density coefficients across all analytical frequencies for the amount of information transmitted by the patient (caregiver) in the clinical environment as mapped by the topology of the "Hogan Interactional Profile of Physician and Patient Performance" and the spectral density coefficients for white noise as indicated by the Kolmogorov-Smirnov statistic.

Data for this study was generated from the videotaped performance of the communicants. The patient was a newborn infant and her mother, the caregiver. The physician was a resident in the final phase of clinical training in pediatrics in the couzens clinic of the Childrens Hospital of Michgan in cooperation with the Wayne State University School of Medicine. The verbal and non-verbal information for the physician and the patient, as generated by the

caregiver, was coded and digitized for further data analysis. The patient is involved in well baby care or problems associated with young infants. The total time of the interview was 13.92 minutes equivalent to 835,398 milliseconds of interactional time. This time dimension was divided into 200 equal segments of 4,177 milliseconds each.

These 200 segments of time represented the time dimension for analysis of the HIP4 topological vectors that were found to be active and the subsequent template of the vectors which represents the behavioral interaction of each communicant in the clinical environment. The template of HIP4 allows a further micro-analyses of the communication signals into one of two dichotomous classifications, active or inactive. This binary code represents the smallest bit of data permitted in the HIP4. The preservation of the real time associations will allow the analysis of the comunication channels to thousandths of microsecond units. This analytical refinement contributes to the precision of the HIP4 to "tune" in at an appropriate statistical level as dictated by the design of the research problem under investigation.

The HIP4 topology allows for several major categories of behavior, Verbal structure, Verbal Content, Form, Non-verbal content and Amount of Information. Each of these factors is further decomposed into components which yield an array of data across time for the signals which are created by each communicant as they exchange information. The HIP4

has the capacity to identify, for analysis, the behavior of 80 different factors associated with communication. The behaivoral template of the HIP4 indicates that 44% (N=35) of these factors were found to be active between the subjects of this study. The content of the signals of the verbal content demonstrates that the complaint of the patient can be idntified and the subsequent physician behaviors can be retained for analysis and later review.

The medical interview is important in the diagnosis and treatment of a complaint of the patient. The acquisition, evaluation and discussion of medical information serves to provide the patient with "faith" and trust in the physician. A skilled and experienced physician has learned that the transmission of information to the patient must be free of errors (white noise) and subject to unambiguous interpretation within the cultural norms of the patient. The HIP4 represents a method which is capable of demonstrating the complex nature of the clinical encounter with the patient. The difficulties encountered by an unsuspecting physician can result in an inaccurate diagnosis or reduction in the information necessary for effective planning and treatment for the patient.

The physician is not the only subject capable of having a performance evaluation with the HIP4. The increase in the size of the health care team requires that all members have interviewing skills, if they interact and extract valuable information from the patient or assist he patient in

understanding the conditions required to maintain or preserve their health. The hospital nurse, interacting with the patient to conduct interviews or collect data on a patient's physiological or psychological response to the treatment provided in the clinical environment, must send signals via face to face discussions with the patient.

Some researchers have defined the interview as a "specialized pattern" of verbal interaction (Enelow, 1979) initiated for a specific purpose and focused on a specific content area with the elimination of extraneous material (Bradley, 1983). The toplogical codes of the HIP4 assists in the identification of communication patterns and the measure of the qualitatve signals utilized to assist the patient. The work of Feinstein (1967) describes the decision making process of the scientifically valid art of medicine.

> The art of clinical examination comes from the attitues and qualities that are neither easily obtained nor easily detected by scientific procedures (p.7)

The validity of the HIP4 rests in the capacity of this methodology to generate a data base for the accumulation of evidence which supports the continued evolution of a theory which assists the clinical team in working with the patient to reduce and/or eliminate the pain of medical pathologies. In recent years, methods have been shown which provides a foundation for the analysis of information and has been given the name "Information Theory" (Gatlin, 1972). This theoretical foundation allows measurements of information to

retain their importance without incorporating errors in the signals which must transmit the information from one location to another through specific types of media. The HIP4 provides support for this theoretical foundation and further indicates that methods can be developed which allow the qualitiative measures of communication to be quantified and mathematically processed to provide direction in the growth of the medical profession.

The information content of the medical interview has been shown to be related to one or more of the features of the clinical encounter. When a patient is disoriented or confused, a change may be noted in the communication signals transmitted by that patient. Facial contortions may be random events or they may have some unknown etiology. The HIP4 allows the stochastic properties of such confusion to be documented and used to provide further evidence of the pathology of concern. A series of probabilities can be produced with the HIP4 which can be associated with any set of communication signals which allow a diagnostician to identify certain threats to the well being of the patient.

Cerebral arterioclerosis, uremia, neoplamic conditions and drug intoxication are candidates for analysis by the methods established in the HIP4. Each of these conditions has the potential to alter the communication signals transmitted by the interactants. The probabilities associated with a variety of ills can be progressively isolated and lowered when the symptoms are mapped by the

HIP4 in the early stages of the disease. Using the HIP4 to demonstrate a normative pattern of communication for each patient can allow the gerontologic difficulties to be isolated from the problems associated with an aging population.

The communicational patterns which reflect random events, those with low or zero probability of correlation with other features of the clinical information exchange, have low or minimal informational content with regard to the complaint of the patient. The discovery that the HIP4 can establish a previuosly unrecognized probability for associating the communication signals, specific to the clinical environment, and the communicants within this environment, implies that a process for recognizing potential information reservoirs under specific conditions which permit the transmission of the information to be uniquely configured is available.

The HIP4 methodology allows the informational content of the interview to be considered as a simultaneous event and as a basic component of both the topology of the interaction and the context of the medical problem under examination by the medical care team. The complex interdependence of precision, reliability and informational content represents the strongest set of assets for allowing research directions to be radically altered with the acceptance of the HIP4.

The model of communication established to assist in

understanding the major elements of communication include considerations of who says what in which channel to whom and with what effect (Lasswell, 1940) . While Shannon and Weaver analyzed communication in terms of isolated dimensions. These included the source of the signal, a transmitter of the signal, a receiver for the signal and a destination for the signal. Berlo (1960) synthesized these early notions into a single unified theory when he proposes the S-M-C-R model as the theory which best describes the communication event in small dyad type groups.

The HIP4 adheres well to the basic tenets of this model by providing an analytical method for understanding, through quantification, the communication events between the patient and the physician. The orientation to a process approach in understanding the communication event denies the possiblity of viewing observation or communication as static entities fixed in time and space. This process orientation has received the support of Gerald Miller (1978) in the Systems Theory when he asserts:

> Process implies that particular instances of communication should not be thought of as discrete events with identifiable beginnings and ends, but rather as parts of a dynamic on-going whole which has no clearly defind temporal boundaries. Process stresses the transactional nature of communication, rather than as a unidirectional linear act (p. 336).

Psychological and behavioral research can been defined by the statistical relationships existing between responding variables. This has involved use of such measures as central

tendency (mean) and/or variability indices for any hypothesized associations. But it is obvious that descriptive statistics are not sensitive to all the underlying forces and dependencies which exist in human response systems which comprise the communicational network typified by the physician-patient dyad. The arithmetic Mean and measures of dispersion (variance) are not sensitive to rhymicity and traditional correlation indices are not capable of reflecting the rhythmic co-occurrence of simultaneous activities which exist in complex interactional sequences and communicational episodes.

Physician communication with the patient provides data which are capable of providing information represented as sequential patterns of stimulus and response networks that are active across time. Appropriate methods to capture these unique pattern of communicational events in the naturalistic environment of the clinical examining room were non existent until recently (Hogan, 1979). An appropriate analytical method for investigating the communicative behavior of the physician requires that the information exchanged with the patient retain its contextural significance and temporal relativity. The data should not be collapsed using reductionistic principles for the purposes of analytical simplicity.

The creation of an instrument, the HIP4, which allows the exchange of information in the clinical environment between the physican and the patient to be captured as

sequential observations which preserves the temporal relationships of the interactants, represents a new method useful in understanding the nature of communication.

The data gathered by the HIP4 methodology can be defined mathematically as representing a "time series" consisting of a continuous string of variables which are sequentially indexed across time. The data obtained from the HIP4 can be analyzed in the time domain or transformed for analysis in the frequency domain. The communication signals measured by the HIP4 are activated for purposes unique to clinical encounters and the exchange of information between the physician and patient and are representative of verbal and non-verbal processes which can be demonstrated as functions of time.

The ability of the HIP4 to demonstrate that the mean activity coefficients of each measured variable are associated with informational flow and a source of energy for sustaining the integrity of the communicational bond between the interactants is a new development in the evaluation of human informational exchange. The continuous flow of information in the clinic is achieved by the interactions of variables which have definite purposes and compatabilities. Questions about the relationships of a variable or multiple variables need to be investigated. The mean activity times that are associated with the acceleration of verbal or non-verbal signals, as well as the deceleration of signal tramsmission, until termination of

the communicational episode is manifest, must be explored if the complaints about physician communication are to satisfied.

The capacity to investigate the time dependent nature of the interactional patterns of the physician allows the HIP4 to generate variables which may be further analyzed using autocorrelation measures. This technique represents an extension of the traditional methods of correlational analyses. The autocorrelation of physician and patient behavior, using the HIP4, allows an index of correlation to be produced by using a "time shifted" version of each detectable, and subsequently recorded, activity.

If the recorded behavior recognized by the HIP4 have any periodic components, the plot of the autocorrelations, or any tranformation of these autocorrelation functions, during different time lags will reflect a natural periodicity as it is produced or preserved.

The autocorrelational techniques of the HIP4 is hypothesized to represent the best method for detecting the periodicity of sequentially preserved behavior as the patient reveals personal and informational material to the physician for analysis and maintanance of helath and/or the reduction of disease conditions, particularly if the interaction is not contaminated by random elements of error.

When the variance of an exchanged communicational signal associated with information represents a small percentage of the total dispersion of the signal, then the

analytical interpretation of the signal becomes dependent on the a priori knowledge of the underlying periodic nature of the process which supports the cause for performing the analysis. The investigation of the sequential nature of HIP4 data matrices, in the frequency domain, is dependent on the spectral density function which is capable of providing a description of the periodic variation of the behavior of the physician (or patient) across time. The major quality of the information exchanged between the physician and the patient is that it may contain properties which may provide a cyclic component to the parameter of interest. The HIP4 provides a procedure to isolate this cyclic component and could provide further clarification on the processes active while interactants are exchanging information in the clinical environment.

The identification and utilization of spectral analysis allows the methods of the HIP4 to produce a detailed informational "fingerprint" on the cyclic and harmonic nature of the physician's behavior as it relates to the patient's behavior. It is hypothesized that spectral analyses of the activated HIP4 variables can produce a spectral density function which represents a Fourier transform of the autocovariance (unstandardized) function. Furthermore, the use of time dependent communicational measures of the HIP4 mrthod allows the study of rhythmicity within and between communicational paramenters activated by either the physician or the patient to be viewed and

correlated with synchronous associations with one another.

Physicians have a need to measure certain properties to describe the health or condition of a patient. Diseases of the cardiovascular system have been recognized as a major cause of death and illness in a contemporary technological society (Weiner, 1982). The conditions associated with this disease can be investigated by noting the variance related with cardio-pulmonary dispositions and respiratory activity. These relationships have been investigated (Lapes, 1976). Yet, the research has been nothing more than a replication of the previously published studies and show a dependence on traditional descriptive methodologies which have "attempted" to reveal the variablity which is associated with the condition causing the greatest predisposition for death of illness (Cheung, 1977; Coles, 1972; Lacey, 1967; Porges, 1969).

Physicians are involved in the investigation of the communication between organ systems that are associated with diseases and retain common descriptive indices for demonstrating the interdependency of their functional purpose. The communication of information in verbal or non-verbal channels of patients are typical of communication systems and are hypothesized in this investigation to have similar interdependent functions for the survival and health of individuals. It is readily apparent that deviant activity in the respiratory or cardiac behavior of patients may produce illness or death, but it must be substantiated that

the psychological or behavioral deviancy based on culturally influenced perceptions received via the active channels of communicative signals can produce an equally devastating effect on the human condition.

Using the HIP4 methodology to investigate physician and patient communication allows spectral techniques to demonstrate that the quantification of verbal and non-verbal behavior allows the periodicity associated with the signals to be related to the amount of information transmitted by either interactant to the other. In addition, the HIP4 methodology allows the partitioning of the variance in each of the measured signals transmitted and compared for synchronicity and bidirectionaly of effect across time. It would be an achievement to identify the communication frequencies which transmit the bulk of the informational variance between the interactants. The HIP4 is hypothesized to be capabable of isolating the frequencies which transmit the bulk of the information transmitted between the physician and the patient.

The communication process between the physician and patient is a complex process which cannot be described or appreciated by attempts to recognize rhythmicity by utilizing an exclusive view of the serially collected behavior in the time dimension. The absence of a pure sinusoidal distribution of the captured behavior could induce a perception of a dysfuctional relationship and result in errors of interpretation, causes or patterns of

associations and further impede the diagnosis of an acceptable condition which requires an appropriate set of behavior for the interactants. However, if a transformation of the interested associations are completed in a frequency domain, as in spectral analysis, significant associations can be revealed when the summed sinusoids are decomposed.

The analysis of frequency domain relationships in HIP4 variables have never been investigated for their significance in describing the complex interactions of direct communication between the physician and the patient. The evolution of this methodology at the Wayne State University Medical School with the cooperation of the Couzins Clinic of the Children's Hospital of Michigan will demonstrate the interdependency of communication signals as measured and preserved in the naturalistic environment of the clinic.

The spectral analyses of HIP4 variables can be compared with the traditional "Analysis of Variance" (ANOVA) tenchniques. This investigation proposes to demonstrate that the variance in the communicational signals of the physician (or patient) may be partitioned in a way which is analogous to the partitioning of the variance in ANOVA. The use of the spectral density function will decompose the Total Mean Squares (TMS) or variance into Mean Squares (MS) over all constituent frequency bands of the interaction, just as ANOVA decomposes the TMS into orthogonal constituent MS, reflected as main effects, interactive effects and error

terms.

Limitations of the study

This study did not investigate the evolving complexity of previous communication netwoks established by these interactants or between each interactant and the individuals of similar cultural norms. The differences in the communication signals are affected by the environment of the communicants and this study keeps the environment constant by video-taping the behavior in the medical clinic.

Suggestions for further Research

The rate at which information is transmitted should be investigated with the HIP4 for both the physician and the patient. The change in the identity of the patient having similar complaints should be compared for the differences in the commmunication signals as a result of personality differences. The long term study of clinical relationships should be investigated to note the harmonious patterns found to exist or the signals which lead to incongruites in physican-patient compliance ratios.

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ABSTRACT

THE EVALUATION AND MEASUREMENT OF
PHYSICIAN & PATIENT COMMUNICATION

BY

SHEDRICK ERVIN WARD

DECEMBER, 1988

ADVISER: Dr. Martin J. Hogan & Dr. Claire Irwin
MAJOR: Research and Evaluation
DEGREE: Doctor of Philosophy

This project demonstrates a research method to measure and investigate the nature of the communication signals between two cooperating individuals, a physician and a patient (or caregiver) in a specified environment. Each of the cooperating individuals are involved with one another in a medical clinic for "well-baby" care and are preserved on video-tape for analysis. The interaction was coded and digitized from the recorded video-tape by a method to be known as the HIP4 (Hogan Interactional Profile of Physician-Patient Performance).

The dicotomized signals from the HIP4 vectors allowed mean activity scores to be generated for 44% (N=35) of the (N=80) HIP4 vectors. Anova results of the HIP4 communication template of behavior indicate significant differences were found to exist in the mean activity scores for communication signals ($F = 15.9$, d.f. = 11,188, $p<0.05$) between the physician and the patient.

Multiple comparisons were subsequently completed to identify the location of significant relationships. In addition Pearson product moment correlations were calculated

for the activity scores across active vectors. A "Data-Myte" digicoder was used to preserve verbal and non-verbal behaviors of communicants.

Spectral density coefficients were generated from the HIP4 for 100 individual frequencies, up to and including the Nyquist frequency, of the interaction for each of the active variables. These coefficients were hypothesized to be no different than the coefficients of white noise as indicated with the Komolmogorov-Smirnov Probability ratio.

Several behavioral scores for the physician and patient's communication signals were found and classified as stochastic and not associated with HIP4 variables that were active. Nonverbal behaviors are treated as communication vectors and were found to be associated to the amount of information transmitted between the physician and the patient.

AUTOBIOGRAPHICAL STATEMENT

Shedrick Ervin Ward, the first born son of Mable (Polk) and Robert Lee Ward, was born May 26, 1949 in New Iberia, Louisiana. He attended the Detroit Public Schools and graduated from Mumford High School in 1966. During his undergraduate studies at Wayne State University he was a chemistry major and completed the requirements for graduation in 1975. He worked various odd jobs to pay for his education being employed as a dishwasher, janitor, truck-driver, and finally as Surgical Physician's Assistant at Henry Ford Hospital during his undergraduate study.

After being employed as a science teacher in the Detroit School system at Burroughs Junior high school, he began graduate studies in psychology earning his Master's degree (1976) and initiated doctoral studies in the fall of 1979. During graduate studies he has been employed as a high school chemistry teacher at Detroit's Central High School. His efforts and concern about classroom instruction brought honor, in 1985, as "Chemistry Teacher of the Year", an award allowing him to become recognized and promoted as the chemistry teacher at Detroit's Renaissance High School where he is currently teaching. He has been a lecturer in statistical methods at The University of Michigan and has been an active participant in developing research skills in the urban high school student.

He is a single parent and is a member, or has been a member of Phi Delta Kappa, AERA, NSTA, AAAS, ACS, MDSTA.