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A COMPUTER SIMULATION OF SHAPING AND "MEF" RELATIONS IN A FUNCTIONAL APPROACH TO SYNTACTIC VERBAL BEHAVIOR.

The University of Oklahoma, Ph.D., 1975
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GRADUATE COLLEGE

A COMPUTER SIMULATION OF SHAPING AND "MEF" RELATIONS IN A FUNCTIONAL APPROACH TO SYNTACTIC VERBAL BEHAVIOR

A DISSERTATION

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

DOCTOR OF PHILOSOPHY

By

Steven L. Renshaw

Norman, Oklahoma

1975

A COMPUTER SIMULATION OF SHAPING AND "MEF"
RELATIONS IN A FUNCTIONAL APPROACH
TO SYNTACTIC VERBAL BEHAVIOR

APPROVED BY

DISSERTATION COMMITTEE

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ABSTRACT

The purpose of this study was to develop and simulate an axiomatic system based on a structural/functional approach to language interaction in communication. Though communication is often defined as process, few approaches have dealt adequately with the systematic relation of constructs over time. Thus, the rationale for the study is based upon a review of basic structural and functional concerns in language behavior, the need for a combination of both, theoretical bases which may aid in the construction of such an approach, and a set of pre-theoretic assumptions which provide guidelines for a rigorous development of an axiomatic system.

The axiomatic system proceeds from a set of primitives to a series of definitions, axioms, and theorems. The four basic relations which emerge in the system concern the language interaction of persons over time. These relations include: (1) shaping (Sha) toward similarity, (2) mutual effect (Mef) toward similarity, (3) counter-shaping (CSha) toward dissimilarity, and (4) counter-mutual-effect (CMef) toward dissimilarity.

Based upon the axiomatic system, a mathematical model was derived, and a simulation program was written to test the internal validity and logic of the system. The justification for such a procedure was based, in part, on the need for further clarification and development of the system. As a result of the simulation, (1) two axioms were falsified, and substitutions were found; (2) twelve additional axioms and/or theorems were developed; (3) due to the existence of unique cases, two additional definitions of relations were developed including shape-counter-shape (ShaCSha) and mutual effect-counter-mutual effect (MefCMef); (4) a method for describing combinations of individuals within n-member groups was established.

Suggestions are made for further development of the logical structure of the axiomatic system, and guidelines are proposed for (1) the empirical validation of the structure, (2) the relation of the structure to other variables and constructs, and (3) the impact of the approach on the broader context of social and cultural systems.

ACKNOWLEDGMENTS

To acknowledge every person or work which has had an influence on one's intellect and scholarship is an impossible task. However, there are certain persons which deserve special mention with regard to this research.

Dr. Wayland Cummings has been an unending source of ideas and encouragement throughout the three years I have been at Oklahoma. He has been tolarant of my mistakes and excited by my own attempts at creativity. Dr. Blaine Goss has provided a foundation for many of the ideas developed in this work and has considerably aided in the clarification of some of the basic concepts. Dr. Willaim Carmack has helped me to view communication from several perspectives. Drs. Alan Nicewander and Roger Mellgren provided valuable insight in the development of both the simulation and axiomatic system. My friend and colleague, Paula Wright, also helped me to clarify some of the basic ideas of this work. Gary Whitley of the O.U. computer center aided in the placement of the computer program on an object module.

My wife, Sharon, deserves very special mention. Her intellect and creativity have considerably influenced the development of my own. I think our relation has been one of mutual-effect since we have known each other.

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INTRODUCTION

That communication entails both process and interaction seems to be generally accepted by researchers in the field. One has but to look at most fundamentals textbooks (Giffin and Patton, 1971; Scheidel, 1972; Wenburg and Wilmot, 1973; and Burgoon, 1974) to find definitions of communication as process, interaction, transaction, or some combination of these. Yet despite a growing emphasis on communication as process, the concept seems to remain elusive. After turning past the introductory chapters of most communication texts, one still finds the doubtful dichotomy between source and receiver variables and a general lack of conceptual relations of variables as they interact over time.

The major thrust of this research work revolves around the question of how communication behaviors of participants in social interaction effect and are mutually effected by those of others. The purpose is twofold: (1) to develop a formal axiomatic system of language interaction on which a more complete theoretical system may be built, and (2) to extract a mathematical model from the axiomatic system and simulate language behavior within different communication settings. The need for a structural/functional approach to language behavior is presented in Chapter I. This rationale includes a review of relevant theoretical bases and research, and a set of pre-theoretic assumptions on which a structural/functional theory may be built. A formal axiomatic system of interactive language behavior is presented in Chapter II. Based upon this system, a mathematical model, steps in the simulation, and execution of the simulation are presented in Chapter III. Chapter IV is devoted to the results of this simulation, and Chapter V includes a discussion of these results together with conclusions and speculations about the future of research in this type of system.

A COMPUTER SIMULATION OF SHAPING AND "MEF" RELATIONS IN A FUNCTIONAL APPROACH TO SYNTACTIC VERBAL BEHAVIOR

CHAPTER I

RATIONALE AND THEORETICAL APPROACHES

That language forms the basis of communication exchange seems apparent. That it is one of the most difficult communication variables to pursue empirically also seems evident. As Cherry (1966) states:

> Language makes a hard mistress and we are all her slaves. It is difficult to exaggerate the influence which she exerts upon our lives, yet she is aloof and mysterious. Anyone who would consort with her, to study and understand her, leaves himself open to a severe discipline and much disappointment (p. 77).

Perhaps because of this difficulty, it has not been until recent times that communication researchers have pursued with any vigor language encodings as they relate to the interactive nature of communication. As both Lashbrook (1974) and Cummings (1974b) have indicated, it may indeed be such message variables that lead to the evolution of a distinct field of "Communication" based upon information exchange. One has but to look at most research in message factors (See McGuire's 1969 review for example) to see that the emphasis has not been the interaction of persons through language, but rather such variables as fear appeals, style, and order effects. Though these variables may have their importance, it would seem that they have more or less run their course, and their contribution to our understanding of the interactive nature of communication seems to remain at best doubtful.

What then is the role of language as a message variable in the study of human communication? If, indeed, communication is to be viewed as both process and interaction, then it would seem that the previously mentioned treatment of messages as independent variables and primarily source oriented may need to be replaced with a theoretical approach which treats participants as both sources and receivers whose behaviors are mutually interdependent. Since language plays such a central role in this concept, then as Cummings (1974c) further indicates in his plea for a more social interactive approach to communication, "we must be concerned with interdependent language behaviors (p. 14)."

Structure and Function

The quest for an approach to language behavior which is fitting for the interactive nature of communication leads the researcher to a variety of theoretical frameworks. Cherry's reference to the mysterious and often elusive nature of language becomes exceedingly clear. One seems to be immediately confronted with issues such as competence versus performance, mentalism versus behaviorism, natural versus artificial language schemes, and usually the problem of "meaning". Perhaps a more useful typology of theoretical approaches is offered by Catania (1973). He argues that many of the controversies mentioned above rest in what seems to be a lack of understanding of structure and function. Using an analogy with biology, Catania further argues that structure may be compared to a science of anatomy or morphology and function to a science of physiology. The questions of structure thus become ones concerned with the components of a specific concept, questions of "what", and primarily phenomenological concerns. Questions of function are then concerned with problems of "why" or "how", and primarily teleological issues.*

A central point in Catania's argument is that both of these approaches are necessary to a "complete" science of human behavior. Likewise, it can be argued that an understanding of communication as both process and interaction may necessitate not only a specification of the components of the phenomena but also the functional relations of these components over time.

Another central argument of Catania's discourse is that most researchers in social science have tended to confuse structuralism with mentalism, or cognitive concerns and functionalism with behaviorism. As Catania indicates;

> a major argument of /_the author's_/ account is that psychological controversy has often originated because the dichotomy between structure and function has been confused with that between mentalism and behaviorism (p. 435).

Indeed, theorists with structural concerns include both mentalists

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*The reader should consult Rudner (1966) for a discussion of functionalism, teleological issues, and the inextricable relation between time and a precise functional approach. Problems associated with some approaches which have taken a functional orientation are discussed in the section on theoretical bases.

such as Chomsky (1957, 1965) who deal with syntactic structures of the mind, and behavioral learning theorists such as Staats (1968) who are concerned with behavioral structures through classical or other conditioning and associations of stimuli with responses.

The commonality which both of these otherwise disparate approaches have is that they deal with structures of language primarily in an individual with little emphasis on the interaction of these structures with other structures over time. Indeed, it can be argued that few, if any, of the theories of language behavior currently available deal sufficiently with the interaction of behavioral or mental structures in sufficiently precise sense (See again Rudner, 1966).

Both mentalists or cognitive theorists and behaviorists may be so concerned with the differences between their basic assumptions about the nature of man that they fail to realize that the proper domains of their research may lie in dealing with those questions, whether structural or functional, appropriate to both. Cognitive and mentalistic theorists seem to have been somewhat more successful with explanation of phenomena than behaviorists. To the extent structures of the mind are important, the concepts of language acquisition devices, corpus of speech, meaning, and transformational rules, seem to offer at least plausible explanations of language. However, the lack of empirical validation of such mentalistic structures leaves these approaches with little predictive powers and perhaps less to say about the functional relations of language structures in communication interaction (See Cummings, 1974b; Cummings and Renshaw, 1975).

In a similar manner, learning theorists have been somewhat more successful in prediction of behavior than cognitive theorists, yet they too can be criticized for a lack of ability to adequately deal with interactions of behavior. As Cummings (1974c) indicates;

> A learning theory approach to language behavior (and perhaps any behavior) requires a model which will both explain acquisition of language and the "relearning" of language in human social settings. Any learning theory which analyzes either CS-UCS association, response selection (free operant conditioning), or stimulus selection (discrimination learning) is inadequate (p. 12).

Thus learning theories which rely primarily on a passive organism and its acquisition of certain behaviors through conditioning may not provide an adequate basis for an interaction of language behaviors in communication. Indeed, Skinner's (1953) concept of the "lump of clay" being passively shaped and molded may need to be replaced by a concept which entails both shaping and the mutual effecting of the linguistic structures of humans as they interact socially.

It can be seen from the brief analysis above that both behaviorists and mentalists have fallen short of contributing to an understanding of human interaction over time within social settings. Both to one degree or another seem to have been preoccupied with the structures of man, whether cognitive or behavioral. Though the importance of these should not be minimized, expansion of these philosophical bases may be necessary to answer fundamental questions concerned with the interactive nature of communication. As Catania argues;

> Structural analyses of grammar and speech . . . cannot tell us when a person will decide to speak, or what he will talk about. It is precisely these latter questions that are the concern of a functional analysis of language (p. 436).

It is certainly not the contention of this research that structural approaches to language be eliminated. As Mahood (1974) has recently argued, perhaps the question of "what" is more important at this stage of our knowledge of communication than questions of "how". To be sure, structural theorists in language are concerned with "what". It would seem, however, that the researcher interested in communication as social interaction must be concerned with both "what" and "how", concept and relation, structure and function.

The value of structures, thus, seems to lie in their ability to predict to human interaction in social settings. A structure need not necessarily be observable to fit this criterion. As Robinson (1972) argues in an analogy with the electron;

> Questions like "What are electrons for?" would probably be ruled as inappropriate in the discourse of electronics. Even if we were to allow electrons an existential rather than a conceptual status, we would not consider answers like "To carry negative electric charges" as good physics. . . . they are not _for_ anything, they just are - or we might prefer to say that the concept of "electron" _is useful_ (p. 38, italics mine).

Thus, one does not reject the concept of electron simply because it has not been observed. Its usefulness lies in the explanatory and predictive powers it has in the fields of physics and chemistry. Likewise, one cannot totally reject hypothetical structures because they are not easily observed. However, and perhaps most important, their usefulness lies in their power both to explain and aid prediction of language behavior.

It is the major contention of this analysis that an approach to communication which treats that phenomena as social interaction and process must be concerned with the functions of structures especially as they interact over time. Toward this end, many of the concepts advanced both by cognitive theorists and behaviorists may prove useful.

Theoretical Bases: Toward Structure and Function

There are several theoretical bases which have contributed to the development of the structural/functional system presented in Chapter II. These include some of the basic concerns of sociolinguistics, concepts of behavioral reinforcement, content analysis, and processing notions of information theory, particularly probability and stochastic models.

As may have been discerned in the previous section, both sociologists and psycholinguists have to one degree or another been concerned with structures.* However, while the major concern of Chomsky (1968) is the analysis of structures as an end to innateness of mental structures, the major concern of sociologists such as Bernstein (1972) is the "communal" or manifest social structure of language. The general difference between these two approaches in terms of operational and methodological concerns is summed by Cummings

*See Cummings and Renshaw (1975) for further discussion and contrast of these approaches.

and Renshaw:

> The psychological orientation has adopted the distinction between surface and deep structure, and the attendant desire for two operational schema of syntactics. The sociological orientation, however, has generally, but not exclusively, adopted a concern for syntactics of verbal behavior as it is used, i.e., functionalism (Grimshaw, 1973). Both a manifest and latent syntactic analysis, including a complete set of rules, is required for the psychological orientation, whereas the sociological orientation tends to be more concerned with manifest structure (p. 4).

Thus, the sociological orientation would seem to best lend itself to a functional analysis of language interaction over time. The problem with much of the research conducted by scholars in this area is not that social structures of language are avoided, but that there appears to be a lack of a sufficiently precise typology of language behaviors, as well as a general lack of a functional theory relating sociolinguistic structures over time. An approach to language behavior in communication settings of two or more persons would seem to require not only a specification of the social structures of language, but the interaction of these structures as the communication interaction progresses.

The sociolinguistic approach explained above entails the concept of mutual reinforcement and dependent language behaviors of individuals participating in communication interaction. This is not unlike a position which Skinner (1957) takes in his analysis of speaker and listener.

> We need separate but interlocking accounts of the behavior of the speaker and listener if our explanation of verbal behavior is to be complete. In explaining the behavior of the speaker we assume a listener who will reinforce his behavior in certain ways. In accounting for the

> behavior of the listener we assume a speaker whose behavior bears a certain relation to environmental conditions (p. 34).

To be sure, one cannot deny the existence of shaping and reinforcement in any communication situation. The participants effect and are effected by the behaviors of others. For a structural/functional approach to communication as interaction, it would seem to be necessary to consider both the structures of language and the effects, mutual or otherwise, of shaping and reinforcement. In such an approach, none of the participants would be considered a passive receptor of reinforcements, but an active processor and "effector" of the behaviors of others.

The quest for a theoretic typology suitable for research in manifest language structures, and thus the functions of language behavior, has led to a series of measurement theories* commonly subsumed in the broader class of content analysis (Pool, 1959; Stone, Dunphy et al., 1966; Holsti, 1969). Most content analysis research has concerned the encodings of individuals as they relate to internal constructs rather than encodings as they relate to other encodings. As Robinson (1972) indicates;

> Content analysis is normally exploited to find out what the emitter is thinking or feeling rather than what functions the verbal behavior is performing, and the classificatory systems utilized are usually intended to elicit information about the types and strengths of motives, values, or attitudes rather than a specification of other information that might be transmitted (pp. 42, 43).

The application of content analysis to a structural/functional analysis

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*"Theory" here refers to a precise descriptive typology.

of language behavior in communication settings would seem to necessitate a system which at once specifies manifest structures of linguistic syntax and at the same time provides the basis for a functional analysis of structures in relation to the encodings of all participants.

Such a typology has been developed by Cummings (1970a, 1970b). Rather than dealing with syntactic structures in latent form, Cummings' system utilizes the manifest syntax observed in the encodings of an individual involved in a communication situation. The major elements of the system include: (1) subject signs, (2) modifier signs, and (3) connector signs (See Appendix A). Subject signs basically include all subjects and objects of verbs. Modifiers include all signs which modify subject signs and signs which modify connectors. Connectors include all verbs. Of particular interest are the subclassifications of connectors. Besides the common classification of verbs according to tense and mood, Cummings further makes distinctions according to the function of a verb as it compares two subject words (more than, subset, spatial), or as it indicates action. The usefulness of this classification has been demonstrated by Cummings in his research to reflect such cognitive structures as dogmatism, anxiety, attitudes, and intelligence. Its further usefulness may lie in its emphasis on manifest structure and the typology of language categories it provides for a structural/functional analysis of interdependent language interactions.

There is one other theoretical approach which forms the basis for the structural/functional system presented in Chapter II. This approach includes the concepts of probability and stochastic processes as they relate to information theory.

It can be said that one of the most important contributions of Shannon (1948) in his presentation of information theory was the concept of chance in human interaction (Mandelbrot, 1965). Coupled with the work of Shannon was the development of the "law of least effort" by Zipf (1949). What these two approaches seemed to have in common was the importance of probability in the scope of human encoding and decoding. The principle of least effort as applied to encoding was basically an argument that there exists an inverse ratio between word length and frequency of encoding; words of shorter length had a higher probability of being encoded in any message than words of greater length. As Mandelbrot indicates, Zipf's law together with Shannon's principles of "quantity of information" point directly to the concept that man may utilize probability in the words he encodes.

This concept has been further expanded by theorists concerned with perception, decision theory, and organization of information. Broadbent (1971, 1973) in his information processing model of perception has advanced the position that man operates on his world through a series of probabilities. Following each decision based upon these probabilities, a re-evaluation occurs such that new probabilities for similar situations in the future are derived. Broadbent has emphasized the use of Baysian statistics to deal with the changing probabilities. The importance of what Broadbent is saying seems to be in his argument that man actively processes the information in his environment. The responses he makes to this environment are based upon probability notions. Specifically in the field of linguistics, Herden (1962,

1966) has advanced the notion that linguistic encoding may be viewed as a probability and statistical system. A person's store of language behaviors may be viewed as a population from which he samples in any linguistic utterance. Here again, it would seem that probability may play an important role in the choice a person makes for any linguistic utterance.

In the field of Speech Communication, Hawes and Foley (1973) have developed a model of dyadic interaction based upon Markov processes. Essentially, a Markov process is a stochastic process in which the probability of any event is dependent upon the previous event. Since stochastic processes are related to any phenomena to which probability may apply, Markov analysis of communication behavior may indeed be directly related to a functional/structural approach to language behavior.

The commonality of all the theoretical approaches subsumed in the information theory-probability model is that they assume an active information processing individual who makes decisions on the communication he emits. These concepts would seem to form the basis for what Goss (1975) refers to as intrapersonal and interpersonal communication structures, the latter comparable to a manifest structure. Though the primary emphasis of this dissertation is on interpersonal structures and the functions of language in human social settings, the concept of the human organism as an active processor of information plays a central role in this model.

Thus, the theoretic bases elucidated in this section point to a structural/functional approach which includes a primary emphasis on the manifest structures of language and the interaction of these structures in communication. Such an approach would assume active processors of information who may both shape and mutually effect the manifest structures of one another as they interact.

Relevant Research

There are some specific areas of research within the theoretical bases presented above which deserve note here as they relate to structural/functional concerns. Robinson (1972) indicates that most functional approaches in both psychology and linguistics have emphasized content classifications of speech behavior. He cites as examples Bales' (1950, 1970) Interaction Process Analysis and Halliday's (1969) functional models of language. Robinson indicates that though these approaches may be concerned with the "uses" of language, they tend to be either narrow in scope, or they use definitions which "are far from precise and they are given no structural realizations nor possible differentiating concomitants on the behavioral side (p. 46)." Thus research utilizing these classification schemas has not really dealt adequately with either specification of manifest structures or the functional relations of these structures. Indeed, their contribution to an understanding of communication, specifically linguistic aspects of communication as process, seems to be doubtful.

Some interesting research is provided by Newcomb (1953, 1956, 1958) relating to the interaction of individuals over time. Though dealing primarily with interpersonal attraction and similarity of attitudes, Newcomb nevertheless has a concern for interaction as process. He offers evidence that as individuals interact over time, they tend to acquire similar attitudes. The value of Newcomb's research in a structural/functional approach to language interaction does not lie in his use of the construct of attitude, but rather in his emphasis on the mutual effect on the participants in dyadic interaction. This concept indeed plays an important role in the system presented in Chapter II.

Some evidence on the similarity of language behavior within a dyadic situation is offered by Ruesch and Bateson (1951), Runkel (1956), and Triandis (1960). Although mainly concerned with cognitive similarity, these researchers noted that patients in therapy situations tended to acquire the jargon of the psychiatrists as they interacted over time. Here, at least, is some evidence that the choice of linguistic utterances of individuals within dyadic communication is affected by interaction, and in this situation, a similarity primarily through the dominance of one person seems to emerge.

The merit of the research reported above seems to lie in the orientation with which each situation is approached. Instead of concern with one act of the participants, the researchers appear to be dealing with the effects of interaction on each member over time. The major ideas which seem to surface in these perspectives are: (1) that persons may effect one another in interaction and become similar over time, (2) one participant may be more dominant in influencing the verbal behavior of the other as similarity is realized, and (3) the general concept that persons cannot communicate without effecting one another.

Such perspectives would seem to form the heart of a structural/functional approach to communication. Though none of the researchers mentioned above specify the relations between either persons or their language behavior and interaction over time, their orientation may provide the groundwork for an approach which seeks to not only specify structures of language, but also the functional relations of variables as they interact over time.

Other research of particular interest for a structural/functional approach to communication is presented by Hawes (1972). Hawes' basic concern was the effect of differing interview styles on clients involved in therapy sessions. Hawes found that certain interviewer styles, specifically directive and non-directive, had an effect on the communication behaviors of clients either increasing certain content classes or decreasing in some cases. In a re-analysis of the same data, Hawes and Foley (1973) utilized their Markov analysis of the content categories selected. Utilizing both state and transitional probabilities, they were able to plot the development and change of verbal behaviors over time. The importance of this research is seen in the emphasis on communication as a process, the use of probabilities of what is encoded, and the concern with the interactions of encodings over time. Some problems which may limit the generalizability of this research include: (1) the use of the medical interview rather than a natural setting, (2) emphasis on the dyad, (3) and a primary concern with one of the participants (the interviewer) as the primary "shaper" in the interaction.

Perhaps as important as the research conducted by Hawes and Foley are some assumptions about the communication act provided by Hawes (1973). These assumptions include the following:

> Communication is a spatio-temporal series of concatenous acts. . . a series of interconnected things or events.
>
> Communication is a process phenomenon simultaneously involving two or more symbol-using animals.
>
> Communication functions to create and validate symbol systems which define social reality and regulate social action (pp. 13, 14, 15).

These assumptions would seem to be tacitly important to an approach which considers both linguistic structures and their functions (Cummings, 1974c).

The research strategies and studies mentioned above seem to offer empirical evidence that the behaviors of individuals in communication interactions are to some degree at least effected by those of others. Yet there does not appear to be an approach which specifies the manifest <u>linguistic</u> structures of individuals and the functional relations of individuals and these structures. Toward that end, the development of such an approach is presented in Chapter II.

Pre-Theoretic Assumptions

The previous sections of this chapter have concerned: (1) the rationale for a structural/functional approach to the interaction of language in communication situations, (2) theoretical bases which would seem most viable for such an approach, and (3) some relevant research relating to these concerns. Taken together, these sections form the pre-theoretic bases for a precise axiomatic system on which a structural/functional theory may be built. It has not been the purpose of these sections to develop any one theoretical base to the exclusion of others. All appear to have defects as well as merits.

Research is presented to provide a view of an orientation which is concerned with the interaction of humans over time in specific situations.

It is the major contention of this chapter that several approaches may contribute to a broader theory of language interaction over time within communication settings. Toward that end, a case has been made that few, if any, of the theoretical or research perspectives should be eliminated, but rather that a synthesis of the several approaches may be necessary.

Based upon the concepts elucidated in the first three sections of this chapter as well as the general perspective presented above, the following pre-theoretic assumptions are made:*

1. Man is an active processor of information.

2. In any social situation, man has a repertoire of behaviors, including language behaviors.

3. Man operates on his environment as an active organism and may make decisions on the appropriate behaviors based upon probability.

4. The probabilities of selection for any language behavior are dependent upon three factors: (1) prior learning, (2) restraints of syntax, and (3) effects of interaction in the given communication situation.

5. A communication interaction includes two or more individuals, behavioral repertoires, and the alteration of selection from each repertoire by effecting relations between the participants.

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*Precedence for proceding from pre-theoretic assumptions to an axiomatic system stems from procedures generally adopted in set theory and other general mathematics (See McCoy, 1968; Youse, 1970).

6. The manifest language structures of individuals in a communication interaction function to both define and regulate the relations of individuals in that interaction.

These assumptions form the basis of the axiomatic system developed in the following chapter. No claim can be made that the system deals with every assumption. However, as mentioned above, the system is designed to form the basis for a structural/functional theory which may integrate the most viable parts of the theoretic bases provided in this chapter.

CHAPTER II

AN AXIOMATIC SYSTEM

Because a fully formalized theory or model as articulated by Rudner (1966) is beyond the scope of this work, the system presented here, based upon the assumptions given in the previous chapter, should be more appropriately called "toward a structural/functional theory" rather than a complete formalized theory. However, the construction of the system presented here represents the basis for a more formalized theory of interaction. A primary consideration of the approach taken here is that a theory of communication as interaction should be based upon a sufficiently precise set of statements that falsification of the concepts through empirical research is possible.

The criteria for construction of this axiomatic system is based upon that set forth by Rudner. In general, the system proceeds from a set of primitives which have varying means of operationalization. Definitions based upon these primitives and statements derived from combinations of definitions and axioms are then presented. The language and rules for formation of statements are mathematical in nature and based upon set theory, algebra, and differential calculus. A brief key to symbols used may be found in Appendix B. Transformational rules which determine what theorems may be derived from other statements is based upon a symbolic logic of propositions.

The System

The following terms used in the axiomatic system are held to be primitive:

1. person
2. behavior
3. word
4. time

These terms have varying degrees of operationalization. Without getting into a detailed discussion of the difficulty in operationalizing these terms, it can be seen that the two most easily determined are time and person. Time may be expressed in years, days, hours, minutes, or seconds. The basic unit of time used within the system is an interval of 1. Time may be considered to be isomorphic with the set of positive real numbers, and the exact measure awaits empirical validation which is beyond the scope of this particular study. Person may be operationalized as a unit of 1, a set of persons being expressed in some subset of positive integers. The terms not so easily operationalized are word and behavior. Behavior may be considered an act of a human, but the researcher who wishes to test the system must delimit the concept to specific acts. The researcher may also be concerned with behaviors not necessarily human. The concept of word as used in the system entails the notion that a word is a behavior. Specific delimitation of this term may entail numerous problems, and particular classifications of utterances may need to be used (Cummings, 1970a; Cummings and Renshaw, 1975). Behavior and word may, of course, be considered in units isomorphic with the set of positive integers.

> Definition 1. A behavioral repertoire (R) is by definition a set of subsets each element of which is a behavior.

Specific identification of a behavioral repertoire necessitates a classification system of behavioral acts. The researcher who utilizes this system may limit the scope of behaviors with which he is concerned. Since the primary concern of this work is the interaction of language behaviors within communication settings, the language repertoire becomes the primary focus.

> Definition 2. A language repertoire (L) is by definition a subset of R in which each r in L is a set of words.

Cummings (1970a, 1970b) has developed a classification system which may provide the basis for this set of subsets. A more precise description is found in Chapter I.

> Definition 3. A situation behavioral repertoire (K) is by definition a subset of R such that if P is a set of persons and T a set of time intervals, then for each t in T and p in P, K exists.

> Definition 4. A situation language repertoire (W) is by definition a subset of L such that if P is a set of persons and T a set of time intervals, then for each t in T and p in P, W exists.

These situational repertoires represent specific sets of behaviors which may occur in a given time segment.

> Definition 5. An interact set (I) is by definition a set of persons P, time intervals T, language repertoires (L) corresponding to each p in P, and a set of subsets W of L for each p in P and t in T.

The concepts elucidated above basically represent the hypothetical linguistic behaviors available to a person at a given time. In any given time segment, a subset of the total possible behaviors exists. The basic elements necessary for communication at this point must include: (1) persons, (2) behavioral repertoires for each person, (3) language repertoires for each person, and (4) a subset of these language repertoires at any given time segment.

Axiom 1. For any p in P and t in T, $W \subseteq L$ may equal $\emptyset$.

Definition 6. Let $p \in P$, $t \in T$, and $W \subseteq L$ corresponding to p and t. Then for each $w \in W$, a word index (v) is by definition the cardinal number of w divided by the cardinal number of W.

The word index provides a convenient means of assessing the use of certain language categories. Within a specific category system, the word index would simply be the frequency of a certain category divided by the total of all frequencies in all categories for a fixed time interval.

Definition 7. Let $Q \subseteq P$, $t \in T$, and $W \subseteq L$ corresponding to $p \in Q$ and t. Let n equal the cardinal number of Q. Then an interact combination (c) $= \sum_{i=1}^{n} v_i$.

An interact combination is basically a mean word index for a group of n persons.

Definition 8. Let $Q \subseteq P$, $M \subseteq P$, c_Q and c_M corresponding to Q and M for some $t \in T$. Then Difference (D_{QM}) is equal to $|c_Q - c_M|$.

Definition 8a. Similarity (S_{QM}) is equal to $1-D_{QM}$.

Definition 9. Let $Q \subseteq P$ and c_{tQ} defined for some $t \in T$, c_{t-1Q} for $t-1 \in T$. Then change in c_{tQ} (Δc_{tQ}) is equal to $(c_{tQ} - c_{t-1Q})$.

Definition 10. Let $Q \subseteq P$ and c defined for every $t \in T$. Then the change in c with respect to time is equal to the derivative of c with respect to time ($\frac{dc}{dt}$).

In essence, word indexes and interact combinations can be expressed as functions of time. The derivatives of these equations provide a means of assessing change over time.

Definition 11. Let $Q \subseteq P$, $M \subseteq P$, D_{QM} and S_{QM} defined for every $t \in T$. Q Sha M means by definition that the following conditions hold:

1. $c_Q = a_1 \tanh(t) + b_1$ for all t.
2. $c_M = a_2 \tanh(t) + b_2$ for all t.
3. $\Delta c_{tQ} * \Delta c_{tM} \geq 0$ for every $t \in T$.
4. $|\Delta c_{tM}| > |\Delta c_{tQ}|$ for some $t \in T$, $|\Delta c_{tM}| \not< |\Delta c_{tQ}|$ for any t.
5. $D_{QM} = A\tanh(t) + B$, $A<0$, for all t.

Definition 11a. In general the Sha relation holds if conditions 1, 2, and 5 hold, and the derivatives of each c conform to conditions 3 and 4.

Theorem 1. If $D_{QM} = A\tanh(t) + B$ for all t, then $B = |c_{Q0} - c_{M0}|$

Proof: $D_{QM0} = A\tanh(0) + B$.
$D_{QM0} = B$ since $\tanh(0) = 0$.
$D_{QM0} = |c_{Q0} - c_{M0}|$ by definition 8.
$B = |c_{Q0} - c_{M0}|$

Theorem 2. If $c_Q = a_1 \tanh(t) + b_1$ for every t then $b = c_{Q0}$.

Proof: Follows as in theorem 1 by taking tanh(0).

Theorem 3. If Q Sha M then $a_1<0$ and $a_2<0$,
or $a_1>0$ and $a_2>0$,
or $a_1=0$ or $a_2=0$ but not both.

Proof: Case 1
$\$\ a_1=0$ and $a_2=0$.
Then $c_Q = b_1$
$c_M = b_2$ from definition 11.
$D_{QM} = |b_1 - b_2|$ from substitution and definition 8.
$D_{QM} = B$ from theorems 1 and 2.
$D_{QM} = B$ implies that $A\tanh(t) = 0$ which implies that $A=0$ or $\tanh(t)=0$.
Since tanh(t) cannot equal 0 for all t,
$A=0$, a contradiction to Definition 11.
$\therefore$ $a_1=0$ and $a_2=0$ cannot hold.

Case 2
$\$\ a_1>0$ and $a_2<0$.
From definition 11a, taking the derivative of c_Q and c_M,
$a_1 \mathrm{sech}^2(t) * a_2 \mathrm{sech}^2(t) \geq 0$.
Let $k = \mathrm{sech}^2(t)$.
Then $a_1 k * a_2 k \geq 0$.
$k=0$ implies that $\mathrm{sech}^2(t)=0$ for all t,
a contradiction.

For $k>0$, $a_1k>0$ and $a_2k<0$ which implies that $a_1k*a_2k<0$, a contradiction.

$\therefore$ $a_1>0$ and $a_2<0$ cannot hold.

Case 3

$\nexists$ $a_1<0$ and $a_2>0$

Proof follows as in Case 2 that this condition cannot hold.

Taking each of these cases by elimination, only the three conditions in the theorem may hold.

Axiom 2. Let Q, M, O be subsets of P. Then if Q Sha M and M Sha O, then Q Sha O.

Definition 12. Let $Q \subseteq P$, $M \subseteq P$, D_{QM} and S_{QM} defined for every $t \in T$. Q CSha M means by definition that the following conditions hold:

1. $c_Q = a_1 \tanh(t) + b_1$ for all t.
2. $c_M = a_2 \tanh(t) + b_2$ for all t.
3. $\Delta c_{tQ} * \Delta c_{tM} \geq 0$ for every t.
4. $|\Delta c_{tM}| > |\Delta c_{tQ}|$ for some $t \in T$, $|\Delta c_{tM}| \not< |\Delta c_{tQ}|$ for any t.
5. $D_{QM} = A \tanh(t) + B$, $A>0$.

Definition 12a. In general the CSha relation holds if conditions 1, 2, and 5 hold, and the derivatives of each c conform to conditions 3 and 4.

Theorem 4. If Q CSha M then $a_1<0$ and $a_2<0$
or $a_1>0$ and $a_2>0$
or $a_1=0$ or $a_2=0$ but not both.

Proof: Follows in same manner as that for Theorem 3.

Axiom 3. Let Q, M, O be subsets of P. Then if Q CSha M and M CSha O, then Q CSha O.

Theorem 5. Let Q, M be subsets of P. Then if Q Sha M then not M Sha Q.

Proof: From section 4 of definition 11, Q Sha M implies no change in c_M is less than the change in c_Q. But M Sha Q implies that such a relation exists for some t, a contradiction.

Theorem 6. Let Q, M be subsets of P. Then if Q CSha M then not M CSha Q.

Proof: Follows as in Theorem 5.

The relations specified in the previous statements are the shaping (Sha) and counter-shaping (CSha) concepts. Essentially, shaping involves the acquisition of similarity over time primarily as the result of change in one interact combination. Counter-shaping involves the acquisition of increasing difference over time primarily due to changes in one interact combination.

Definition 13. Let $Q \subseteq P$, $M \subseteq P$, D_{QM} and S_{QM} defined for every $t \in T$. Q Mef M means by definition that the following conditions hold:

1. $c_Q = a_1 \tanh(t) + b_1$.
2. $c_M = a_2 \tanh(t) + b_2$.
3. $\Delta c_{tQ} * \Delta c_{tM} < 0$ for some t and $\not> 0$ for any t, or $|\Delta c_{tQ}| = |\Delta c_{tM}|$ for every t.
4. $D_{QM} = A \tanh(t) + B$, $A \leq 0$.

Definition 13a. In general the Mef relation holds if conditions 1, 2, and 4 hold, and the derivatives of each c conform to condition 3.

Theorem 7. If Q Mef M then $a_1 < 0$ and $a_2 > 0$
or $a_1 > 0$ and $a_2 < 0$
or $a_1 = 0$ and $a_2 = 0$.

Proof: Utilizing a procedure similar to that in theorem 3, the proof follows.

Axiom 4. Let Q, M, O be subsets of P. Then if Q Mef M and M Mef O then Q Mef O.

Theorem 8. If Q Mef M then M Mef Q.

Proof: Follows simply from section 3 of definition 13; condition holds regardless of order of Δc.

Definition 14. Let $Q \subseteq P$, $M \subseteq P$, D_{QM} and S_{QM} defined for every $t \in T$. Q CMef M means by definition that the following conditions hold:

1. $c_Q = a_1 \tanh(t) + b_1$.
2. $c_M = a_2 \tanh(t) + b_2$.
3. $\Delta c_{tQ} * \Delta c_{tM} < 0$ for some t and $\not> 0$ for any t, or $|\Delta c_{tQ}| = |\Delta c_{tM}|$ for every t.
4. $D_{QM} = A \tanh(t) + B$, $A > 0$.

Definition 14a. In general the CMef relation holds if conditions 1, 2, and 4 hold, and the derivatives of each c conform to condition 3.

Theorem 9. If Q Mef M, then $a_1>0$ and $a_2<0$
or $a_1<0$ and $a_2>0$

Proof: Again follows from similar procedure as in Theorem 3.

Axiom 5. Let Q, M, O be subsets of P. Then if Q CMef M and M CMef O, then Q CMef O.

Theorem 10. If Q CMef M then M CMef Q.

Proof: Follows as in Theorem 8.

The relations defined above are the mutual-effect (Mef) and counter-mutual-effect (CMef). The Mef relation involves the acquisition of similarity over time through the mutual change of both interact combinations. It should also be noted that the unique case of $a_1=0$ and $a_2=0$ as well as A=0 occur only in the Mef relation. The Mef relation was chosen for these cases as the lack of any effect (or the presence of an equal change in the same direction for both combinations) implies that neither have been dominant in change over the other, and difference has not increased or decreased. The CMef relation involves the acquisition of dissimilarity over time again through the mutual change of both interact combinations.

Definition 15. A communication interaction (C) contains by definition a set of persons (P), subsets of P (Q, M, O,...), sets of R corresponding to each $p \in P$, a set of time intervals (T), subsets of R (W) corresponding to each $t \in T$ and $p \in P$ and at least one of the following relations: Sha, CSha, Mef, or CMef.

The major thrust of the axiomatic system presented here revolves around the interaction of behaviors over time within communication settings. It can be seen that in any situation, the basic components of an interact include persons, behavioral repertoires, behaviors for a given time segment, and the four defined relations. With a specific emphasis on language behaviors, each word index at a given time can be viewed as a probability for that behavior in the next time frame. Thus, changes in encoding behavior at any time become directly related to the probabilities of other individuals involved in the interaction.

Obviously, the system cannot be considered complete or closed. It may be noted that the system at present concerns primarily the description of interaction over time. No specification of any extraneous variables leading to one or more of the relations is made. Thus, the system, would seem quite open to development along at least two lines: (1) a specification of the combinations of relations and derived statements for differing communication settings may be added to the set, and (2) a specification of the relation between the system and other variables such as learning theory, cognitive processing, leadership, and power in groups. The second area is so large as to be prohibitive for one or two research projects. The first, though quite extensive, appears to lend itself to a procedure which would allow an analysis of different situations and values, given the assumptions of the system. Such a procedure is available through the use of computer simulation. The remaining portions of this work are concerned with this type of procedure. A more specific justification and precise questions are presented in the following chapter. Suggestions concerned with the second area are given in Chapter V.

CHAPTER III

A MODEL AND SIMULATION

Justification and Procedure

Abelson (1968) defines simulation as the "exercise of a flexible imitation of processes and outcomes for the purpose of clarifying or explaining the underlying mechanisms involved (p. 275)." A simulation of a given phenomenon, thus, should provide both a clarification and a specification of the relations involved in that phenomenon. According to Abelson, simulations have been used to assess phenomena ranging from social interaction to human intelligence. Since the usual method for testing a theory or axiomatic system involves the generation and testing of hypotheses, it would seem necessary to justify any departure from this procedure.

In the choice of a computer simulation for the further development of the system under consideration in this work, the following justifications were considered. First, a simulation would provide more information than any one empirical study. In the previous chapter, it was noted that the further development of the axiomatic system necessitated further specification of combinations and statements concerned with differing communication settings. With the digital computer, a variety of situations ranging from 2 to n member groups could be viewed in hypothetical situations. This would seem to provide more information about the nature of the defined relation than, for example, a single study with twenty dyads. Second, a simulation would provide a means of assessing parameters for research in a variety of situations. Such parameters would also provide a means of establishing a criteria for judging the fit of the axiomatic system to empirical data. Third, a simulation would provide a means of viewing a number of possible situations in order to assess whether or not certain of the axioms hold, for example, the transitive property of shaping (Sha). Finding one possible case where this property does not hold would negate that axiom, and actually provide a test of the logical structure of the system. Fourth, a simulation would provide a means of developing combination properties of the defined relations, for example, if Q shapes M (Q Sha M) and M counter-shape O (M CSha O), then what is the relation between Q and O. Though many of these combinations may be derived from the system analytically, a simulation would limit the number which may be integral to the system. Fifth, a simulation in general should provide a means of assessing any unusual cases which may occur but cannot be explained by the system.

It should be pointed out that the simulation reported in this chapter was not an empirical or external validation or falsification of the axiomatic system, but instead was an internal validation of that structure. It was designed primarily to amplify and clarify the basic relations. On this basis and the justification mentioned above, the following specific research questions were of primary concern:

1. What possible conditions will the system not describe accurately?

2. Given certain individual relations within n-member groups, what types of relations emerge when individual scores are combined?

3. What possible situations, if any, contradict axioms or theorems within the system?

4. What new theorems or axioms can be developed from the simulation which concern combinations of the defined relations?

5. Given initial index or combination values, are there other equations which fit better than the tanh function?

The computer simulation designed to answer these questions was developed using the following procedure (Some steps are taken from Abelson, p. 283):

1. A detailed mathematical model was developed to determine the equations to be used in the simulation.

2. This model was then translated into a specific sequence of steps which could be computerized (This included the development of a flowchart).

3. Storage requirements were assessed in relation to computer facilities available.

4. Choice of the appropriate computer language was then made.

5. The program was written.

6. The program was simulated by hand.

7. Debugging took place.

8. The program was run on full-scale hypothetical data.

In developing the simulation, two programs were written. The first contained a sufficient number of iterations as to be prohibitive of any objective analysis. The model in the following section (Model I) and output in Appendix C are reported for illustrative purposes only.

The importance of this model is found in its illustration of the difficulty found in trying to iterate many initial values as well as trying to establish equations when only initial values are known. The plot function built into the program based upon this model is useful in that it should provide the reader with a graphic view of the defined relations. Instructions for reading representative output are included with these graphs in Appendix C. The program based upon Model I will not be reported as its relevance to the basic questions raised in the previous section is minimal.

Mathematical Models

The following two models are derived from the statements in the axiomatic system. Iterated values in Model I are starred (*).

<u>Model I</u>

1. Let $w_{a0}*$ and $w_{b0}*$ be initial index values at time 0, $w_{a0}>w_{b0}$.
2. $S_{ab}= *A\tanh(t) + B$
3. $B = 1 - (w_{a0}-w_{b0})$ since $S=1-D$, thus $S_0=B=1-(w_{a0}-w_{b0})$.
4. Let $A>0$. (Case 1)
5. Let $w_a = *a_1\tanh(t) + b_1$, (Various curves for w_a)
6. $b_1= w_{a0}$
7. $w_b=w_a-|1-S_{ab}|$. (Values for w_b derived from w_b)
8. Let $A\leq 0$ (Case 2)
9. Let $w_a= *a_1\tanh(t) + b_1$
10. $w_b=w_a-|1-S_{ab}|$.

Model II

1. Let n be the number of persons in I.

2. Let w_{i0} be an index for the ith person at time 0.

3. Let w_{i1} be an index for the ith person at time 1.

4. $b_i = w_{i0}$.

5. Since $w_i = a_i \tanh(t) + b_i$ and $w_{i1} = a_i \tanh(1) + b_i$,

$$a_i = \frac{w_{i1} - b_i}{\tanh(1)},$$

hence $w_i = \left(\frac{w_{i1} - b_i}{\tanh(1)}\right)\tanh(t) + b_i$.

Condition: If $w_i > 1.0$ or $w_i < 0.0$, model does not fit.

6. Let w_i and w_j be different indexes, $0 < i \leq n$, $0 < j \leq n$, $i \neq j$.

7. Estimated D (Equation from points given):

$$D_{ij} = |w_i - w_j| = A_{ij}\tanh(t) + B_{ij}.$$

$$B_{ij} = |w_{i0} - w_{j0}|.$$

$$D_{ij1} = |w_{i1} - w_{j1}|.$$

$$D_{ij1} = A_{ij}\tanh(1) + B_{ij}.$$

$$A_{ij} = \frac{D_{ij1} - B_{ij}}{\tanh(1)},$$

hence $D_{ij} = \left(\frac{D_{ij1} - B_{ij}}{\tanh(1)}\right)\tanh(t) + B_{ij}$

Condition: If $D_{ij} > 1.0$ or $D_{ij} < 0.0$ for any t, then model does not fit.

8. Let $w_{i0} - w_{i1} = c$ and $w_{j0} - w_{j1} = g$

9. Let $e = cg$.

10. If $e < 0$ or $|c| = |g|$ and $A_{ij} \leq 0$, then the relation "Mef" holds.

11. If $e < 0$ or $|c| = |g|$ and $A_{ij} > 0$, then the relation "CMef" holds.

12. If $e \geq 0$ and $A_{ij} < 0$, then the relation "Sha" holds.

13. If $e \geq 0$ and $A_{ij} > 0$, then the relation "CSha" holds.

14. Let k= the number of interact combinations in the group of size n.

15. Let l_m, 0<m<k, be the number of persons in each interact combination m.

16. $c_{m0} = \sum_{r=1}^{k} \frac{w_{r0}}{k}.$

17. $c_{m1} = \sum_{r=1}^{k} \frac{w_{r0}}{k}.$

18. Repeating steps 4 through 13 for each interact combination, relations between each are established.

The simulation program developed in this chapter was based upon this mathematical model. Each of the statements was derived from the basic axioms, definitions, and theorems of the system.

Simulation Program

Following the second step of the procedure, Model II was translated into steps which could be computerized. The flowchart for this procedure may be seen in illustration 1. The facilities available at The University of Oklahoma included an IBM 370-158 digital computer. Since estimates of storage requirements did not exceed 100K, and the actual program took only approximately 75K, no problems were encountered.

The programming language chosen for translation was PL/I. The advantages of this language over Fortran IV lay not only in its flexibility and conciseness in execution, but also in its flexibility for use by the general programmer. After the program was written, it was simulated by hand using one set of dummy values. Several runs were necessary before the program was ready for full-scale date. The completed program may be seen in illustration 2.

ILLUSTRATION 1 - FLOWCHART FOR SIMPLEX

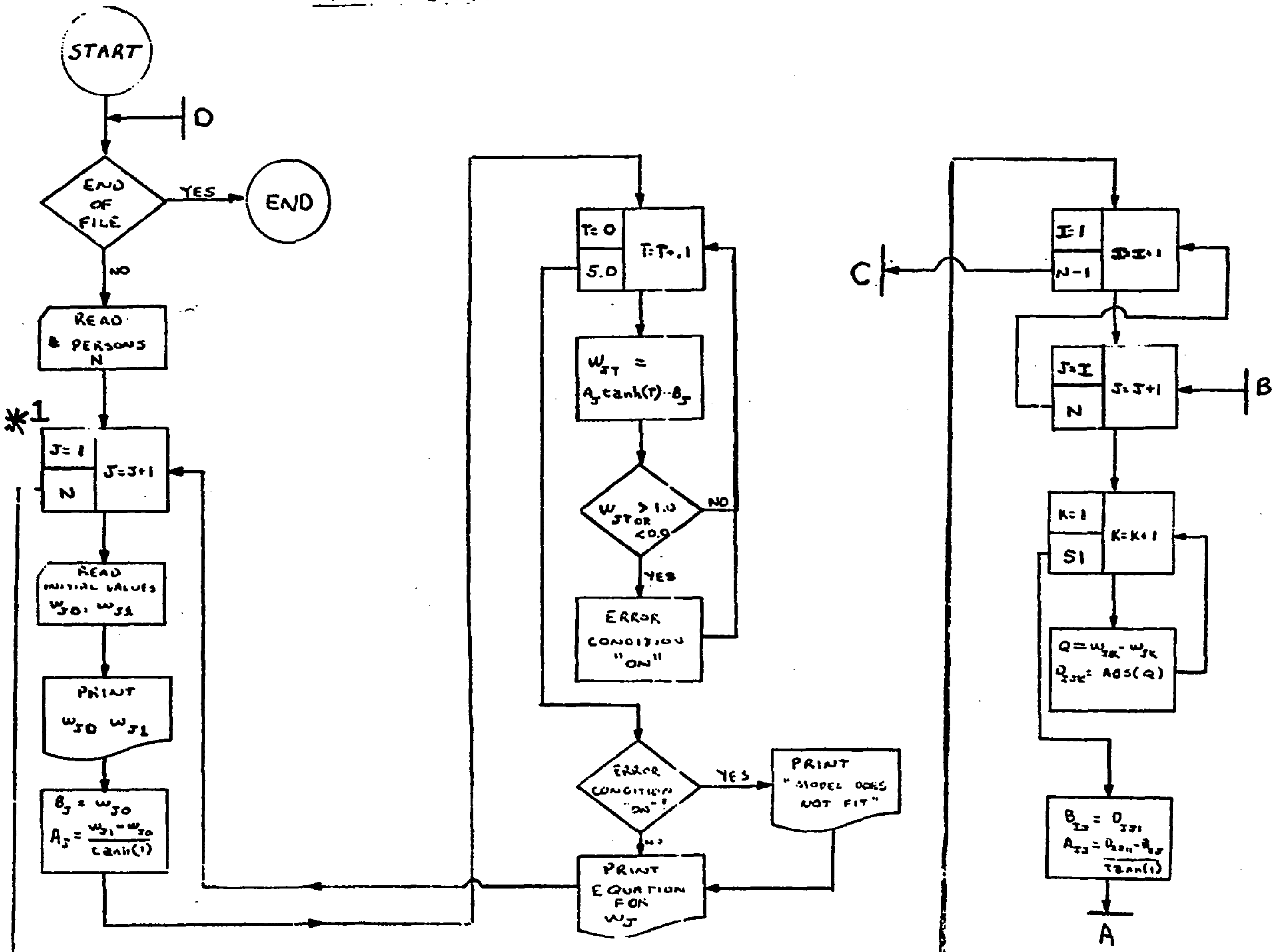


ILLUSTRATION 1 - CONTINUED

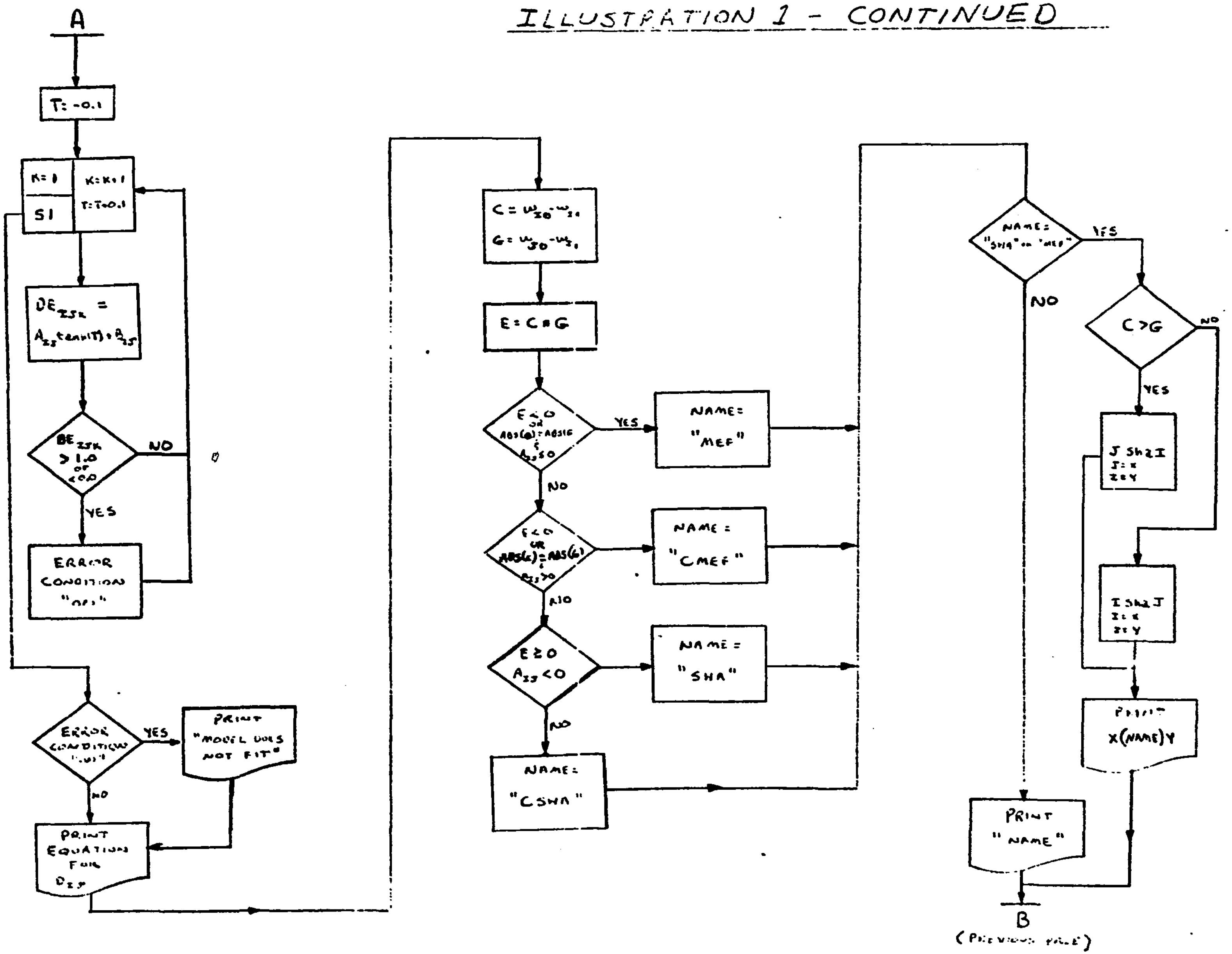


ILLUSTRATION 1- CONTINUED

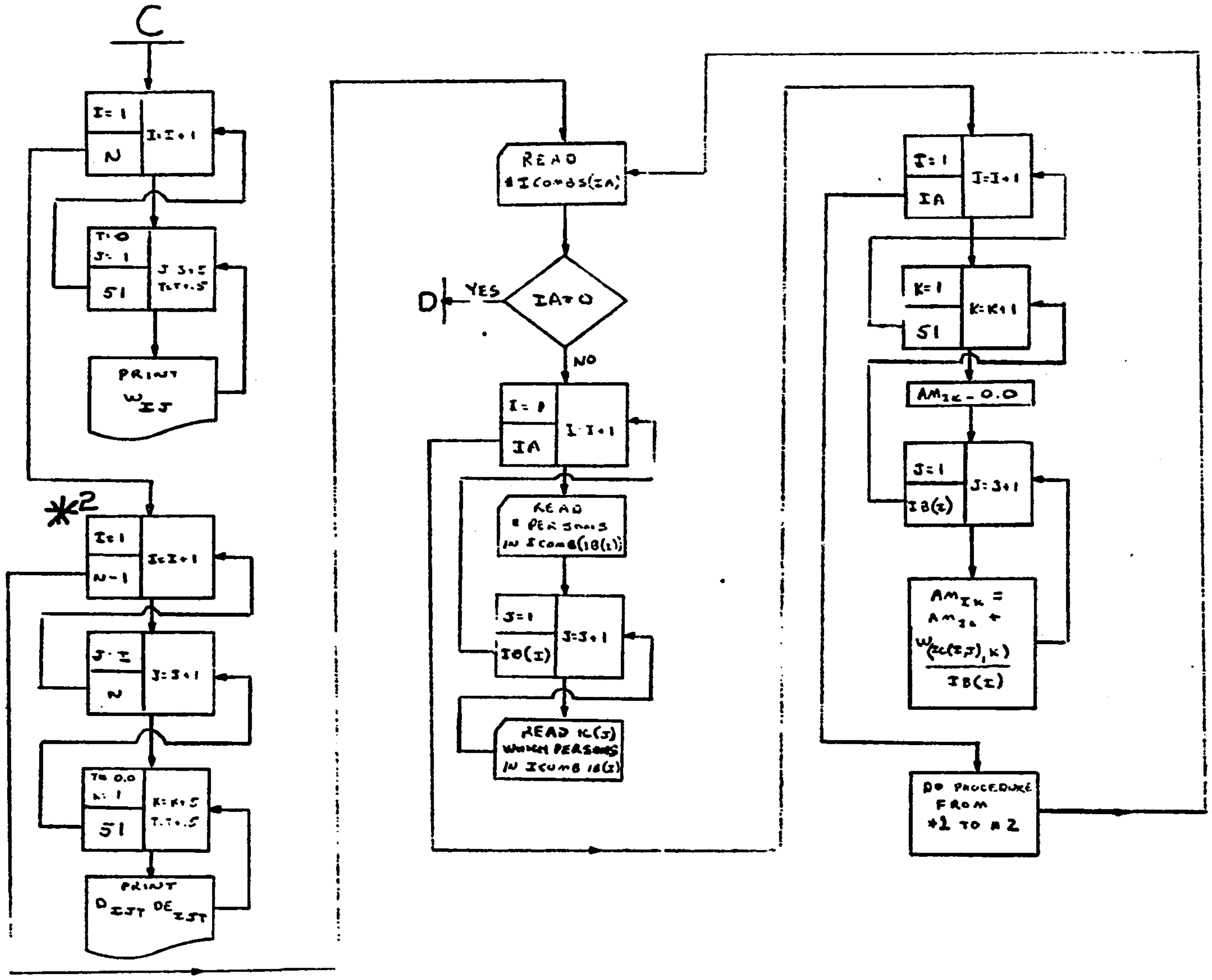


ILLUSTRATION 2.- SIMPLEX PROGRAM

```
STMT LEVEL NEST
  1              SIMPLEX: PROC OPTIONS(MAIN);

                 /*                 INSTRUCTIONS FOR USE OF SIMPLEX                    *
                 *                                                                     *
                 *  IN FIRST CARD CODE NUMBER CF PERSONS IN GROUP.                    *
                 *  CODE THE INITIAL AND SUBSEQUENT WORD INDEX FOR EACH PERSON        *
                 *  IN .XXXX FORM.  AS AN EXAMPLE, A GROUP OF 2 PERSONS WHOSE         *
                 *  INITIAL AND SUBSEQUENT WORD INDEXES ARE 0.2323 - 0.2424 AND       *
                 *  0.2656 - 0.4565 RESPECTIVELY WOULD BE CODED AS FOLLOWS:           *
                 *  CC1  2                                                             *
                 *  CC2-6   .2323          WORD INDEX 1 FOR PERSON 1                   *
                 *  CC7-11  .2424          WORD INDEX 2 FOR PERSON 1                   *
                 *  CC12-16  .2656         WORD INDEX 1 FOR PERSON 2                   *
                 *  CC17-21  .4565         WORD INDEX 2 FOR PERSON 2                   *
                 *                                                                     *
                 *  IF THERE ARE INTERACT COMBINATIONS DESIRED, PUNCH THE NEXT        *
                 *  CARD AS FOLLOWS:                                                   *
                 *  ONE-IN THE FIRST CC CODE THE NUMBER OF ICOMBS                      *
                 *  TWO-IN THE NEXT CC CODE THE NUMBER OF PERSONS IN ICOMB 1          *
                 *  THREE-IN EACH SUCCESSIVE COLUMN UP TO THE NUMBER IN STEP TWO.     *
                 *    CODE THE NUMBERS OF EACH PERSON.                                 *
                 *  FOUR-REPEAT FOR EACH ICOMB STEPS TWO AND THREE                    *
                 *  AS AN EXAMPLE, SUPPOSE 3 PERSONS WERE IN A GIVEN GROUP,           *
                 *  AND ICOMBS WERE DESIRED BETWEEN PERSON 3 AS 1 ICOMB AND           *
                 *  PERSONS 1&2 AS THE OTHER ICOMB.  THE CARD WOULD BE CODED          *
                 *  AS FOLLOWS: BEGINNING IN CC1  213212                               *
                 *  IF NO ICOMBS ARE DESIRED, THEN PLACE A BLANK CARD.                *
                 *                                                                     *
                 *  REPEAT PROCEDURE FOR EACH SET OF DATA.                            *
                 *  BE SURE A BLANK CARD IS PLACED AT THE END OF THE DATA SET         *
                 *  THIS WOULD INCLUDE A BLANK CARD AFTER EACH SET OF ICOMBS.         *
                 *  THE FOLLOWING ORDER OF DATA SERVES AS AN EXAMPLE:                 *
                 *  FIRST CARD- DATA***INITIAL INDEXES                                 *
                 *  SECOND CARD- FIRST ICOMBS                                          *
                 *  THIRD CARD- SECOND ICOMBS                                          *
                 *  FOURTH CARD- BLANK                                                 *
                 *  FIFTH CARD- SECOND SET OF INDEX VALUES                            *
                 *  SIXTH CARD- BLANK                                                  *
                 *  SEVENTH CARD- THIRD SET OF INDEXES                                 *
                 *  EIGHTH CARD- FIRST ICOMB VALUES                                    *
                 *  NINTH CARD- BLANK                                                  *
                 *                                                                     *
                 *  SIMPLEX IS LIMITED TO GROUPS OF SIZE 5 OR SMALLER AT THIS TIME   */

  2      1       DCL (W(5,51),DE(5,5,51),D(5,5,51),A(5,5),B(5,5),AW(5),BW(5),Z(5),Y,X,
                 C,G,E) DECIMAL FIXED(8,4),  (I,J,K,L,N) BIN FIXED(20),
                 (IA,IB(5),IC(5,5)) BIN FIXED(20),
                 Q FIXED DECIMAL(8,4),
                 AM(5,51) FIXED DECIMAL(8,4),
                 R(5,5) FIXED DECIMAL(5,3),
```

```
STMT LEVEL NEST

                     AE FIXED DECIMAL(8.4). NAME CHAR(4) VAR;
   3      1          ON ENDFILE (SYSIN) GO TO EOJ;

                     /*  READ IN VALUES  */
   5      1          START: PUT PAGE; GET EDIT(N)(F(1));
   7      1          PUT EDIT('INITIAL INDEX VALUES')(X(5).A(20));
   8      1          PUT EDIT('EQUATIONS FOR EACH INDEX')(X(15).A(24)); PUT SKIP;
  10      1          DO J=1 TO N;
  11      1    1     GET EDIT(W(J.1).W(J.11))(F(5.4).F(5.4));
  12      1    1     PUT EDIT('W('.J.'.1)='.W(J.1).'W('.J.'.11)='.W(J.11))
                     (A(2).F(1).A(4).F(5.4).X(5).A(2).F(1).A(5).F(5.4));
                     /* DETERMINE ESTIMATED EQUATIONS FOR EACH W  */
  13      1    1     BW(J)=W(J.1);
  14      1    1     AW(J)=(W(J.11)-W(J.1))/(TANH(1.0000));
  15      1    1     T=-0.1000; Z(J)=0.0;
  17      1    1     DO K=1 TO 51;
  18      1    2     T=T+0.1000;
                     /* DETERMINE VALUES FOR EACH W  */
  19      1    2     W(J.K)=(AW(J)*(TANH(T)))+BW(J);
  20      1    2     IF (W(J.K)<0.)|(W(J.K)>1.0) THEN Z(J)=1;  END;
  23      1    1     IF Z(J)=1.0 THEN PUT EDIT('MODEL DOES NOT FIT')(X(14).A(18));
  25      1    1          PUT EDIT('W='.AW(J).'TANH(T)+'.BW(J))(X(12).A(2).F(6.3).A(8).F(5.
                     4));
  26      1    1     PUT SKIP; END;


  28      1          PUT SKIP(2);
  29      1          PUT EDIT('EQUATIONS')(X(5).A(9));
  30      1          DO I=1 TO N-1;
  31      1    1     DO J=I+1 TO N;
  32      1    2     DO K=1 TO 51;
                     /*  DIFFERENCE SCORES CALCULATED FROM W EQUATIONS  */
  33      1    3     Q=W(I.K)-W(J.K);
  34      1    3     D(I.J.K)=ABS(Q); END;
                     /*  DETERMINATION OF ESTIMATED DIFFERENCE EQUATIONS  */
  36      1    2     B(I.J)=D(I.J.1);
  37      1    2     R(I.J)=0.0;
  38      1    2     A(I.J)=(D(I.J.11)-B(I.J))/(TANH(1.0000));
                     /*  CALCULATION OF ESTIMATED DIFFERENCES FROM DE EQUATIONS  */
  39      1    2     T=-0.1000;
  40      1    2     DO K=1 TO 51;
  41      1    3     T=T+0.1000;
  42      1    3     DE(I.J.K)=(A(I.J)*(TANH(T)))+B(I.J);
                     /*  DETERMINATION OF WHETHER OR NOT MODEL FITS  */
  43      1    3     IF DE(I.J.K)<0.0 THEN R(I.J)=1.0;
  45      1    3     IF DE(I.J.K)>1.0 THEN R(I.J)=1.0;
  47      1    3     IF (DE(I.J.K)¬<(D(I.J.K)+0.001))|(DE(I.J.K)¬>(D(I.J.K)-0.001))
  48      1    3     THEN R(I.J) =1.0;
  49      1    3     END;
```

```
STMT LEVEL NEST

 50     1    2     IF R(I.J)¬=0 THEN DO;
 52     1    3     PUT SKIP;
 53     1    3     PUT EDIT('D'.I.J.'-MODEL DOES NOT FIT')(A(1).F(1).F(1).A(19));
 54     1    3     END; DO;
 56     1    3     PUT SKIP;
                   /*  PRINT DIFFERENCE EQUATIONS  */
 57     1    3     PUT EDIT('D'.I.J.'='.A(I.J).'TANH(T)+'.B(I.J))
                   (A(1).F(1).F(1).A(1).F(7.4).A(8).F(5.4));
                   /*  DETERMINE RELATIONS  */
 58     1    3     C=W(I.1)-W(I.11);
 59     1    3     G=W(J.1)-W(J.11);
 60     1    3     E=C*G;
 61     1    3     C=ABS(C);
 62     1    3     G=ABS(G);
 63     1    3     IF (C<(G+0.0005))&(C>(G-0.0005)) THEN C=G;
 65     1    3     IF (A(I.J)<0.0002)&(A(I.J)>-0.0002) THEN A(I.J)=0.0000;
 67     1    3     IF((E<0.0)|(C=G))&(A(I.J)<=0.0) THEN NAME='ME=';
 69     1    3     ELSE IF ((E<0.0)|(C=G))&(A(I.J)>0.00) THEN NAME='CMEF';
 71     1    3     IF ((E>=0.0)&(A(I.J)<0.0)) THEN NAME='SHA';
 73     1    3     IF ((E>=0.0)&(A(I.J)>0.0)) THEN NAME='CSHA';
 75     1    3     IF (NAME='SHA')|(NAME='CSHA') THEN DO;
 77     1    4     IF C>G THEN PUT EDIT(J.NAME.I)(X(4).F(1).A(4).F(1));
 79     1    4     ELSE PUT EDIT(I.NAME.J)(X(4).F(1).A(4).F(1)); END;
 81     1    3     ELSE DO;
 82     1    4     PUT EDIT(NAME)(X(4).A(4)); END;
 84     1    3     END;
 85     1    2     END; END;


                   /*  PRINT OUT ALL VALUES IN SIMULATION  */
 87     1          PUT SKIP;
 88     1          PUT EDIT('EXPECTED VALUES')(X(40).A(15));
 89     1          PUT SKIP;
 90     1          PUT EDIT('TIME')(A(10));
 91     1          T=-0.5000;
 92     1          DO I=1 TO 51 BY 5;
 93     1    1     T=T+0.5000;
 94     1    1     PUT EDIT(T)(F(10.4));
 95     1    1     END;
 96     1          DO I=1 TO N;
 97     1    1     PUT SKIP;
 98     1    1     PUT EDIT('W'.I.'=')(A(1).F(1).X(7).A(1));
 99     1    1     DO J=1 TO 51 BY 5;
100     1    2     PUT EDIT(W(I.J))(F(10.4));
101     1    2     END; END;
103     1          DO I=1 TO N-1;
104     1    1     DO J=I+1 TO N;
105     1    2     PUT SKIP;
106     1    2     PUT EDIT('D'.I.J.'=')(\(1).F(1).F(1).X(6).A(1));
```

```
STMT LEVEL NEST

107      1    2      DO K=1 TO 51 BY 5;
108      1    3      PUT EDIT(D(I,J,K))(F(10,4));
109      1    3      END;
110      1    2      PUT SKIP;
111      1    2      PUT EDIT('DE',I,J,'=')(A(2),F(1),F(1),X(5),A(1));
112      1    2      DO K=1 TO 51 BY 5;
113      1    3      PUT EDIT(DE(I,J,K))(F(10,4)); END;
115      1    2      END; END;

117      1           START1: GET SKIP;
                     /*  READ IN VALUES FOR ICOMBS  */
118      1           GET EDIT(IA)(F(1));
119      1           IF IA=0 THEN GO TO FINE;
121      1           DO I=1 TO IA;
122      1    1      GET EDIT(IB(I))(F(1));
123      1    1      DO J=1 TO IB(I);
124      1    2      GET EDIT(IC(I,J))(F(1)); END; END;
                     /*  DETERMINE MEANS FOR ICOMBS  */
127      1           DO I=1 TO IA;
128      1    1      DO K=1 TO 51;
129      1    2      AM(I,K)=0.0;
130      1    2      DO J=1 TO IB(I);
131      1    3      AM(I,K)=AM(I,K)+(W(IC(I,J),K)/IB(I));
132      1    3      END; END; END;

                     /*  REPEAT ABOVE PROCEDURES FOR ICOMBS-PRINTOUT IS SAME  */
135      1           PUT PAGE;
136      1           PUT EDIT('INITIAL ICOMB VALUES')(X(5),A(20));
137      1           PUT EDIT('EQUATIONS FOR EACH ICOMB')(X(15),A(24)); PUT SKIP;
139      1           DO J=1 TO IA;
140      1    1      PUT EDIT(J,'COMB')(F(1),A(4));
141      1    1      DO I=1 TO IB(J);
142      1    2      PUT EDIT(IC(J,I))(F(1)); END;
144      1    1      PUT EDIT(AM(J,1))(X(5-IB(J)),F(7,4));
145      1    1      BW(J)=AM(J,1);
146      1    1      AW(J)=(AM(J,11)-AM(J,1))/(TANH(1.0000));
147      1    1      T=-0.1000; Z(J)=0.0;
149      1    1      DO K=1 TO 51;
150      1    2      T=T+0.1000;
151      1    2      AM(J,K)=(AW(J)*(TANH(T)))+BW(J);
152      1    2      IF (AM(J,K)<0.)|(AM(J,K)>1.0) THEN Z(J)=1.; END;
155      1    1      IF Z(J)=1.0 THEN DO;
157      1    2                PUT EDIT('MODEL DOES NOT FIT')(X(26),      A(18));
158      1    2      PUT EDIT('M=',AW(J),'TANH(T)+',BW(J))(X(12),      A(2),F(6,3),A(8),
159      1    2      F(5,4)); END;  ELSE
160      1    1      PUT EDIT('M=',AW(J),'TANH(T)+',BW(J))(X(24),      A(2),F(6,3),A(8),
                     F(5,4));
```

```
STMT LEVEL NEST

161      1    1     PUT SKIP; END;


163      1          PUT SKIP(2);
164      1          PUT EDIT('EQUATIONS')(X(5),A(9));
165      1          DO I=1 TO IA-1;
166      1    1     DO J=I+1 TO IA;
167      1    2     DO K=1 TO 51;
168      1    3     O=AM(I.K)-AM(J.K);
169      1    3     D(I.J.K)=ABS(O); END;
171      1    2     B(I.J)=D(I.J.1);
172      1    2     R(I.J)=0.0;
173      1    2     A(I.J)=(D(I.J.11)-B(I.J))/(TANH(1.0000));
174      1    2     T=-0.1000;
175      1    2     DO K=1 TO 51;
176      1    3     T=T+0.1000;
177      1    3     DE(I.J.K)=(A(I.J)*(TANH(T)))+B(I.J);
178      1    3     IF DE(I.J.K)<0.0 THEN R(I.J)=1.0;
180      1    3     IF DE(I.J.K)>1.0 THEN R(I.J)=1.0;
182      1    3     IF (DE(I.J.K)¬<(D(I.J.K)+0.001))|(DE(I.J.K)¬>(D(I.J.K)-0.001))
183      1    3     THEN R(I.J) =1.0;
184      1    3     END;
185      1    2     IF R(I.J)¬=0 THEN DO;
187      1    3     PUT SKIP;
188      1    3     PUT EDIT('D',I.J,'-MODEL DOES NOT FIT')(A(1).F(1).F(1).A(19));
189      1    3     END; DO;
191      1    3     PUT SKIP;
192      1    3     PUT EDIT('D'.I.J.'='.A(I.J).'TANH(T)+'.B(I.J))
                    (A(1).F(1).F(1).A(1).F(7.4).A(8).F(5.4));
193      1    3     C=AM(I.1)-AM(I.11);
194      1    3     G=AM(J.1)-AM(J.11);
195      1    3     E=C*G;
196      1    3     C=ABS(C);
197      1    3     G=ABS(G);
198      1    3     IF (C<(G+0.0005))&(C>(G-0.0005)) THEN C=G;
200      1    3     IF (A(I.J)<0.0002)&(A(I.J)>-0.0002) THEN A(I.J)=0.0000;
202      1    3     IF((E<0.0)|(C=G))&(A(I.J)<=0.0) THEN NAME='MEF';
204      1    3     ELSE IF ((E<0.0)|(C=G))&(A(I.J)>0.00) THEN NAME='CHEF';
206      1    3     IF ((E>=0.0)&(A(I.J)<0.0)) THEN NAME='SHA';
208      1    3     IF ((E>0.0)&(A(I.J)>0.0)) THEN NAME='CSHA';
210      1    3     IF (NAME='SHA')|(NAME='CSHA') THEN DO;
212      1    4     IF C>G THEN PUT EDIT(J.NAME.I)(X(4).F(1).A(4).F(1));
214      1    4     ELSE PUT EDIT(I.NAME.J)(X(4).F(1).A(4).F(1)); END;
216      1    3     ELSE DO;
217      1    4     PUT EDIT(NAME)(X(4).A(4)); END;
219      1    3     END;
220      1    2     END; END;
```

```
STMT LEVEL NEST

222     1          PUT SKIP;
223     1          PUT EDIT('EXPECTED VALUES')(X(40),A(15));
224     1          PUT SKIP;
225     1          PUT EDIT('TIME')(A(10));
226     1          T=-0.5000;
227     1          DO I=1 TO 51 BY 5;
228     1    1     T=T+0.5000;
229     1    1     PUT EDIT(T)(F(10,4));
230     1    1     END;
231     1          DO I=1 TO IA;
232     1    1     PUT SKIP;
233     1    1     PUT EDIT('M',I,'=')(A(1),F(1),X(7),A(1));
234     1    1     DO J=1 TO 51 BY 5;
235     1    2     PUT EDIT(AM(I,J))(F(10,4));
236     1    2     END; END;
238     1          DO I=1 TO IA-1;
239     1    1     DO J=I+1 TO IA;
240     1    2     PUT SKIP;
241     1    2     PUT EDIT('D',I,J,'=')(A(1),F(1),F(1),X(6),A(1));
242     1    2     DO K=1 TO 51 BY 5;
243     1    3     PUT EDIT(D(I,J,K))(F(10,4));
244     1    3     END;
245     1    2     PUT SKIP;
246     1    2     PUT EDIT('DE',I,J,'=')(A(2),F(1),F(1),X(5),A(1));
247     1    2     DO K=1 TO 51 BY 5;
248     1    3     PUT EDIT(DE(I,J,K))(F(10,4)); END;
250     1    2     END; END;
252     1          GO TO START1;
253     1          FINE: GET SKIP; GO TO START;
255     1          EOJ: END SIMPLEX;
```

To avoid having to compile the program each time data was input, an object module was created. Thus, several runs could be made without compilation each time.

Input

Instructions for coding data to be placed in the program are contained in illustration 2. The researcher wishing to use the program should read these instructions carefully. Essentially, values at time 0 and time 1 are coded, and types of interact combinations then may be specified.

Several criteria were used to determine what values to be simulated as well as the number of cases to be viewed. First, values were selected on the basis of possible word index scores based upon the categories found in Appendix A. Based upon research utilizing these categories (Cummings, 1970a, 1970b), various values ranging from 0.0 and 0.50 were used. Because Cummings' data tended to show a cluster of values on most variables between 0.05 and 0.35, a majority of the simulations contained values within this range. Besides grosser increments such as 0.5, some values to 4 significant digits were used to check the accuracy of the program (0.1654 for example)*. Second, the criteria used to determine how many simulations were "sufficient" based upon whether or not the addition of cases produced any new information or

---

*Since the use of fixed decimal numbers in PL/I produces a truncation error of approximately 0.0001 when the tanh function is used, a tolerance factor of 0.0002 was written into the program. Thus, values such as 0.1654 and 0.1655 would be considered equal. It will also be noted that the other equations used produced similar truncation error. This is discussed more fully in the next chapter.

trends. When simulations of certain combinations of values became redundant, they were eliminated. Third, in a group of 5 initial index values, combinations could be specified so that all information on each dyad, triad, four member group, and any other combination of these could be obtained from the program. Hence, simulations used for analysis were all based upon 5 member groups. This criteria was in part based upon the issues raised above. It was quickly found that no new information could be obtained by simulating values in dyads which could as easily be simulated in groups of size 5.

Twelve sets of values were simulated and 30 combinations were specified on each set in order to assess what changes would occur in the basic relations when individuals were combined with others. A full set of the combinations is included with the last data set in Appendix D. In general, these combinations included the following types: (1) Person 1, Person 2, Person 3, Persons 4 and 5; Person 2, Person 3, Person 4, Persons 1 and 5; . . ., (2) Person 1, Person 2, Persons 3, 4, and 5; Person 2, Person 3, Persons 1, 4, and 5; . . . (3) Persons 1 and 2, Persons 3, 4, and 5; Persons 2 and 3, Persons 1, 4, and 5; . . ., and (4) Person 1, Persons 2, 3, 4, and 5; Person 2, Persons 1, 3, 4, and 5; . . .. The selection of both index values and the number of combinations was based on the unique nature of information obtained concerning the basic questions asked. Different simulations were run using other values and combinations to assure that no unique case was missed. After comparison with the above three criteria, the 12 simulation cases were retained as representative.

Output

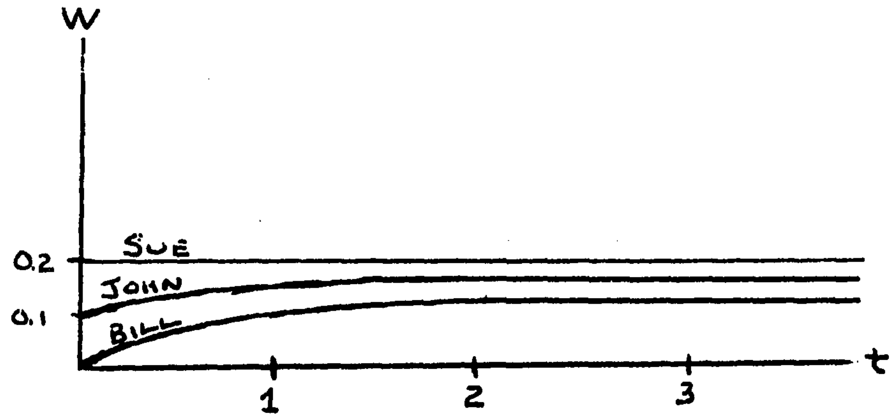
Output from the simulation program may be found in Appendix D. The 12 sets of initial values are all reported. The 30 combinations run on each of these sets provided such a bulk of print-out, that a few of these have been included for the last case only.

Instructions are included with the examples to facilitate reading the print-out. In general, information regarding the fit of the model, projected relations, and obtained values is included.

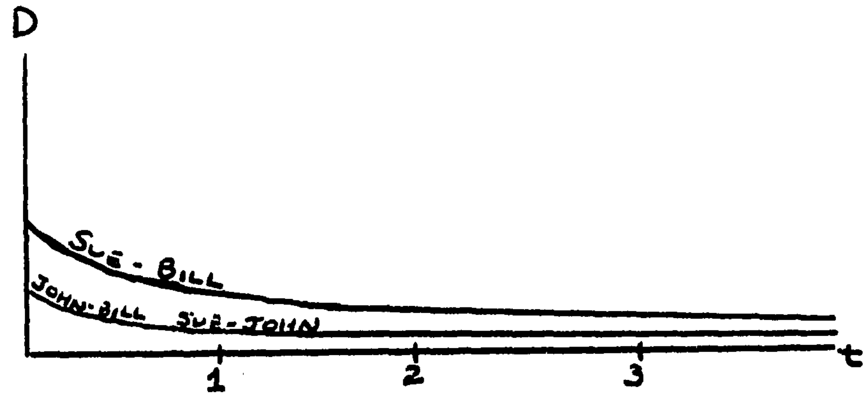
As an example of the output, the following illustration may prove useful to the reader. Let us suppose that three persons are involved in a communication interaction: Bill, John, and Sue*. Let us also suppose that empirical validation of the model for this situation has shown that a time interval of 1 is equivalent to 1 hour. Suppose that it has also been found that negative verbs tend to be a category which fit the mathematical model. Through pre-testing of the individuals involved in this situation, it has been found that Bill normally has an index value on this category of 0.0, that is, he uses practically no negative verbs; John has an initial value of 0.1, and Sue a value of 0.2. For convenience in research, an hour is subdivided into 10 equal intervals of 6 minutes. Now suppose that after an hour the last six minute interval produces the following index values for the participants: Bill's value is now 0.1; John is now at 0.15; and Sue now has a value of 0.20.

---

*Data for this illustration may be found in case 12 of Appendix D.



Graphs of Equations for Index Values



Graphs of the Estimated Difference Equations

Illustration 3.- Graphs for Example of Triad

Inserting the values obtained empirically above, the model would produce the following explanatory equations for each participant:

Bill- W=0.131tanh(t)+0.0
John- W=0.066tanh(t)+0.1
Sue - W=0.000tanh(t)+0.2

The similarity (or difference equations as produced by the model) would be as follows:

Bill-John D=-0.0655tanh(t)+0.1
Bill-Sue D=-0.1311tanh(t)+0.2
John-Sue D=-0.0656tanh(t)+0.1

Noting the criteria for the different relations (the reader may verify these himself), the following relations would emerge*:

1. John Sha Bill
2. Sue Sha Bill
3. Sue Sha John

These relations are graphed in illustration 3.

It can be seen in this illustration that if relations 3 and 1 were known only from the interaction of these two dyads by themselves, then relation 2 could be predicted by the transitive property of Sha. It will be seen in the following chapter that such predictions are much more difficult when other types of relations emerge. The future development of a method for dealing with such situations is discussed in Chapter V. The illustration presented here should provide the reader with knowledge of the process through which the model describes

---

*The reader may note a similarity between these relations and leadership characteristics such as those described in the Lashbrook and Bodaken (1969) PROANA-5 system. The relations described above may provide a more precise operationalization of these kinds of characteristics. Other such areas are discussed in Chapter V.

and predicts certain relations when at least two values are known for each participant in the communication interaction.

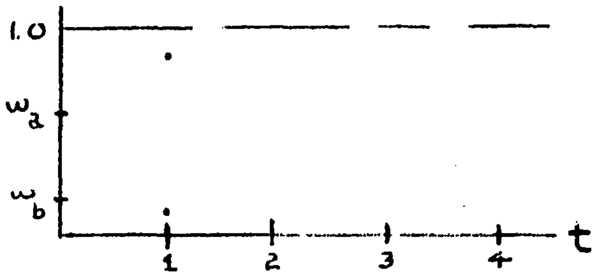
CHAPTER IV

RESULTS

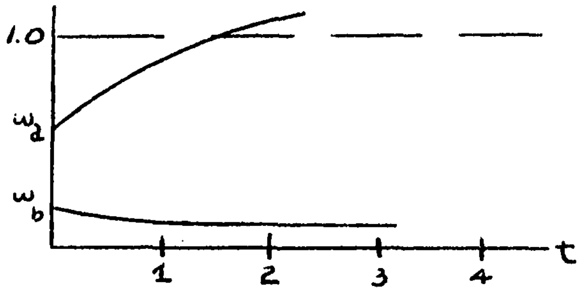
Results of the simulation provided a plethora of information regarding the questions posed in the previous chapter. No claim can be made that every single possible case was simulated as this would have produced far too many volumes of printout. However, utilizing the procedure outlined in the previous chapter, the 12 data sets provided sufficient information to establish some answers to the questions.

Question 1. What possible conditions will the system not describe accurately?

The criteria for determining whether or not the model fit was as follows: (1) the estimated difference equations could produce no value greater than 1.0 or less than 0.0, and (2) the word index equations could produce no value greater than 1.0 or less than 0.0. It will be observed that the critical element for determining these equations was the time point 1. As expected, some cases were simulated in which initial and subsequent word indexes were so disparate that values for the indexes at time points 3, 4, or 5 exceeded 1.0 or were less than 0.0. An example of this may be seen in illustration 4. Suggestions for dealing with these kinds of situations in empirical data are discussed in the next chapter.

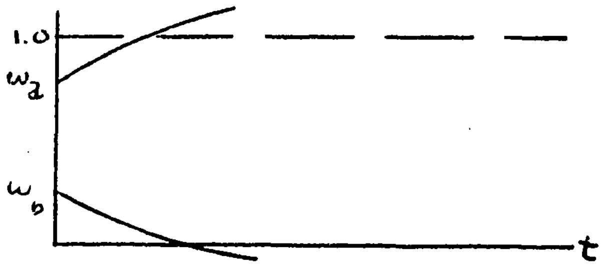


Initial Index Values

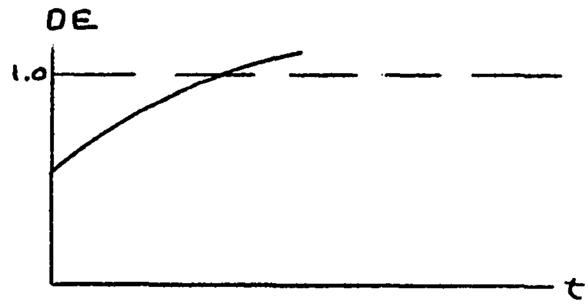


Equations

The equation for w_a does not hold because it supplies values grater than 1.0



Index Equations



DE Equation

The DE equation does not hold because it supplies values for DE greater than 1.0

Illustration 4.- Examples of Equations for Which the Models Do Not Fit

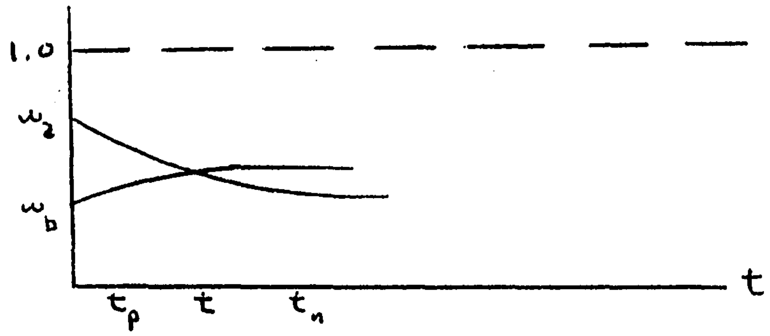
The most unusual finding of the simulations concerned cases in which the estimated difference equations produced values less than 0.0. This occurred only when word index equations "crossed each other" or more specifically, when for some t greater than 0 and less than 5,

1. At $t_q<t$, $w_a>w_b$.
2. At t, $w_a=w_b$.
3. At $t_n>t$, $w_a<w_b$. (See illustration 5)

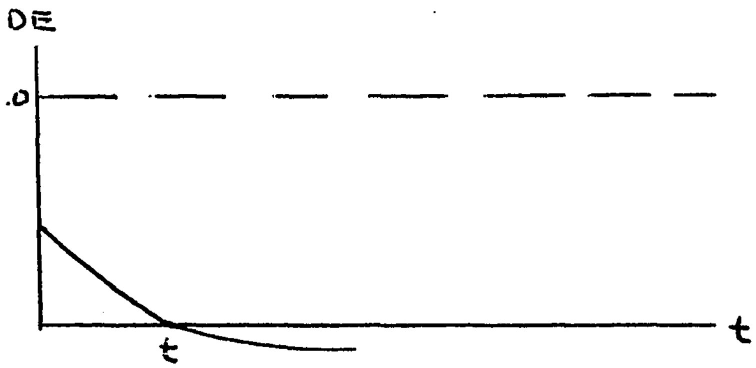
Again the time unit of 1 plays an essential role in analyzing this case. It was found that when the indexes were equal at a point in time greater than 1, the absolute value of the difference equation equaled that of the computed difference between the index equations. The choice of time unit for determining the difference equations, thus, becomes very important. The existence of "crossed equations" in a number of cases (See Appendix D) indicates the need, perhaps, for an additional set of definitions. Perhaps two new relations, Shape-Counter-shape (ShaCSha), and Mutual effect-Counter mutual effect (MefCMef), are necessary. The possibilities of these relations are discussed in the next chapter.

Question 2. Given certain individual relations within n-member groups, what types of relations emerge when individual scores are combined?

It was observed in the numerous combinations of the 12 data sets that an individual might change his relation with other individuals by combining with another or some group of these individuals, for example, A Counter-Mutually effects B (A CMef B) and B Counter-Mutually effects C (B CMef C); BC Shapes A (BC Sha A). Though the program could compute all combinations that an individual might make, no discernible rules seemed to hold without going through the entire simulation process.



Word Index Equations



DE Equation

Illustration 5.- Example of DE Equation Less Than 0.

However, a method for plotting these relations within a group was developed. This method together with prospects for a more rigorous set of statements which deal with these combinations is presented in the next chapter.

Question 3. What possible situations, if any, contradict axioms or theorems within the system?

Two axioms within the system were found not to hold in the simulations. These included the transitive properties for the Mef relation and the transitive properties for the CMef relation. The substitution for these axioms may be found in the next section. Each is starred (*).

Question 4. What new theorems or axioms can be developed from the simulation which concern combinations of the defined relations?

The following statements were developed from the simulation; no contradictory cases were found. They may be added to the axiomatic system as either theorems or axioms depending upon whether they are derivable analytically or not.

1. If Q, M, O are interact combinations and subsets of P, then if Q Sha M and M Mef O, then any of the following may hold:
    1. Q Mef O
    2. Q CMef O
    3. Q Sha O
    4. Q CSha O

2. If Q Sha M and M CMef O then (1) Q CSha O or (2) Q CMef O.

3. If Q Sha M and M CSha O then (1) Q CSha O or (2) Q Sha O.

4. If Q CSha M and M Sha O then (1) Q CSha O or (2) Q Sha O.

5. If Q CSha M and M Mef O then (1) Q Mef O or (2) Q Sha O.

6. If Q CSha M and M CMef O then any of the following may hold:

1. Q Mef O
2. Q CMef O
3. Q Sha O
4. Q CSha O

7. If Q Mef M and M CSha O then any of the following may hold:
1. Q Mef O
2. Q CMef O
3. Q Sha O
4. Q CSha O

8. If Q Mef M and M CMef O then any of the following may hold:
1. Q Mef O
2. Q CMef O
3. Q Sha O
4. Q CSha O

*9. If Q Mef M and M Mef O then any of the following may hold:
1. Q Mef O
2. Q CMef O
3. Q Sha O or
4. O Sha Q but not both.
5. Q CSha O or
6. O CSha Q but not both.

10. If Q Mef M and M Sha O then any of the following may hold:
1. Q Mef O
2. Q CMef O
3. Q Sha O
4. Q CSha O

11. If Q CMef M and M Mef O then any of the following may hold:
1. Q Mef O
2. Q CMef O
3. Q Sha O
4. Q CSha O

*12. If Q CMef M and M CMef O then any of the following may hold:
1. Q CSha O or
2. O CSha Q but not both.
3. Q Mef O
4. Q Sha O

13. If Q CMef M and M CSha O then (1) Q CMef O or (2) Q Mef O

14. If Q CMef M and M Sha O then any of the following may hold:
1. Q Mef O
2. Q CMef O
3. Q Sha O

It is probable that many of the statements above could be derived from the definitions and theorems in the axiomatic system. However, the simulation has limited the number of possibilities. A brief look at some of the statements indicates that proofs for some of these theorems would indeed be quite laborious and detailed.

It should also be noted that the transitive relations of Sha and CSha held throughout the simulations. It may also be possible to change these axioms to theorems through analytic means.

> Question 5. Given initial index or combination values, are there other equations which fit better than the tanh function?

Two other equations were utilized besides the tanh function in the simulations. These included: (1) $t / t{+}1$ and (2) $1 - e^{-t}$. In using these equations, it was felt that each would offer an alternative to the tanh(t) function and at the same time maintain the same basic curve desired in the system. Each equation produced different values, though for most cases, a change in the time parameter created isomorphic values. There were a few cases for each of the alternative equations in which the tanh function at time point 1 fit and they did not. No case was found in which either of the alternative equations fit and the tanh(t) function did not. Truncation error up to 0.0002 occurred using all equations. This was probably due to the fixed decimal nature of the data declaration within the program.

Summary

In general, results of the simulation indicated that (1) unique cases are directly related to choice of time parameter for the estimated equations, (2) rules for predicting combinations of individuals will be related to the type and magnitude of the relation involved, (3) two of the axioms within the system are false, i.e., the transitive property for Mutual Effect (Mef) and Counter-Mutual Effect (CMef), (4) substitutions may be made for the falsified axioms and 12 additional statements may be added to the system as either axioms or theorems, and (5) the tanh function appears at present to be the most appropriate equation for use in the system.

CHAPTER V

SUMMARY AND DISCUSSION

The guiding principle of this study has been the need for an approach to language behavior in communication which entails the concept of process. Based upon the doubtful ability of previous constructs to deal with process, an axiomatic system was developed to form the basis of a theory which would combine both structural and functional concerns in language. As a primary step in the development of this system, a simulation program was developed and run on various combinations of values in order to further specify and test the internal validity of the system. The success or failure of this simulation must be judged in relation to the criteria and questions raised in Chapter III.

There appear to be at least four specific areas which warrant discussion in this chapter: The first concerns adaptations and refinements in the basic axiomatic system as a result of the simulation. This includes a discussion of procedures for adding statements to the system. The second area concerns the empirical validity of the system while the third is concerned with the relation between the system and variables which concern similar concepts. The fourth area concerns the operation of the system in the broader context of social and cultural systems. These areas provide specific guidelines for the development of the system in any future research.

Adaptations of the System

In general, the simulation was quite successful in clarifying some of the basic concepts of the system and providing parameters for adaptation. Based upon the results of the simulation, the following changes seem necessary:

First, specification of two new definitions seem in order based upon the occurrance of the case DE<0. Mathematically, these may be expressed as follows:

Definition 16. Let $Q \subseteq P$, $M \subseteq P$, D_{QM} and S_{QM} defined for every $t \in T$. Q MefCMef M means by definition that the following conditions hold:

1. $D_{QM} = |A\tanh(t) + B|$, $A \leq 0$.
2. For one and only one t_α, $D_{QM}=0$.
3. $\Delta c_{tQ} * \Delta c_{tM} < 0$ for some t and $\not> 0$ for any t, or $|\Delta c_{tQ}| = |\Delta c_{tM}|$ for every t.
4. $c_Q = a_1\tanh(t) + b_1$ when $t < t_\alpha$.
5. $c_M = a_2\tanh(t) + b_2$ when $t < t_\alpha$.
6. $c_Q = a_2\tanh(t) + b_2$ when $t \geq t_\alpha$ and $c_M = a_1\tanh(t) + b_1$, or
7. $c_M = a_1\tanh(t) + b_1$ when $t \geq t_\alpha$ and $c_Q = a_2\tanh(t) + b_2$

Definition 17. Let $Q \subseteq P$, $M \subseteq P$, D_{QM} and S_{QM} defined for every $t \in T$. Q ShaCSha M means by definition that the following conditions hold:

1. $D_{QM} = |A\tanh(t) + B|$, $A < 0$.
2. For one and only one $t_\alpha > 0$, $D_{QM}=0$.
3. $\Delta c_{tQ} * \Delta c_{tM} \geq 0$ for every $t \in T$.
4. $|\Delta c_{tM}| > |\Delta c_{tQ}|$ for some $t \in T$, $|\Delta c_{tM}| \not< |\Delta c_{tQ}|$ for any t.
5. Conditions 4, 5, and 7 in definition 16 hold.

These definitions are isomorphic with the findings of the simulation. The MefCMef relation basically indicates that the individuals involved mutually effect one another to gain similarity up to a point in time, but then mutually effect each other to gain dissimilarity thereafter. The ShaCSha relation essentially indicates that one individual is responsible for shaping toward similarity and then at some point in time, responsible for counter-shaping toward dissimilarity. As was noted in the results section, the equation for the estimated difference did not fit actual differences unless the two index scores became equal at some point beyond the time unit used to determine the equations. To solve this problem in relation to the two defined relations, a simple theorem may be used:

Theorem 11. If either the ShaCSha or MefCMef relation holds, then if $c_Q=c_M$ at time t_α, then
$$D_{QM} = \left|\left(\frac{-B}{\tanh(t_\alpha)}\right) \tanh(t) + B\right|.$$

Proof: Let t_α be the time point at which $c_Q=c_M$.
Then D_{QM} at $t_\alpha = 0$ since the difference at that point is 0.
Hence, $0=A\tanh(t_\alpha) + B$.
Thus $A = \dfrac{-B}{\tanh(t_\alpha)}$,
and the theorem follows.

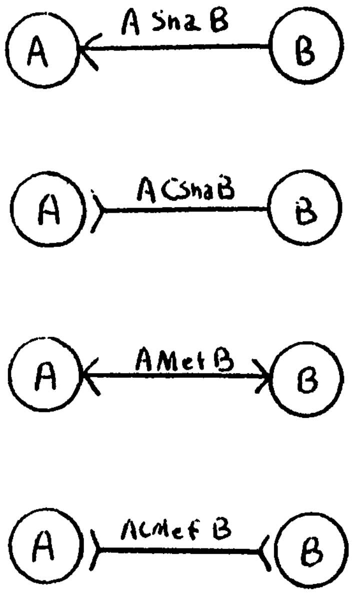
This provides a convenient means of determining the difference equations with points known. Again, the specific time parameters to be used in actual research may affect procedures throughout the system.

The second area in which adaptation of the axiomatic system seems necessary is in some of the axioms. It was found that both axioms relating to the transitive properties of Sha and CSha held, but the transitive properties for Mef and CMef did not. It was fortunate that neither of these axioms was necessary for any of the theorems or later definitions within the system. As such, the substitutions for these axioms with the findings reported in the results section may be made. In addition to these changes, each of the other 12 statements deserve inclusion in the axiomatic system. In further logical development of the theory, specification of which of these statements are axioms and which are theorems should be made.

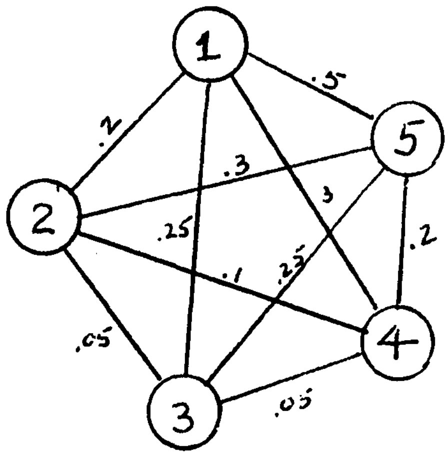
The third area in which the axiomatic system may be adapted concerns the manner in which different combinations of individuals may change the relations involved. As was noted in the results section, no discernible rules were generated by the analysis of the simulation. The simulation did, however, provide a new data set which should provide a test of any rules developed. It was quickly found that any set of rules governing the combinations of individuals would have to include a rather complex mathematical formulation. It may be noted that the "a" values in each word index and icomb equation represent a degree of change for that set. The "A" value in the difference equations also represents a degree of change. It would seem necessary in any formulation of rules for combining individuals to account for these degrees of change as well as the direction of that change. Perhaps a rule which assesses each relation an individual has with all other individuals in terms of the direction and magnitude of each relation will prove fruitful. Then a measure of "power of shaping" or "degree of mef" might be established.

To aid in the development of these rules, a method of graphing group relations was developed. An example of this method may be seen in illustration 6. Using this method, the researcher may specify the distances between individuals at time 0, then the relations and distances at time n. An example of an icomb relation is also shown in illustration 6.

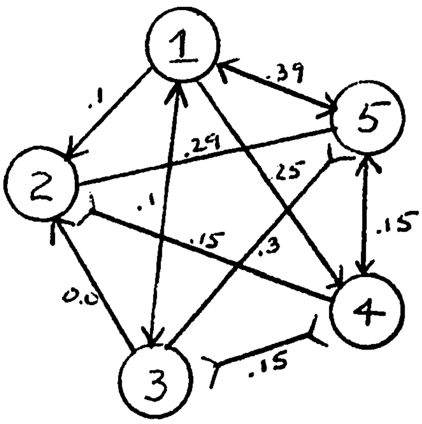
The graphs in illustration 6 are taken from one of the cases in Appendix D. The procedure for graphing icomb relations involves the following:



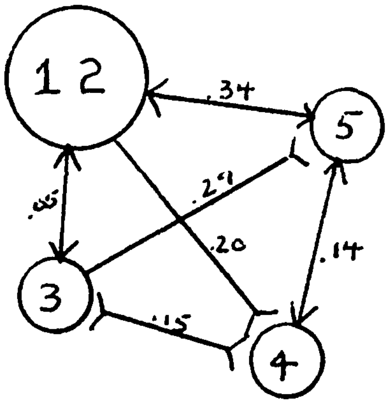
Basic Relations



Time 0



Time 2



Icomb Time 2

Illustration 6.- Examples of Icomb Analysis.

1. At time 0, straight lines between individuals with initial distances specified.

2. Specification at time n of the relation and the distances between individuals at that time.

3. For any combination, specification of the relation and distances.

The values used in graphing the relations may be taken directly from the computer print-out, or in actual data, from the values obtained.

Without knowing the actual rules for combinations of individuals, icomb analysis provides a means of graphing the projected relations based on the simulation program. Hence, the researcher may take initial values in his data, graph these values, specify what combination of individuals he wishes to study in the program, and graph the projected relations and distances provided by the computer program. As such, the simulation program and icomb analysis provide at least a means of assessing specific cases under consideration.

The full development of icomb analysis may necessitate a three-dimensional model in which a visual measure of the distances between individuals may be produced. As more empirical evidence is added to the axiomatic system, plots of changes in relations over time may be discerned, such as ShaCSha, or instances in which many relations can be defined for individuals over time.

In order to account and predict relations between individuals, it will be necessary to develop combinatorial rules which work in all situations involving groups of size 2 to n. Since the simulation has provided both a data set and a program which may be used in specific situations, any rules which are developed may be tested.

Empirical Validity

The major purpose of the simulation reported here was to test the logical structure of the axiomatic system, as well as, provide procedures for development. One major test of the system must remain its validity in empirical data. In fact, as a priority in research, this step would be considered very important. Research along this line may move through several phases, each of which is related to the others.

The first phase of research involves a nominal decision. Do the relations exist or not? If they do exist, for which language categories or behaviors do they exist? General hypotheses and research designs at this stage may proceed along simple proportionality tests. The curves either fit or they do not. In relation to this phase, specific time parameters must be established. This step may entail long range research projects. To find that in 100 dyadic interactions which took place for 10 minutes, that the curves do not fit would be valuable information, but would not be a complete test of the axiomatic system. On the other hand, a long range study of interactions over a year's time which fails to produce any of the relations would be evidence that the system was being falsified*. Since the time parameter plays such an important role in the system, special attention should be placed on establishing parameters which fit different research

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*To aid in the collection and analysis of data, a program written by Cummings and Renshaw (1975) may be used. Appendix A contains the categories analyzed by this program. Using punched cards for input, the program analyzes each message according to the language categories under consideration. Since the program produces index cards and punched output, analysis is considerably shortened.

situations. Examples of dummy data which did not fit the simulation may not occur in actual data. If these situations do occur in actual data, differing time units used to establish estimated difference equations may be needed. As a third phase, attention must be placed on the use of the tanh function. Other equations such as those used in the simulation may give better fit to specific data. In these first three phases, research designed to falsify or add support to the axiomatic system must include: (1) collection of language data in differing communication situations and in differing time frames, (2) the analysis of this data into word indexes for specific time intervals, (3) the derivation of an equation of best fit to the actual data, (4) a comparison of that equation with the one predicted by the model, (5) initiation of any reassessment of time parameters or equations if the model does not fit, and (6) a proportionality test to determine the existence of the relations in a sample of size n.

Following the initial phases of research in the validation of the relations, further testing of the system must involve hypotheses concerned with combinations of the relations. Again, this research may proceed along nominal lines. For each of the axioms and theorems originally in the system, as well as those derived through the simulation, existence is an either-or question. Complicated statistical designs will not be necessary to test these relations. In fact, the existence of one interaction in which the transitive property of Sha, for example, does not hold, would be sufficient evidence that the axiom does not hold. Such a finding would certainly necessitate a re-evaluation of the axiomatic system.

In general, research in this area should provide answers to the following questions: (1) Do the relations hold, and if so, for what specific language categories? (2) If the relations occur, in what situations do they occur? (3) If the relations do occur, do the axioms and theorems hold in all cases?

Relation to Other Variables

Research prospects outlined in the previous section are designed to test the empirical validity of the axiomatic system as a concept in itself. Full validity of the system as either a descriptive or predictive tool in communication will necessitate studies relating it to other variables and concepts*. Such research should also provide a view of the system in relation to the basic assumptions underlying it.

In the area of small groups, the axiomatic system could be studied in relation to concepts such as leadership, power, status, deviates, propinquity, networks, and consensus. Some possible hypotheses relating the system to these variables might include the following:

> H_1: There will be a correlation between Mef behaviors and democratic leadership.**
>
> H_2: There will be a correlation between counter-shaping behavior and deviate behavior within groups.***

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*See Guilford (1954) for a discussion of this type of validity.

**See Selvin (1960) for discussion of democratic leadership.

***See Schachter (1951) for a discussion of deviation.

H_3: Group morale will increase as the number of Mef (mutual effect) relations increases within a group.*

These hypotheses are only a few of the many which might be advanced in relation to the axiomatic system. They have purposely been worded in different ways to give a general view of the possibilities.

In the area of language development, there are several interesting areas of research which may be pursued. As an alternative to a strictly learning theory approach, one might assess the relation between shaping and learning, but also determine at what time in a child's development this relation becomes one of mutual-effect or counter-shaping (See Cummings, 1974c). Such studies would aid in the validation of the system as a useful tool in describing communication behaviors over time.

Since one of the assumptions of the axiomatic system is that probability plays an essential role in communication behavior, further construct validity of the system would seem to necessitate studies of its relation to other variables which might influence those probabilities. For example, what prior syntactic or cognitive behaviors lead to the choice of certain categories? Is there a relation between prior learning and susceptibility to shaping or mutual effect? Overall, some of the most important questions which may be raised in this area of research involve those variables which lead to one or more of the defined relations. Though the system may provide a definitive explanation or description of interactive language behaviors, its development in

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*See Homans (1950) for a discussion of morale and satisfaction within a group.

relation to other factors which influence the relations seems to be a necessity.

The Broader Context

There are several prospects for development and use of the axiomatic system in the study of communication. The major guideline in the development of the system was that a theoretical approach which combined both structural and functional approaches was not only appropriate at this time, but also necessary if communication was to be studied as process. The most important element of the system involves the attempt to describe interaction in relation to time. The element of time seems to provide a basis on which a truly systemic view of communication may be obtained. As such, the application of the system to social and cultural contexts would seem most appropriate. For example, the socialization of an individual through language interaction may be studied in terms of the basic relations involved. Like the example in the previous section on language behavior, an important question here would be at what point the individual ceases to be shaped and instead develops mef relations. In other contexts, the axiomatic system would seem to be applicable to studies in family counseling, organizations, and education. For example: What types of relations exist between parents and children? What types of language behaviors and relations are most congruent with high morale or productivity in organizations? These questions would seem quite open to analysis and study in relation to the system.

Overall, the axiomatic system, with empirical validation, would seem to provide a means of explaining and predicting interdependent communication behaviors. Knowing the relations between certain individuals or groups, one might predict what would occur when certain combinations are taken together. Through further development, the system may provide the basis for a truly "process" theory of communication.

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APPENDIX A

LANGUAGE CATEGORIES

KEY TO VARIABLE NAMES

THIS REPRESENTS A LIST OF ALL VARIABLES USED IN THE PROGRAM. OTHER VARIABLES MAY BE ADDED. THE READER WHO WISHES TO DO SO SHOULD CONSULT THE INSTRUCTION MANUAL FOR USE OF THE PROGRAM. DETAILED INFORMATION CONCERNING THE VARIABLES USED IN T HIS ANALYSIS MAY BE FOUND IN CUMMINGS, H. WAYLAND (1970) SPECIFIED COGNITIVE STRUCTURES AND THEIR EFFECTS ON LANGUAGE EN CODING BEHAVIOR. UNPUBLISHED PH.D. DISSERTATION, MICHIGAN STATE UNIVERSITY.

TOT-1	TOTAL WORDS ENCODED
S1P	TOTAL SUBJECT WORDS WHICH HAVE NO MODIFIER
S1D	TOTAL SUBJECT WORDS WHICH HAVE ONE OR MORE MODIFIERS
C1P	TOTAL CONNECTORS WHICH HAVE NO MODIFIERS
C1D	TOTAL CONNECTORS WHICH HAVE ONE OR MORE MODIFIERS
S1-A	TOTAL SUBJECT WORDS WHICH ARE JUDGED AFFERENT
S1-E	TOTAL SUBJECT WORDS WHICH ARE JUDGED EFFERENT
LS1-A	TOTAL MODIFIERS OF SUBJECT WORDS WHICH ARE JUDGED AFFERENT
LS1-E	TOTAL MODIFIERS OF SUBJECT WORDS WHICH ARE JUDGED EFFERENT
LC1-A	TOTAL MODIFIERS OF CONNECTORS WHICH ARE JUDGED AFFERENT
LC1-E	TOTAL MODIFIERS OF CONNECTORS WHICH ARE JUDGED EFFERENT
IPA	TOTAL CONNECTORS WHICH ARE INDICATIVE, PAST TENSE
IPR	TOTAL CONNECTORS WHICH ARE INDICATIVE, PRESENT TENSE
IFU	TOTAL CONNECTORS WHICH ARE INDICATIVE, FUTURE TENSE
ICE	TOTAL COMPARISON-EQUIVALENCE CONNECTORS
ICM	TOTAL COMPARISON-MORE/THAN CONNECTORS
ICS	TOTAL COMPARISON SUBSET CONNECTORS
ICP	TOTAL COMPARISON SPATIAL CONNECTORS
ICT	TOTAL COMPARISON TIME CONNECTORS
IADJ	TOTAL CONNECTORS ASSOCIATING SUBJECT SIGN WITH ADJECTIVE
IEXT	TOTAL CONNECTORS ASSOCIATING SUBJECT SIGN WITH DEMONSTRATIVES
IT	TOTAL ACTION CONNECTORS WHICH ARE TRANSITIVE, INDICATIVE
IR	TOTAL ACTION CONNECTORS WHICH ARE INTRANSITIVE, INDICATIVE
SPA	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, PAST TENSE
SPR	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, PRESENT TENSE
SFU	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, FUTURE TENSE
SCE	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, COMPARISON EQUIVALENCE
SCM	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, COMPARISON MORE/THAN
SCS	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, COMPARISON SUBSET
SCP	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, COMPARISON SPATIAL
SCT	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, COMPARISON TIME
SADJ	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, ASSOCIATING SUBJECT SIGN WITH AN ADJECTIVE
SEXT	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, ASSOCIATING A SUBJECT SIGN WITH A DEMONSTRATIVE
ST	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, TRANSITIVE
SR	TOTAL CONNECTORS WHICH ARE SUBJUNCTIVE, INTRANSITIVE
NS1P	TOTAL PRIMITIVE SUBJECT WORDS NEGATED
NS1D	TOTAL DEFINED SUBJECT WORDS NEGATED
NIPA	TOTAL NEGATED CONNECTORS WHICH ARE INDICATIVE, PAST TENSE
NIPR	TOTAL NEGATED CONNECTORS WHICH ARE INDICATIVE, PRESENT TENSE
NIFU	TOTAL NEGATED CONNECTORS WHICH ARE INDICATIVE, FUTURE TENSE
NICE	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE INDICATIVE, EQUATING
NICM	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE INDICATIVE, MORE/THAN
NICS	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE INDICATIVE, SUBSET
NICP	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE INDICATIVE, SPATIAL
NICT	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE INDICATIVE, TIME
NIADJ	TOTAL NEGATED INDICATIVE CONNECTORS WHICH ASSOCIATE A UNIT SIGN WITH AN ADJECTIVE
NISXT	TOTAL NEGATED INDICATIVE CONNECTORS WHICH ASSOCIATE A UNIT SIGN WITH A DEMONSTRATIVE PRONOUN
NIT	TOTAL NEGATED ACTION CONNECTORS WHICH ARE TRANSITIVE
NIR	TOTAL NEGATED ACTION CONNECTORS WHICH ARE INTRANSITIVE
NSPA	TOTAL NEGATED PAST TENSE CONNECTORS WHICH ARE SUBJUNCTIVE
NSPR	TOTAL NEGATED PRESENT TENSE CONNECTORS WHICH ARE SUBJUNCTIVE
NSFU	TOTAL NEGATED FUTURE TENSE CONNECTORS WHICH ARE SUBJUNCTIVE
NSCE	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE SUBJUNCTIVE, EQUATING

NSCM	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE SUBJUNCTIVE, MORE/THAN
NSCS	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE SUBJUNCTIVE, SUBSET
NSCP	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE SUBJUNCTIVE, SPATIAL
NSCT	TOTAL NEGATED COMPARISON CONNECTORS WHICH ARE SUBJUNCTIVE, TIME
NSADJ	TOTAL NEGATED SUBJUNCTIVE CONNECTORS WHICH ASSOCIATE A UNIT SIGN WITH AN ADJECTIVE
NSEXT	TOTAL NEGATED SUBJUNCTIVE CONNECTORS WHICH ASSOCIATE A UNIT SIGN WITH A DEMONSTRATIVE PRONOUN
NST	TOTAL NEGATED CONNECTORS WHICH ARE SUBJUNCTIVE, TRANSITIVE
NSR	TOTAL NEGATED CONNECTORS WHICH ARE SUBJUNCTIVE, INTRANSITIVE
NS1-A	TOTAL NEGATED SUBJECT WORDS WHICH ARE AFFERENT
NS1-E	TOTAL NEGATED SUBJECT WORDS WHICH ARE EFFERENT
NC1P	TOTAL NEGATED CONNECTORS WHICH ARE PRIMITIVE
NC1D	TOTAL NEGATED CONNECTORS WHICH ARE DEFINED
NLS1-A	TOTAL NEGATED SUBJECT WORD LIMITERS WHICH ARE AFFERENT
NLS1-E	TOTAL NEGATED SUBJECT WORD LIMITERS WHICH ARE EFFERENT
NLC1-A	TOTAL NEGATED CONNECTOR LIMITERS WHICH ARE AFFERENT
NLC1-E	TOTAL NEGATED CONNECTOR LIMITERS WHICH ARE EFFERENT
AO	TOTAL SUBJECT WORDS WHICH REFER TO A SPECIFIC PERSON OR GROUP
GO	TOTAL SUBJECT WORDS WHICH REFER TO UNSPECIFIC PERSONS OR GROUPS, I.E., THIRD PERSON PERSONAL PRONOUNS
S-S	TOTAL SUBJECT WORDS WHICH REFER TO THE SOURCE, I.E., FIRST PERSON PERSONAL PRONOUNS
T-O	TOTAL SUBJECT WORDS WHICH REFER TO THE RECEIVER, I.E., SECOND PERSON PERSONAL PRONOUNS
NAO	TOTAL NEGATED SUBJECT WORDS WHICH REFER TO A SPECIFIC PERSON OR GROUP
NGO	TOTAL NEGATED SUBJECT WORDS WHICH REFER TO UNSPECIFIC PERSONS, GROUPS, I.E., THIRD PERSON PERSONAL PRONOUNS
NS-S	TOTAL NEGATED SUBJECT WORDS WHICH REFER TO THE SOURCE, I.E., FIRST PERSON PERSONAL PRONOUNS
NT-O	TOTAL NEGATED SUBJECT WORDS WHICH REFER TO THE RECEIVER, I.E., SECOND PERSON PERSONAL PRONOUNS
ART	TOTAL ARTICLES
PREP	TOTAL PREPOSITIONS
OTH	TOTAL OTHER
COMP	TOTAL FREQUENCY OF COMPARISON CONNECTORS
ACTC1	TOTAL FREQUENCY OF ACTION CONNECTORS
IC1	TOTAL FREQUENCY OF INDICATIVE CONNECTORS
SC1	TOTAL FREQUENCY OF SUBJUNCTIVE CONNECTORS
TC1	TOTAL FREQUENCY OF TRANSITIVE CONNECTORS
RC1	TOTAL FREQUENCY OF INTRANSITIVE CONNECTORS
NC1	TOTAL FREQUENCY OF NEGATIVE CONNECTORS
AFF	TOTAL FREQUENCY OF AFFERENT SUBJECT WORDS AND LIMITERS
EFF	TOTAL FREQUENCY OF EFFERENT SUBJECT WORDS AND LIMITERS
L	TOTAL FREQUENCY OF LIMITERS
S1	TOTAL FREQUENCY OF SUBJECT WORDS
C1PA	TOTAL FREQUENCY OF PAST TENSE CONNECTORS
C1PR	TOTAL FREQUENCY OF PRESENT TENSE CONNECTORS
C1FU	TOTAL FREQUENCY OF FUTURE TENSE CONNECTORS
PRIM	TOTAL FREQUENCY OF PRIMITIVE SUBJECT WORDS AND CONNECTORS
DEFD	TOTAL FREQUENCY OF DEFINED SUBJECT WORDS AND CONNECTORS
PC1	TOTAL FREQUENCY OF POSITIVE (NON-NEGATIVE) CONNECTORS
C1	TOTAL FREQUENCY OF POSITIVE AND NEGATIVE CONNECTORS
DEM	DEMONSTRATIVES
COLL	COLLECTIVES
TOT-2	TOTAL WORDS ENCODED LESS THE SUM OF ARTICLES, PREPOSITIONS, AND OTHER
TOT-3	TOTAL FREQUENCY OF SUBJECT WORDS, LIMITERS, AND CONNECTORS

APPENDIX B

KEY TO MATHEMATICAL SYMBOLS

The following symbols are utilized in the axiomatic system presented in Chapter II. A list of references has also been included for the reader who is unfamiliar with some basic concepts in algebra, set theory, and calculus. The list is only representative. There are numerous texts on these subjects.

Symbol	Definition
$A \subseteq B$	A is a subset of B
$a \in A$	a is an element of A
$\emptyset$	The null or empty set
$\sum_{i=1}^{n} a$	a is summed n times
$\|a\|$	the absolute value of a (if a 0, a = a.) (if a 0, a =-a) (if a=0, a = 0)
Δa	change in a, (defined in text)
$\frac{dy}{dx}$	the derivative of y with respect to x (See Thomas, 1969 below; pp. 59-98).
$a < b$ $a > b$	a less than b a greater than b
*	multiplication, used only in statements within system
$a \not> b$ $a \not< b$	a not greater than b a not less than b

References

Riddle, D. F. (1970) Calculus and Analytic Geometry. Belmont, Calif.: Wadsworth.

Thomas, G. B. (1969) Calculus. Reading, Mass.: Addison Wesley.

McCoy, N. H. (1968) Introduction to Modern Algebra. Boston: Allyn and Bacon.

Youse, B. K. (1970) An Introduction to Mathematics. Boston: Allyn and Bacon.

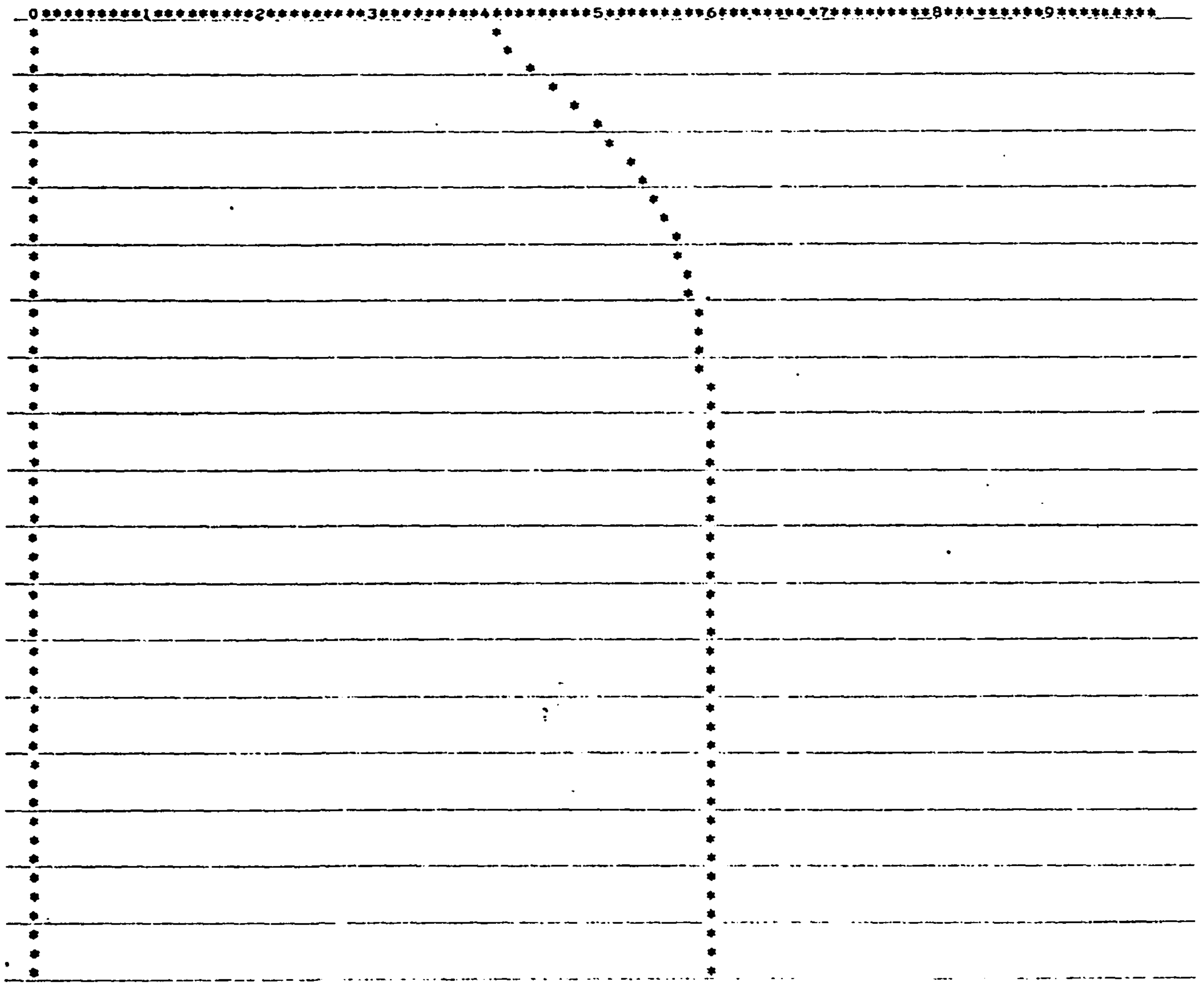
APPENDIX C

PLOTS OF BASIC RELATIONS

Instructions for Reading Output

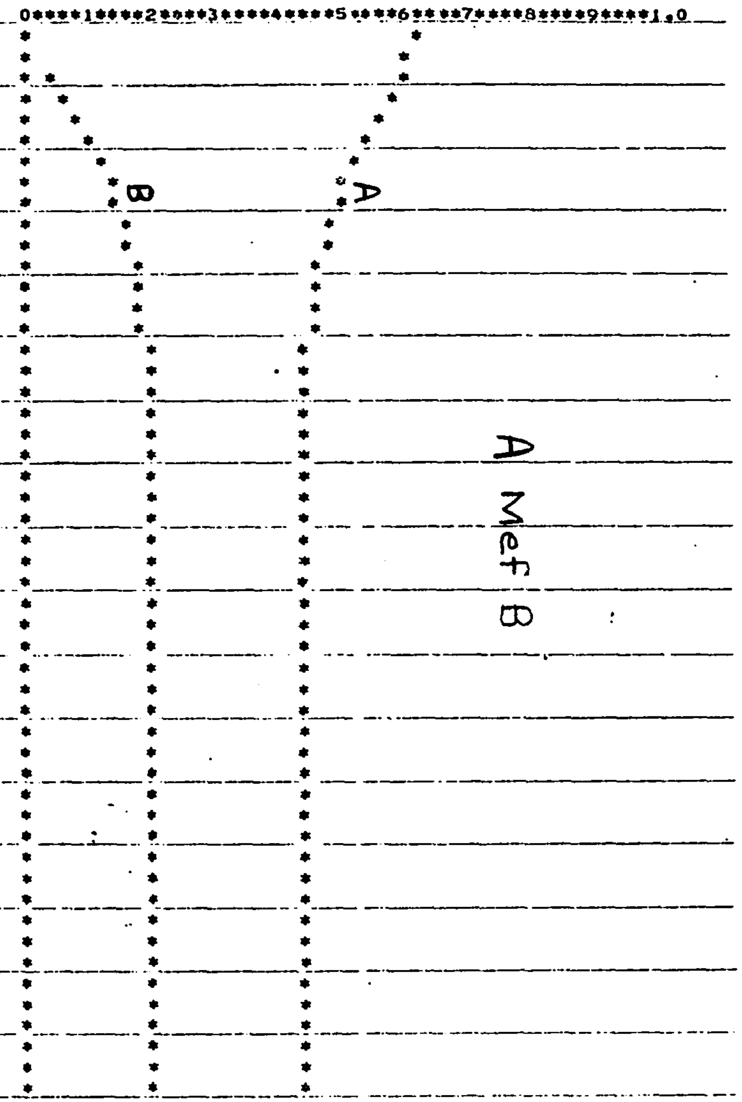
The following pages give representative examples of the plots of the basic relations. Each plot of the basic relation between w_a and w_b is preceded by a plot of either the similarity equation (1-D) or the difference equation (1-S). The similarity equation is noted for examples of Sha and Mef. The difference equation is printed for examples of CSha and CMef. For each of the relations, the equation for w_a is given ($w_b = w_a - |1-S|$). Values for each of w_a, w_b, S or D, and t are printed. Identification of which plot represents the appropriate w may be determined by these values. The relation exemplified has been noted at the top of each page.

PLOT OF S=0.20TANH(T)+0.40

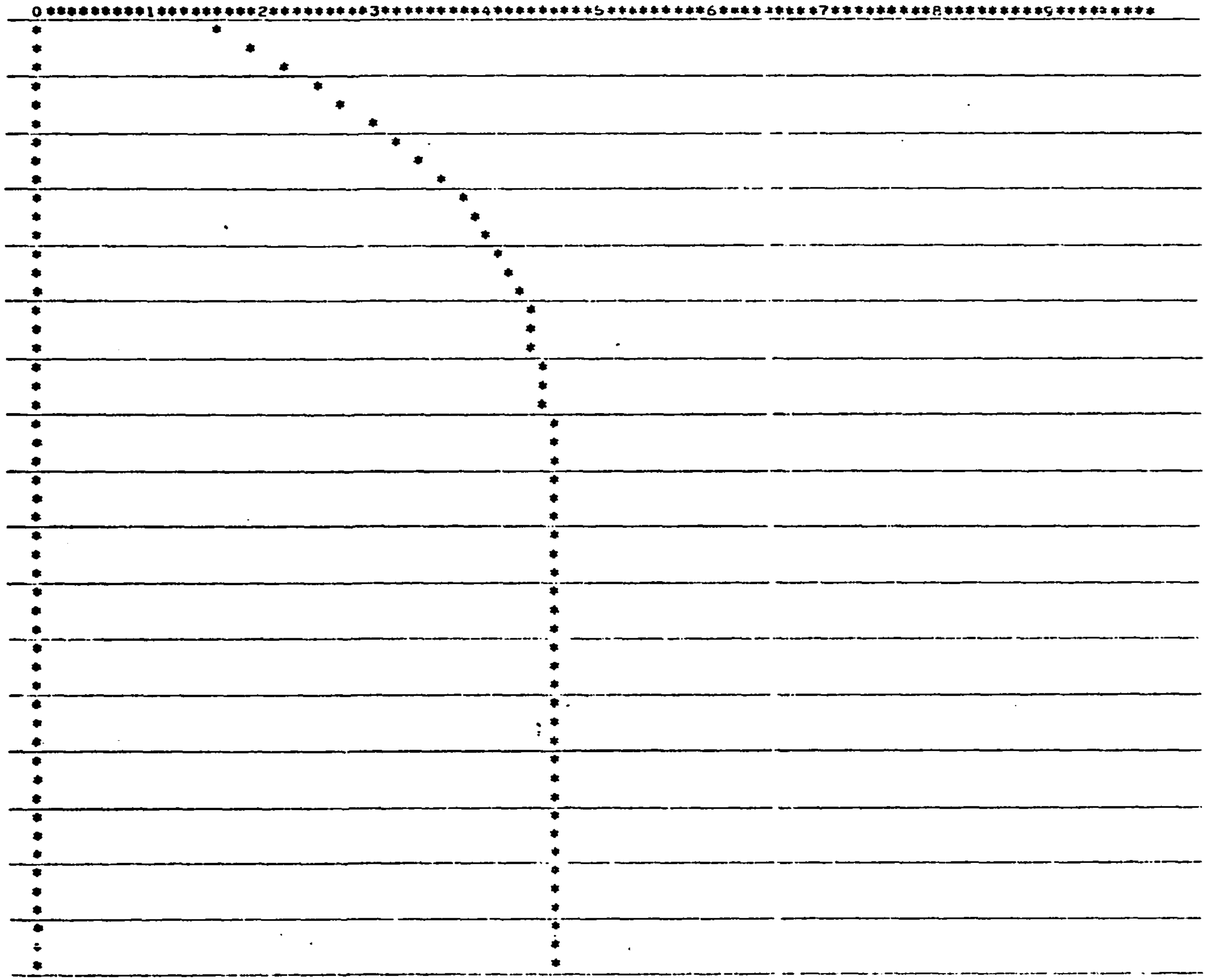


WA=1-(0.20TANH(T)+(1-0.60))

S	WA	WB	T
0.4000	0.6000	0.0000	0.0000
0.4398	0.5800	0.0198	0.1000
0.4789	0.5605	0.0394	0.2000
0.5165	0.5417	0.0582	0.3000
0.5519	0.5240	0.0759	0.4000
0.5848	0.5075	0.0923	0.5000
0.6148	0.4925	0.1073	0.6000
0.6417	0.4791	0.1208	0.7000
0.6656	0.4671	0.1327	0.8000
0.6865	0.4567	0.1432	0.9000
0.7046	0.4476	0.1522	1.0000
0.7201	0.4399	0.1600	1.1000
0.7334	0.4332	0.1666	1.2000
0.7446	0.4276	0.1722	1.3000
0.7541	0.4229	0.1770	1.4000
0.7620	0.4189	0.1809	1.5000
0.7686	0.4156	0.1842	1.6000
0.7741	0.4129	0.1870	1.7000
0.7787	0.4106	0.1893	1.8000
0.7824	0.4087	0.1911	1.9000
0.7856	0.4071	0.1927	2.0000
0.7881	0.4059	0.1940	2.1000
0.7902	0.4048	0.1950	2.2000
0.7920	0.4039	0.1959	2.3000
0.7934	0.4032	0.1966	2.4000
0.7946	0.4026	0.1972	2.5000
0.7956	0.4021	0.1977	2.6000
0.7964	0.4017	0.1981	2.7000
0.7970	0.4014	0.1984	2.8000
0.7975	0.4012	0.1987	2.9000
0.7980	0.4009	0.1989	3.0000
0.7983	0.4008	0.1991	3.1000
0.7986	0.4006	0.1992	3.2000
0.7989	0.4005	0.1994	3.3000
0.7991	0.4004	0.1995	3.4000
0.7992	0.4003	0.1995	3.5000
0.7994	0.4002	0.1996	3.6000
0.7995	0.4002	0.1997	3.7000
0.7995	0.4002	0.1997	3.8000
0.7996	0.4001	0.1997	3.9000
0.7997	0.4001	0.1998	4.0000
0.7997	0.4001	0.1998	4.1000
0.7998	0.4000	0.1998	4.2000
0.7998	0.4000	0.1998	4.3000
0.7998	0.4000	0.1998	4.4000
0.7999	0.4000	0.1999	4.5000
0.7999	0.4000	0.1999	4.6000
0.7999	0.4000	0.1999	4.7000
0.7999	0.4000	0.1999	4.8000
0.7999	0.4000	0.1999	4.9000
0.7999	0.4000	0.1999	5.0000

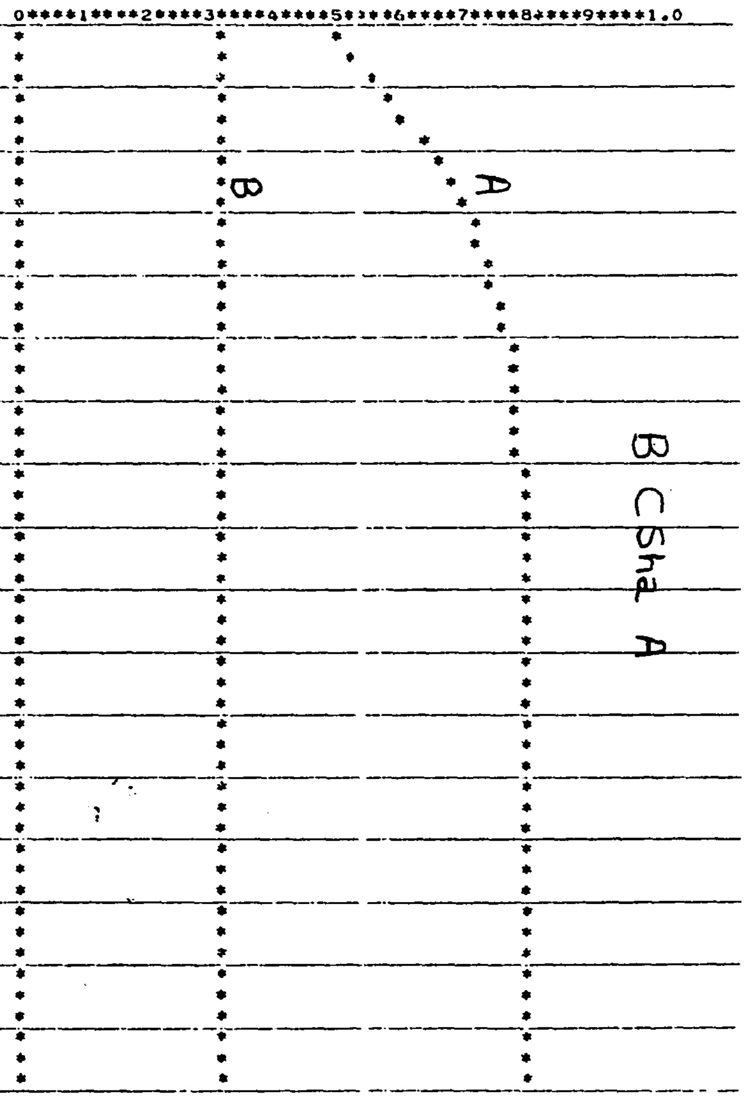


PLOT OF D=0.31TANH(T)+0.15

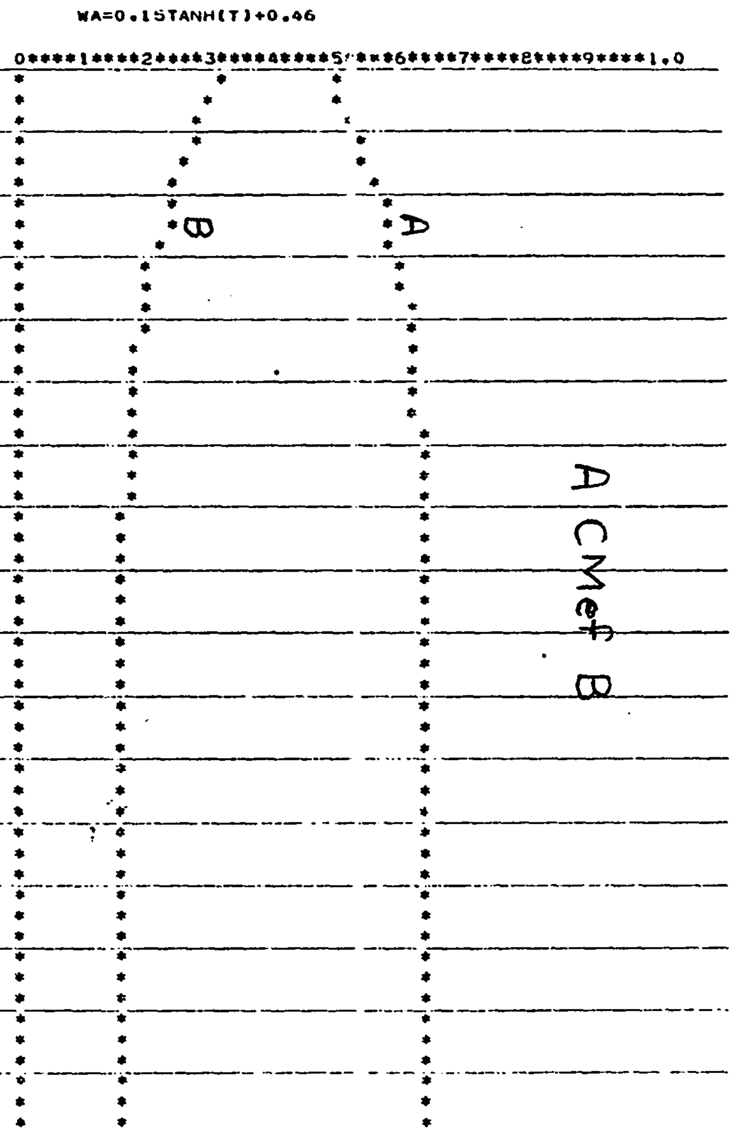


WA=0.31TANH(T)+0.46

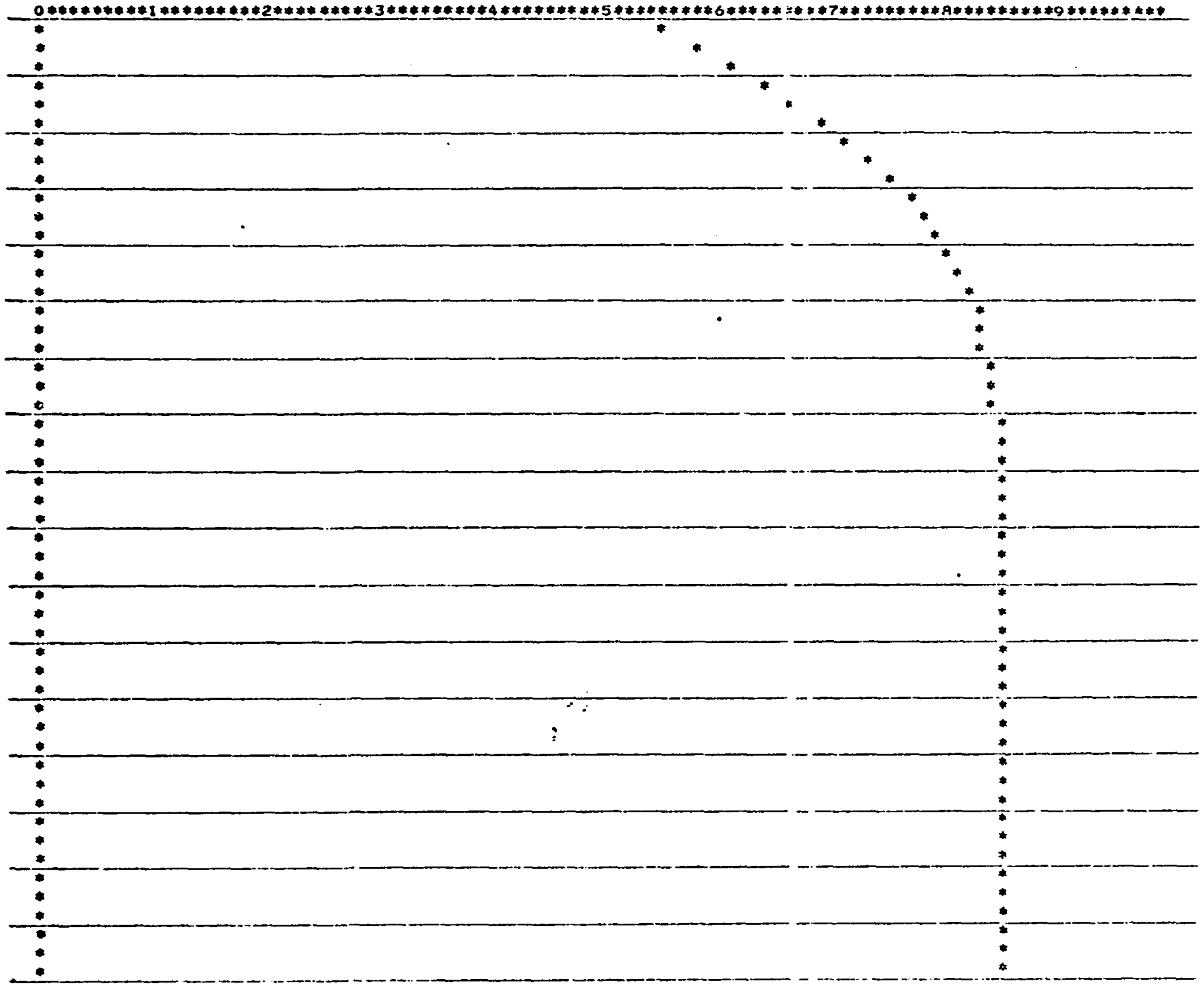
D	WA	WB	T
0.1500	0.4600	0.3100	0.0000
0.1800	0.4900	0.3100	0.1000
0.2100	0.5200	0.3100	0.2000
0.2400	0.5500	0.3100	0.3000
0.2600	0.5700	0.3100	0.4000
0.2900	0.6000	0.3100	0.5000
0.3100	0.6200	0.3100	0.6000
0.3300	0.6400	0.3100	0.7000
0.3500	0.6600	0.3100	0.8000
0.3700	0.6800	0.3100	0.9000
0.3800	0.6900	0.3100	1.0000
0.3900	0.7000	0.3100	1.1000
0.4000	0.7100	0.3100	1.2000
0.4100	0.7200	0.3100	1.3000
0.4200	0.7300	0.3100	1.4000
0.4300	0.7400	0.3100	1.5000
0.4300	0.7400	0.3100	1.6000
0.4300	0.7400	0.3100	1.7000
0.4400	0.7500	0.3100	1.8000
0.4400	0.7500	0.3100	1.9000
0.4400	0.7500	0.3100	2.0000
0.4500	0.7600	0.3100	2.1000
0.4500	0.7600	0.3100	2.2000
0.4500	0.7600	0.3100	2.3000
0.4500	0.7600	0.3100	2.4000
0.4500	0.7600	0.3100	2.5000
0.4500	0.7600	0.3100	2.6000
0.4500	0.7600	0.3100	2.7000
0.4500	0.7600	0.3100	2.8000
0.4500	0.7600	0.3100	2.9000
0.4500	0.7600	0.3100	3.0000
0.4500	0.7600	0.3100	3.1000
0.4500	0.7600	0.3100	3.2000
0.4500	0.7600	0.3100	3.3000
0.4500	0.7600	0.3100	3.4000
0.4500	0.7600	0.3100	3.5000
0.4500	0.7600	0.3100	3.6000
0.4500	0.7600	0.3100	3.7000
0.4500	0.7600	0.3100	3.8000
0.4500	0.7600	0.3100	3.9000
0.4500	0.7600	0.3100	4.0000
0.4500	0.7600	0.3100	4.1000
0.4500	0.7600	0.3100	4.2000
0.4500	0.7600	0.3100	4.3000
0.4500	0.7600	0.3100	4.4000
0.4500	0.7600	0.3100	4.5000
0.4500	0.7600	0.3100	4.6000
0.4500	0.7600	0.3100	4.7000
0.4500	0.7600	0.3100	4.8000
0.4500	0.7600	0.3100	4.9000
0.4500	0.7600	0.3100	5.0000



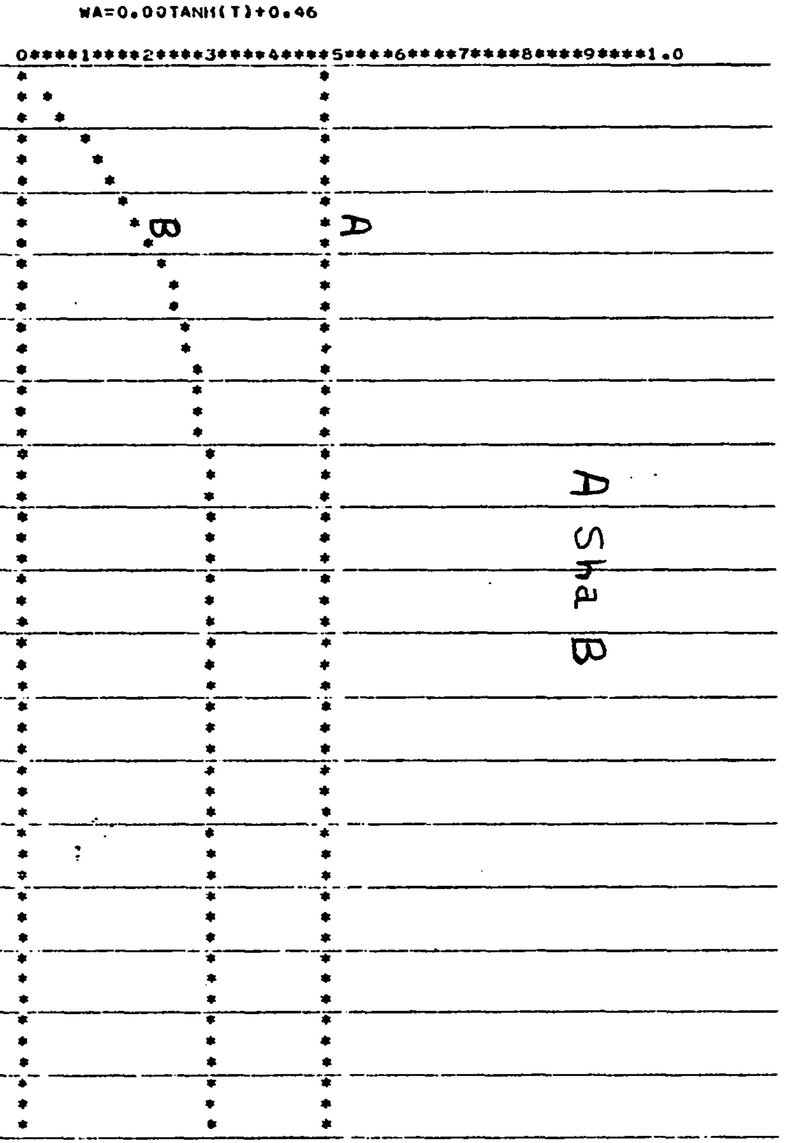
D	WA	WB	T
0.1500	0.4600	0.3100	0.0000
0.1800	0.4700	0.2900	0.1000
0.2100	0.4800	0.2700	0.2070
0.2400	0.5000	0.2600	0.3000
0.2600	0.5100	0.2500	0.4000
0.2900	0.5200	0.2300	0.5000
0.3100	0.5400	0.2300	0.6000
0.3300	0.5500	0.2200	0.7000
0.3500	0.5500	0.2000	0.8000
0.3700	0.5600	0.1900	0.9000
0.3800	0.5700	0.1900	1.0000
0.3900	0.5800	0.1900	1.1000
0.4000	0.5800	0.1800	1.2000
0.4100	0.5800	0.1700	1.3000
0.4200	0.5900	0.1700	1.4000
0.4300	0.5900	0.1600	1.5000
0.4300	0.5900	0.1600	1.6000
0.4300	0.6000	0.1700	1.7000
0.4400	0.6000	0.1600	1.8000
0.4400	0.6000	0.1600	1.9000
0.4400	0.6000	0.1600	2.0000
0.4500	0.6000	0.1500	2.1000
0.4500	0.6000	0.1500	2.2000
0.4500	0.6000	0.1500	2.3000
0.4500	0.6000	0.1500	2.4000
0.4500	0.6000	0.1500	2.5000
0.4500	0.6000	0.1500	2.6000
0.4500	0.6000	0.1500	2.7000
0.4500	0.6000	0.1500	2.8000
0.4500	0.6000	0.1500	2.9000
0.4500	0.6000	0.1500	3.0000
0.4500	0.6000	0.1500	3.1000
0.4500	0.6000	0.1500	3.2000
0.4500	0.6000	0.1500	3.3000
0.4500	0.6000	0.1500	3.4000
0.4500	0.6000	0.1500	3.5000
0.4500	0.6000	0.1500	3.6000
0.4500	0.6000	0.1500	3.7000
0.4500	0.6000	0.1500	3.8000
0.4500	0.6000	0.1500	3.9000
0.4500	0.6000	0.1500	4.0000
0.4500	0.6000	0.1500	4.1000
0.4500	0.6000	0.1500	4.2000
0.4500	0.6000	0.1500	4.3000
0.4500	0.6000	0.1500	4.4000
0.4500	0.6000	0.1500	4.5000
0.4500	0.6000	0.1500	4.6000
0.4500	0.6000	0.1500	4.7000
0.4500	0.6000	0.1500	4.8000
0.4500	0.6000	0.1500	4.9000
0.4500	0.6000	0.1500	5.0000



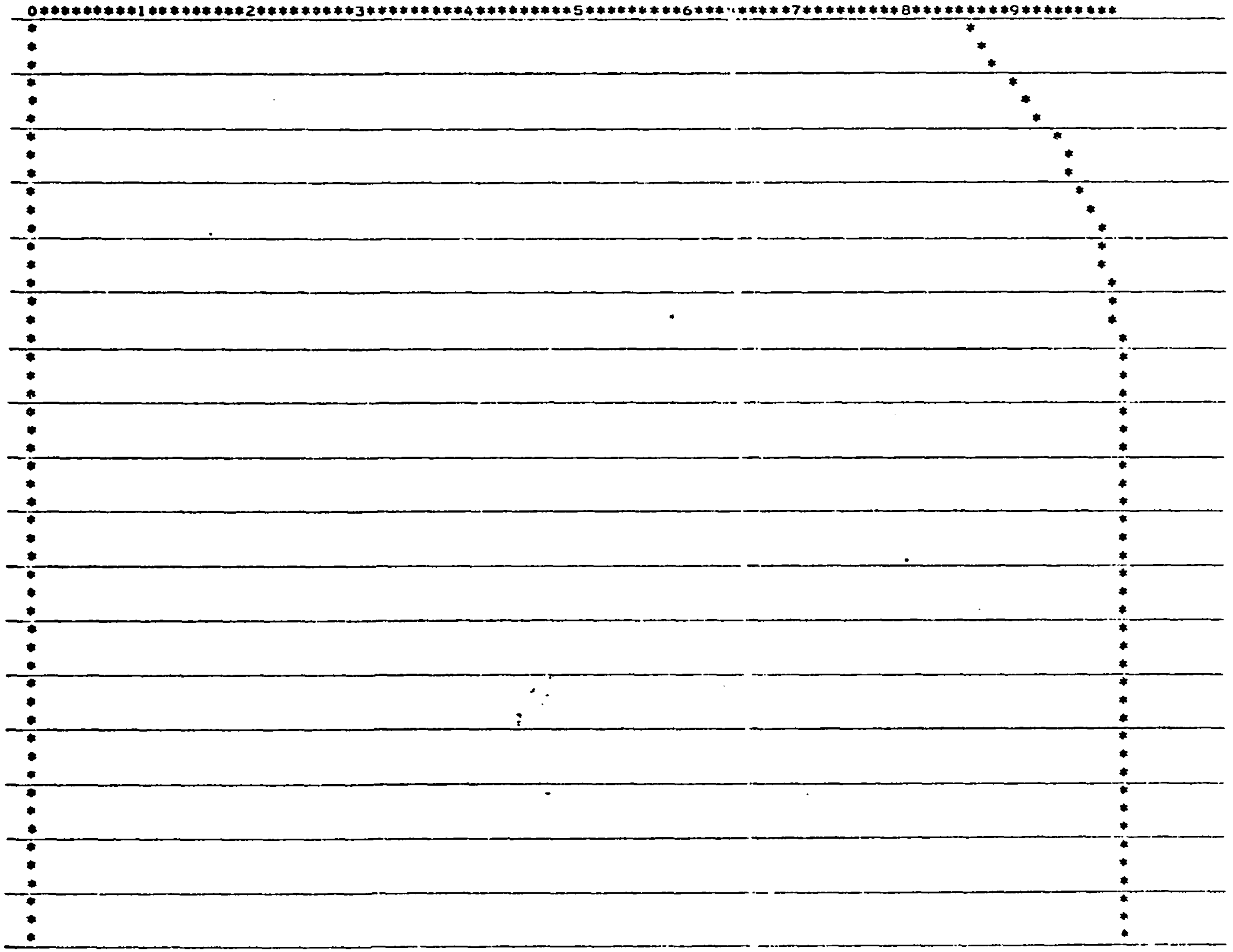
PLOT OF S=0.31TANH(T)+0.54



S	WA	WB	T
0.5400	0.4600	0.0000	0.0000
0.5700	0.4500	0.0200	0.1000
0.6000	0.4500	0.0500	0.2000
0.6300	0.4500	0.0800	0.3000
0.6500	0.4500	0.1000	0.4000
0.6800	0.4500	0.1300	0.5000
0.7000	0.4500	0.1500	0.6000
0.7200	0.4500	0.1700	0.7000
0.7400	0.4500	0.1900	0.8000
0.7600	0.4500	0.2100	0.9000
0.7700	0.4500	0.2200	1.0000
0.7800	0.4500	0.2300	1.1000
0.7900	0.4500	0.2400	1.2000
0.8000	0.4500	0.2500	1.3000
0.8100	0.4500	0.2600	1.4000
0.8200	0.4500	0.2700	1.5000
0.8200	0.4500	0.2700	1.6000
0.8200	0.4500	0.2700	1.7000
0.8300	0.4500	0.2800	1.8000
0.8300	0.4500	0.2800	1.9000
0.8300	0.4500	0.2800	2.0000
0.8400	0.4500	0.2900	2.1000
0.8400	0.4500	0.2900	2.2000
0.8400	0.4500	0.2900	2.3000
0.8400	0.4500	0.2900	2.4000
0.8400	0.4500	0.2900	2.5000
0.8400	0.4500	0.2900	2.6000
0.8400	0.4500	0.2900	2.7000
0.8400	0.4500	0.2900	2.8000
0.8400	0.4500	0.2900	2.9000
0.8400	0.4500	0.2900	3.0000
0.8400	0.4500	0.2900	3.1000
0.8400	0.4500	0.2900	3.2000
0.8400	0.4500	0.2900	3.3000
0.8400	0.4500	0.2900	3.4000
0.8400	0.4500	0.2900	3.5000
0.8400	0.4500	0.2900	3.6000
0.8400	0.4500	0.2900	3.7000
0.8400	0.4500	0.2900	3.8000
0.8400	0.4500	0.2900	3.9000
0.8400	0.4500	0.2900	4.0000
0.8400	0.4500	0.2900	4.1000
0.8400	0.4500	0.2900	4.2000
0.8400	0.4500	0.2900	4.3000
0.8400	0.4500	0.2900	4.4000
0.8400	0.4500	0.2900	4.5000
0.8400	0.4500	0.2900	4.6000
0.8400	0.4500	0.2900	4.7000
0.8400	0.4500	0.2900	4.8000
0.8400	0.4500	0.2900	4.9000
0.8400	0.4500	0.2900	5.0000

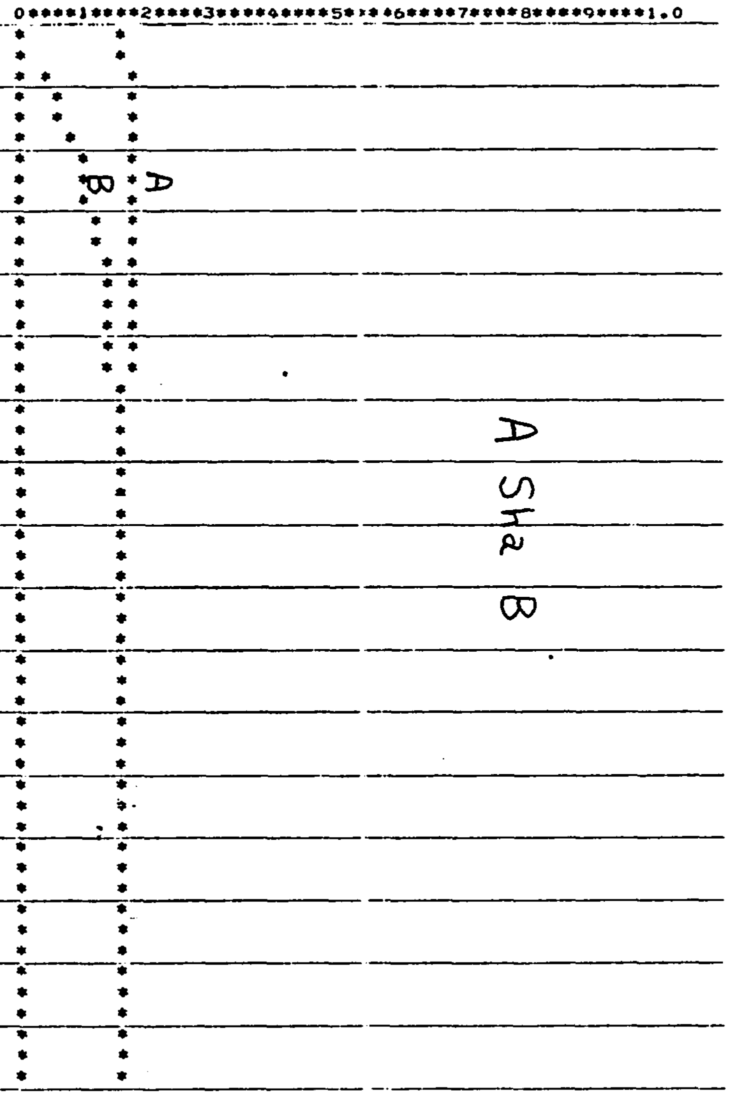


PLOT OF S=0.15TANH(T)+0.85



WA=1-(0.00TANH(T)+(1-0.15))

S	WA	WB	T
0.8500	0.1500	0.0000	0.0000
0.8600	0.1500	0.0100	0.1000
0.8700	0.1500	0.0200	0.2000
0.8900	0.1500	0.0400	0.3000
0.9000	0.1500	0.0500	0.4000
0.9100	0.1500	0.0600	0.5000
0.9300	0.1500	0.0800	0.6000
0.9400	0.1500	0.0900	0.7000
0.9400	0.1500	0.0900	0.8000
0.9500	0.1500	0.1000	0.9000
0.9600	0.1500	0.1100	1.0000
0.9700	0.1500	0.1200	1.1000
0.9700	0.1500	0.1200	1.2000
0.9700	0.1500	0.1200	1.3000
0.9800	0.1500	0.1300	1.4000
0.9800	0.1500	0.1300	1.5000
0.9800	0.1500	0.1300	1.6000
0.9900	0.1500	0.1400	1.7000
0.9900	0.1500	0.1400	1.8000
0.9900	0.1500	0.1400	1.9000
0.9900	0.1500	0.1400	2.0000
0.9900	0.1500	0.1400	2.1000
0.9900	0.1500	0.1400	2.2000
0.9900	0.1500	0.1400	2.3000
0.9900	0.1500	0.1400	2.4000
0.9900	0.1500	0.1400	2.5000
0.9900	0.1500	0.1400	2.6000
0.9900	0.1500	0.1400	2.7000
0.9900	0.1500	0.1400	2.8000
0.9900	0.1500	0.1400	2.9000
0.9900	0.1500	0.1400	3.0000
0.9900	0.1500	0.1400	3.1000
0.9900	0.1500	0.1400	3.2000
0.9900	0.1500	0.1400	3.3000
0.9900	0.1500	0.1400	3.4000
0.9900	0.1500	0.1400	3.5000
0.9900	0.1500	0.1400	3.6000
0.9900	0.1500	0.1400	3.7000
0.9900	0.1500	0.1400	3.8000
0.9900	0.1500	0.1400	3.9000
0.9900	0.1500	0.1400	4.0000
0.9900	0.1500	0.1400	4.1000
0.9900	0.1500	0.1400	4.2000
0.9900	0.1500	0.1400	4.3000
0.9900	0.1500	0.1400	4.4000
0.9900	0.1500	0.1400	4.5000
0.9900	0.1500	0.1400	4.6000
0.9900	0.1500	0.1400	4.7000
0.9900	0.1500	0.1400	4.8000
0.9900	0.1500	0.1400	4.9000
0.9900	0.1500	0.1400	5.0000



APPENDIX D

SIMULATIONS

Instructions for Reading Output

Each item mentioned in the instructions is numbered for reference in the output. Since the program first analyzes each individual case, the first page of print-out includes the index values for each person at time 0 and time 1 (1). Estimated equations (2) are then printed, and if the model does not fit, this is supplied with the equation (3)*. Equations for the difference (estimated) scores are then printed (4) and indication if the model does not fit (5). If one of the nonsymetric relations is found between individuals, this information is supplied, i.e. 1Sha 2 for example (6). If one of the other relations exists, this is indicated (7). The program then prints a table of values which includes time (8), indexes (9), computed differences (10), and estimated differences (11).

Following the last case, examples of interaction combinations are reported **. The printout looks virtually the same except that interaction combination values are used. The number of the interact combination is printed (12) and then the numbers of the persons which comprise that "icomb" (13). The initial icomb value at time 0 is then printed (14).

---

*An example of 3 may be found in the 6th case.

**Following case 12.

CASE 1

INITIAL INDEX VALUES		EQUATIONS FOR EACH INDEX
1 W(1,1)=.6000	W(1,11)=.5000	2 W=-0.026TANH(T)+.6000
W(2,1)=.4000	W(2,11)=.4500	W= 0.066TANH(T)+.4000
W(3,1)=.3000	W(3,11)=.3200	W= 0.026TANH(T)+.3000
W(4,1)=.2000	W(4,11)=.1800	W=-0.026TANH(T)+.2000
W(5,1)=.1800	W(5,11)=.0500	W=-0.171TANH(T)+.1600

EQUATIONS	
4 D12=-0.0917TANH(T)+.2000	7 HFF
D13=-0.0523TANH(T)+.3000	HFF
D14= 0.0000TANH(T)+.4000	HFF
D15= 0.1444TANH(T)+.4200	6 ICSHAS
D23= 0.0393TANH(T)+.1000	SCSHA2
D24= 0.0917TANH(T)+.2000	CHFF
D25= 0.2362TANH(T)+.2200	CHFF
D34= 0.0523TANH(T)+.1000	CHFF
D35= 0.1958TANH(T)+.1200	CHFF
D45= 0.1440TANH(T)+.0200	HCSHAS

EXPECTED VALUES

8 TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.5009	0.5878	0.5803	0.5762	0.5747	0.5741	0.5739	0.5738	0.5738	0.5738	0.5738
W2	=	0.3999	0.4443	0.4499	0.4593	0.4632	0.4647	0.4652	0.4654	0.4655	0.4655	0.4655
9 W3	=	0.2999	0.3121	0.3199	0.3237	0.3252	0.3258	0.3260	0.3261	0.3261	0.3261	0.3261
W4	=	0.1999	0.1878	0.1803	0.1762	0.1747	0.1741	0.1739	0.1738	0.1738	0.1738	0.1738
W5	=	0.1799	0.1011	0.0500	0.0255	0.0155	0.0116	0.0102	0.0097	0.0095	0.0094	0.0094
10 D12	=	0.2000	0.1575	0.1301	0.1169	0.1115	0.1094	0.1087	0.1084	0.1083	0.1083	0.1083
11 DE12	=	0.1999	0.1574	0.1301	0.1169	0.1115	0.1095	0.1087	0.1084	0.1083	0.1083	0.1083
D13	=	0.3000	0.2757	0.2601	0.2525	0.2495	0.2483	0.2479	0.2477	0.2477	0.2477	0.2477
DE13	=	0.2999	0.2756	0.2601	0.2526	0.2495	0.2484	0.2479	0.2477	0.2477	0.2477	0.2477
D14	=	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000	0.4000
DE14	=	0.3999	0.3999	0.3999	0.3999	0.3999	0.3999	0.3999	0.3999	0.3999	0.3999	0.3999
D15	=	0.4200	0.4867	0.5300	0.5507	0.5592	0.5625	0.5637	0.5641	0.5643	0.5644	0.5644
DE15	=	0.4199	0.4867	0.5299	0.5507	0.5592	0.5624	0.5636	0.5641	0.5643	0.5645	0.5645
D23	=	0.1000	0.1182	0.1300	0.1356	0.1380	0.1389	0.1392	0.1393	0.1394	0.1394	0.1394
DE23	=	0.0999	0.1181	0.1299	0.1355	0.1376	0.1387	0.1391	0.1392	0.1392	0.1392	0.1392
D24	=	0.2000	0.2425	0.2699	0.2831	0.2885	0.2906	0.2913	0.2916	0.2917	0.2917	0.2917
DE24	=	0.1999	0.2423	0.2698	0.2830	0.2884	0.2904	0.2912	0.2915	0.2916	0.2916	0.2916
D25	=	0.2200	0.3292	0.3999	0.4338	0.4477	0.4531	0.4550	0.4557	0.4560	0.4561	0.4561
DE25	=	0.2199	0.3291	0.3998	0.4337	0.4477	0.4530	0.4558	0.4557	0.4560	0.4561	0.4561
D34	=	0.1000	0.1243	0.1399	0.1475	0.1505	0.1517	0.1521	0.1523	0.1523	0.1523	0.1523
DE34	=	0.0999	0.1241	0.1398	0.1473	0.1504	0.1515	0.1520	0.1522	0.1522	0.1522	0.1522
D35	=	0.1200	0.2117	0.2699	0.2982	0.3097	0.3142	0.3158	0.3164	0.3166	0.3167	0.3167
DE35	=	0.1199	0.2109	0.2698	0.2981	0.3097	0.3141	0.3158	0.3164	0.3166	0.3167	0.3167
D45	=	0.0200	0.0867	0.1300	0.1507	0.1592	0.1625	0.1637	0.1641	0.1643	0.1644	0.1644
DE45	=	0.0199	0.0867	0.1299	0.1507	0.1592	0.1624	0.1636	0.1641	0.1643	0.1645	0.1545

CASE 2

```
INITIAL INDEX VALUES                      EQUATIONS FOR EACH INDEX
W(1,1)=.0200      W(1,11)=.0500            W= 0.039TANH(T)+.0200
W(2,1)=.1000      W(2,11)=.0950            W=-0.007TANH(T)+.1000
W(3,1)=.3000      W(3,11)=.2950            W=-0.007TANH(T)+.3000
W(4,1)=.3100      W(4,11)=.4500            W= 0.184TANH(T)+.3100
W(5,1)=.5000      W(5,11)=.4800            W=-0.026TANH(T)+.5000

EQUATIONS
D12=-0.0458TANH(T)+.0800      EFF
D13=-0.0458TANH(T)+.2800      EFF
D14= 0.1444TANH(T)+.2900      ICSHAG
D15=-0.0656TANH(T)+.4801      EFF
D23= 0.0000TANH(T)+.2000      EFF
D24= 0.1902TANH(T)+.2100      CHEF
D25=-0.0198TANH(T)+.4001      2SHA 5
D34= 0.1902TANH(T)+.0100      CHEF
D35=-0.0198TANH(T)+.2001      3SHA 5
D45=MODEL DOES NOT FIT
D45=-0.2100TANH(T)+.1901      EFF
```

5

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.0199	0.0381	[illegible]	0.0555	0.0576	0.0587	0.0591	0.0592	0.0592	0.0592	0.0592
W2	=	0.0999	0.0969	0.0953	0.0941	0.0937	0.0935	0.0935	0.0935	0.0935	0.0935	0.0935
W3	=	0.2999	0.2969	0.2955	0.2941	0.2937	0.2935	0.2935	0.2935	0.2935	0.2935	0.2935
W4	=	0.3099	0.3949	0.4499	0.4765	0.4871	0.4915	0.4928	0.4934	0.4936	0.4937	0.4937
W5	=	0.5000	0.4878	0.4830	0.4762	0.4747	0.4741	0.4739	0.4738	0.4738	0.4738	0.4738
D12	=	0.0800	0.0568	0.0451	0.0386	0.0359	0.0348	0.0344	0.0343	0.0343	0.0343	0.0343
DE12	=	0.0799	0.0568	0.0451	0.0385	0.0358	0.0348	0.0344	0.0342	0.0342	0.0342	0.0342
D13	=	0.2800	0.2568	0.2451	0.2386	0.2359	0.2348	0.2344	0.2343	0.2343	0.2343	0.2343
DE13	=	0.2799	0.2568	0.2451	0.2385	0.2358	0.2348	0.2344	0.2342	0.2342	0.2342	0.2342
D14	=	0.2900	0.3568	0.4009	0.4208	0.4295	0.4326	0.4337	0.4342	0.4344	0.4345	0.4345
DE14	=	0.2899	0.3567	0.3999	0.4207	0.4292	0.4324	0.4336	0.4341	0.4343	0.4343	0.4343
D15	=	0.4831	0.4497	0.4311	0.4217	0.4169	0.4154	0.4148	0.4146	0.4146	0.4146	0.4146
DE15	=	0.4800	0.4497	0.4311	0.4207	0.4168	0.4153	0.4148	0.4146	0.4145	0.4145	0.4145
D23	=	0.2000	[illegible]	[illegible]	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000	0.2000
DE23	=	0.1999	0.1979	0.1999	0.1979	0.1999	0.1999	0.1999	0.1979	0.1999	0.1999	0.1999
D24	=	0.2100	0.2982	0.3549	0.3822	0.3934	0.3978	0.3993	0.3999	0.4001	0.4002	0.4002
DE24	=	0.2099	0.2978	0.3548	0.3821	0.3933	0.3976	0.3992	0.3998	0.4000	0.4001	0.4001
D25	=	0.4001	0.3960	0.3850	0.3821	0.3810	0.3806	0.3804	0.3803	0.3803	0.3803	0.3803
DE25	=	0.4000	0.3919	0.3850	0.3821	0.3810	0.3805	0.3803	0.3803	0.3803	0.3803	0.3803
D34	=	0.0100	0.0981	0.1549	0.1822	0.1934	0.1978	0.1993	0.1999	0.2001	0.2002	0.2002
DE34	=	0.0099	0.0976	0.1546	0.1821	0.1933	0.1976	0.1992	0.1998	0.2000	0.2001	0.2001
D35	=	0.2001	0.1919	0.1850	0.1821	0.1810	0.1806	0.1804	0.1803	0.1803	0.1803	0.1803
DE35	=	0.2001	0.1919	0.1851	0.1821	0.1810	0.1805	0.1803	0.1803	0.1803	0.1803	0.1803
D45	=	0.1901	0.0929	0.0371	0.0001	0.0124	0.0172	0.0189	0.0196	0.0198	0.0199	0.0199

CASE 3

```
        INITIAL INDEX VALUES                      EQUATIONS FOR EACH INDEX
   W(1,1)=.3000     W(1,11)=.28[illegible]          W=-0.026TANH(T)+.3000
   W(2,1)=.2000     W(2,11)=.1[illegible]           W=-0.131TANH(T)+.2001
   W(3,1)=.4000     W(3,11)=.5[illegible]0          W= 0.131TANH(T)+.4001
   W(4,1)=.1686     W(4,11)=.1690                   W= 0.001TANH(T)+.1686
   W(5,1)=.3565     W(5,11)=.3570                   W= 0.001TANH(T)+.3565

        EQUATIONS
   D12= 0.1050TANH(T)+.100[illegible]    TCSHA2
   D13= 0.1574TANH(T)+.1[illegible]      CHEF
   D14=-0.0266TANH(T)+.1314              4SHA 1
   D15= 0.0267TANH(T)+.0565              5CSHA1
   D23= 0.2624TANH(T)+.200[illegible]    CHEF
   D24=MODEL DOES NOT FIT
   D24= 0.0092TANH(T)+.0315              4CSHA2
   D25= 0.1318TANH(T)+.1565              5CSHA2
   D34= 0.1307TANH(T)+.251[illegible]    4CSHA3
   D35= 0.1306TANH(T)+.2435              5CSHA3
   D45= 0.0001TANH(T)+.1679              HEF
```

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.2999	0.2874	0.2800	0.2762	0.2747	0.2741	0.2739	0.2738	0.2738	0.2738	0.2738
W2	=	0.1999	0.1393	0.1003	0.0811	0.0734	0.0704	0.0693	0.0689	0.0687	0.0687	0.0687
W3	=	0.3999	0.4616	0.4999	0.5188	0.5265	0.5295	0.5306	0.5310	0.5312	0.5312	0.5312
W4	=	0.1685	0.1688	0.1089	0.1690	0.1690	0.1690	0.1690	0.1690	0.1690	0.1690	0.1690
W5	=	0.3564	0.3567	0.3569	0.3570	0.3570	0.3570	0.3570	0.3570	0.3570	0.3571	0.3570
D12	=	0.1000	0.1485	0.1800	0.1951	0.2013	0.2037	0.2046	0.2049	0.2051	0.2051	0.2051
DE12	=	0.0999	0.1445	0.1799	0.1950	0.2012	0.2035	0.2044	0.2048	0.2049	0.2049	0.2049
D13	=	0.1000	0.1728	0.2199	0.2426	0.2518	0.2554	0.2567	0.2572	0.2574	0.2570	0.2574
DE13	=	0.0999	0.1727	0.2196	0.2424	0.2517	0.2552	0.2566	0.2571	0.2572	0.2573	0.2575
D14	=	0.1314	0.1198	0.1111	0.1072	0.1057	0.1051	0.1049	0.1048	0.1046	0.1048	0.1048
DE14	=	0.1313	0.1191	0.1111	0.1073	0.1057	0.1051	0.1049	0.1048	0.1046	0.1048	0.1048
D15	=	0.0565	0.0689	0.0769	0.0808	0.0825	0.0829	0.0831	0.0832	0.0832	0.0832	0.0832
DE15	=	0.0566	0.0688	0.0766	0.0806	0.0822	0.0826	0.0830	0.0831	0.0831	0.0831	0.0831
D23	=	0.2000	0.3213	0.3999	0.4377	0.4531	0.4591	0.4613	0.4621	0.4625	0.4625	0.4625
DE23	=	0.1999	0.3212	0.3998	0.4375	0.4529	0.4588	0.4611	0.4619	0.4622	0.4623	0.4623
D24	=	0.0314	0.1205	0.0689	0.0879	0.0956	0.0986	0.0997	0.1001	0.1003	0.1003	0.1003
DE24	=	0.0313	0.0561	0.0688	0.0759	0.0788	0.0799	0.0803	0.0805	0.0805	0.0805	0.0805
D25	=	0.1565	0.2172	0.2566	0.2759	0.2836	0.2866	0.2877	0.2881	0.2883	0.2883	0.2883
DE25	=	0.1564	0.2170	0.2566	0.2757	0.2835	0.2865	0.2876	0.2880	0.2882	0.2882	0.2882
D34	=	0.2314	0.2918	0.3310	0.3496	0.3575	0.3605	0.3616	0.3620	0.3622	0.3622	0.3622
DE34	=	0.2313	0.2917	0.3309	0.3497	0.3573	0.3603	0.3614	0.3618	0.3620	0.3620	0.3620
D35	=	0.0435	0.1039	0.1430	0.1618	0.1695	0.1725	0.1736	0.1740	0.1742	0.1742	0.1742
DE35	=	0.0434	0.1[illegible]	0.1429	0.1617	0.1694	0.1723	0.1734	0.1738	0.1740	0.1740	0.1740

CASE 4

INITIAL INDEX VALUES

		EQUATIONS FOR EACH INDEX
W(1,1)=.0000	W(1,11)=.0000	W= 0.000TANH(T)+.0000
W(2,1)=.0000	W(2,11)=.0000	W= 0.000TANH(T)+.0000
W(3,1)=.2300	W(3,11)=.2002	W=-0.039TANH(T)+.2300
W(4,1)=.3000	W(4,11)=.3570	W= 0.066TANH(T)+.3000
W(5,1)=.5000	W(5,11)=.4900	W=-0.013TANH(T)+.5000

EQUATIONS

D12= 0.0000TANH(T)+.0000	MFF
D13=-0.0392TANH(T)+.2299	1SHA 3
D14= 0.0656TANH(T)+.2999	1CSHA4
D15=-0.0131TANH(T)+.5000	1SHA 5
D23=-0.0392TANH(T)+.2299	2SHA 3
D24= 0.0656TANH(T)+.2999	2CSHA4
D25=-0.0131TANH(T)+.5000	2SHA 5
D34= 0.1049TANH(T)+.0700	CMFF
D35= 0.0261TANH(T)+.2701	5CSHA3
D45=-0.0757TANH(T)+.2001	MEF

EXPECTED VALUES

TIME		0.0000	.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W2	=	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W3	=	0.2299	0.2118	0.2000	0.1944	0.1921	0.1912	0.1908	0.1907	0.1907	0.1907	0.1907
W4	=	0.2999	0.3303	0.3499	0.3593	0.3632	0.3647	0.3652	0.3654	0.3655	0.3655	0.3655
W5	=	0.5000	0.4939	0.4900	0.4881	0.4873	0.4870	0.4869	0.4869	0.4869	0.4869	0.4869
D12	=	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DE12	=	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
D13	=	0.2299	0.2118	0.2000	0.1944	0.1921	0.1912	0.1908	0.1907	0.1907	0.1907	0.1907
DE13	=	0.2298	0.2117	0.2[illegible]	0.1944	0.1921	0.1912	0.1908	0.1907	0.1907	0.1907	0.1907
D14	=	0.2999	.3303	0.3499	0.3593	0.3632	0.3647	0.3652	0.3654	0.3655	0.3655	0.3655
DE14	=	0.2998	0.3302	0.3498	0.3592	0.3631	0.3646	0.3651	0.3653	0.3654	0.3654	0.3654
D15	=	0.5000	0.4939	0.4900	0.4881	0.4873	0.4870	0.4869	0.4869	0.4869	0.4869	0.4869
DE15	=	0.5000	0.4939	0.4900	0.4881	0.4873	0.4870	0.4869	0.4869	0.4869	0.4869	0.4869
D23	=	0.2299	0.2118	0.2000	0.1944	0.1921	0.1912	0.1908	0.1907	0.1907	0.1907	0.1907
DE23	=	0.2298	0.2117	0.2000	0.1944	0.1921	0.1912	0.1908	0.1907	0.1907	0.1907	0.1907
D24	=	0.2999	0.3303	0.3499	0.3593	0.3632	0.3647	0.3652	0.3654	0.3655	0.3655	0.3655
DE24	=	0.2998	0.3302	0.3498	0.3592	0.3631	0.3646	0.3651	0.3653	0.3654	0.3654	0.3654
D25	=	0.5000	0.4939	0.4900	0.4881	0.4873	0.4870	0.4869	0.4869	0.4869	0.4869	0.4869
DE25	=	0.5000	0.4939	0.4900	0.4881	0.4873	0.4870	0.4869	0.4869	0.4869	0.4869	0.4869
D34	=	0.0700	0.1185	0.1499	0.1649	0.1711	0.1735	0.1744	0.1747	0.1748	0.1748	0.1748
DE34	=	0.0699	0.1184	0.1498	0.1649	0.1711	0.1734	0.1743	0.1747	0.1748	0.1748	0.1748
D35	=	0.2701	0.2821	0.2900	0.2937	0.2952	0.2958	0.2961	0.2962	0.2962	0.2962	0.2962
DE35	=	0.2700	0.2821	0.2899	0.2937	0.2952	0.2958	0.2960	0.2961	0.2961	0.2961	0.2961
D45	=	0.2001	0.1636	0.1401	0.1288	0.1241	0.1223	0.1217	0.1215	0.1214	0.1214	0.1214
DE45	=	0.2000	0.1637	0.1401	0.1288	0.1242	0.1224	0.1217	0.1215	0.1214	0.1214	0.1214

CASE 5

INITIAL INDEX VALUES

W(1,1)=.0000	W(1,11)=.1000
W(2,1)=.2000	W(2,11)=.1998
W(3,1)=.2500	W(3,11)=.2000
W(4,1)=.3000	W(4,11)=.3500
W(5,1)=.5000	W(5,11)=.4900

EQUATIONS FOR EACH INDEX

W= 0.131TANH(T)+.0000
W=-0.000TANH(T)+.2000
W=-0.066TANH(T)+.2500
W= 0.066TANH(T)+.3000
W=-0.013TANH(T)+.5000

EQUATIONS

D12=-0.1313TANH(T)+.1999	2SHA 1
D13=-0.1968TANH(T)+.2500	MEF
D14=-0.0655TANH(T)+.2999	4SHA 1
D15=-0.1443TANH(T)+.5000	MEF
D23-MODEL DOES NOT FIT	
D23=-0.0655TANH(T)+.0501	2SHA 3
D24= 0.0657TANH(T)+.1000	2CSHA4
D25=-0.0129TANH(T)+.3001	2SHA 5
D34= 0.1313TANH(T)+.0499	CMEF
D35= 0.0525TANH(T)+.2500	5CSHA3
D45=-0.0787TANH(T)+.2001	MEF

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.0002	0.0696	0.0999	0.1188	0.1265	0.1295	0.1306	0.1310	0.1312	0.1312	0.1312
W2	=	0.1999	0.1999	0.1998	0.1998	0.1998	0.1998	0.1998	0.1998	0.1998	0.1998	0.1998
W3	=	0.2501	0.2196	0.2000	0.1936	0.1867	0.1852	0.1847	0.1845	0.1844	0.1844	0.1844
W4	=	0.2999	0.3303	0.3499	0.3593	0.3632	0.3647	0.3652	0.3654	0.3655	0.3655	0.3655
W5	=	0.5002	0.4939	0.4900	0.4881	0.4873	0.4870	0.4869	0.4869	0.4869	0.4869	0.4869
D12	=	0.1999	0.1393	0.0999	0.0810	0.0733	0.0703	0.0692	0.0688	0.0686	0.0686	0.0686
DE12	=	0.1996	0.1392	0.0999	0.0810	0.0735	0.0705	0.0692	0.0688	0.0686	0.0686	0.0686
D13	=	0.2500	0.1590	0.1001	0.0718	0.0602	0.0557	0.0541	0.0535	0.0532	0.0532	0.0532
DE13	=	0.2501	0.1590	0.1001	0.0718	0.0602	0.0558	0.0541	0.0535	0.0533	0.0532	0.0532
D14	=	0.2999	0.2697	0.2500	0.2405	0.2367	0.2352	0.2346	0.2344	0.2343	0.2343	0.2343
DE14	=	0.2998	0.2696	0.2500	0.2406	0.2367	0.2352	0.2347	0.2345	0.2344	0.2344	0.2344
D15	=	0.5003	0.4333	0.3951	0.3693	0.3608	0.3575	0.3563	0.3559	0.3557	0.3557	0.3557
DE15	=	0.5000	0.4333	0.3911	0.3693	0.3606	0.3576	0.3564	0.3559	0.3557	0.3557	0.3557
D23	=	0.0501	0.0197	0.0002	0.0092	0.0131	.0146	0.0151	0.0153	0.0154	0.0154	0.0154
DE23	=	0.0501	0.0198	0.0002	-0.0091	-0.0132	-0.0145	-0.0150	-0.0152	-0.0153	-0.0153	-0.0153
D24	=	0.1001	0.1334	0.1501	0.1595	0.1634	0.1649	0.1654	0.1656	0.1657	0.1657	0.1657
DE24	=	0.0999	0.1303	0.1500	0.1594	0.1633	0.1648	0.1653	0.1655	0.1656	0.1656	0.1656
D25	=	0.3001	0.2300	0.2907	0.2883	0.2875	0.2872	0.2871	0.2871	0.2871	0.2871	0.2871
DE25	=	0.3000	0.2911	0.2902	0.2884	0.2876	0.2873	0.2872	0.2872	0.2872	0.2872	0.2872
D34	=	0.0499	0.1107	0.1499	0.1687	0.1765	0.1795	0.1805	0.1809	0.1811	0.1811	0.1811
DE34	=	0.0498	0.1105	0.1498	0.1687	0.1764	0.1794	0.1805	0.1809	0.1811	0.1811	0.1811
D35	=	0.2500	0.2743	0.2900	0.2975	0.3006	0.3018	0.3022	0.3024	0.3025	0.3025	0.3025
DE35	=	0.2500	0.2742	0.2899	0.2975	0.3006	0.3017	0.3022	0.3024	0.3024	0.3024	0.3024
D45	=	0.2001	0.1636	0.1401	0.1288	0.1241	0.1223	0.1217	0.1215	0.1214	0.1214	0.1214
DE45	=	0.2000	0.1637	0.1401	0.1288	0.1242	0.1224	0.1217	0.1215	0.1214	0.1214	0.1214

CASE 6

INITIAL INDEX VALUES		EQUATIONS FOR EACH INDEX	
W(1,1)=,0000	W(1,11)=,0000	W= 0,000TANH(T)+,0000	
W(2,1)=,1000	W(2,11)=,8000	3 MODEL DOES NOT FIT	W= 0,919TANH(T)+,1000
W(3,1)=,2300	W(3,11)=,2600	W= 0,039TANH(T)+,2300	
W(4,1)=,3000	W(4,11)=,2900	W=-0,013TANH(T)+,3000	
W(5,1)=,5000	W(5,11)=,5500	W= 0,066TANH(T)+,5000	

EQUATIONS

```
D12=MODEL DOES NOT FIT
D12= 0,9191TANH(T)+,0999       ICSHA2
D13= 0,0393TANH(T)+,2299       ICSHA3
D14=-0,0129TANH(T)+,2999       ISHA 4
D15= 0,0655TANH(T)+,5000       ICSHA5
D23=MODEL DOES NOT FIT
D23= 0,5383TANH(T)+,1300       3CSHA2
D24=MODEL DOES NOT FIT
D24= 0,4069TANH(T)+,2000       CHEF
D25=MODEL DOES NOT FIT
D25=-0,1970TANH(T)+,4001       SSHA 2
D34=-0,0523TANH(T)+,0700       HEF
D35= 0,0261TANH(T)+,2701       3CSHA5
D45= 0,0785TANH(T)+,2001       CHEF
```

EXPECTED VALUES

TIME		0,0000	0,5000	1,0000	1,5000	2,0000	2,5000	3,0000	3,5000	4,0000	4,5000	5,0000
W1	=	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000	0,0000
W2	=	0,0999	0,5247	0,7999	0,9319	0,9860	1,0067	1,0145	1,0174	1,0184	1,0188	1,0190
W3	=	0,2299	0,2481	0,2599	0,2655	0,2678	0,2687	0,2691	0,2692	0,2692	0,2692	0,2692
W4	=	0,2999	0,2939	0,2900	0,2881	0,2873	0,2870	0,2869	0,2869	0,2869	0,2869	0,2869
W5	=	0,5000	0,5393	0,5499	0,5593	0,5632	0,5647	0,5652	0,5654	0,5655	0,5655	0,5655
D12	=	0,0997	0,5247	0,7997	0,9319	0,9860	1,0067	1,0145	1,0174	1,0184	1,0188	1,0190
DE12	=	0,0998	0,5246	0,7998	0,9318	0,9859	1,0066	1,0144	1,0173	1,0183	1,0187	1,0189
D13	=	0,2299	0,2481	0,2599	0,2655	0,2678	0,2687	0,2691	0,2692	0,2692	0,2692	0,2692
DE13	=	0,2298	0,2480	0,2598	0,2654	0,2677	0,2686	0,2690	0,2691	0,2691	0,2691	0,2691
D14	=	0,2999	0,2939	0,2900	0,2881	0,2873	0,2870	0,2869	0,2869	0,2869	0,2869	0,2869
DE14	=	0,2998	0,2939	0,2900	0,2882	0,2874	0,2871	0,2870	0,2870	0,2870	0,2870	0,2870
D15	=	0,5000	0,5393	0,5499	0,5593	0,5632	0,5647	0,5652	0,5654	0,5655	0,5655	0,5655
DE15	=	0,5400	0,5392	0,5498	0,5592	0,5631	0,5646	0,5651	0,5653	0,5654	0,5654	0,5654
D23	=	0,1300	0,2766	0,5400	0,6664	0,7182	0,7380	0,7454	0,7482	0,7492	0,7496	0,7498
DE23	=	0,1299	0,3787	0,5399	0,6172	0,6489	0,6610	0,6656	0,6673	0,6679	0,6681	0,6682
D24	=	0,2000	0,2338	0,5099	0,6458	0,6987	0,7197	0,7276	0,7305	0,7315	0,7319	0,7321
DE24	=	0,1999	0,3885	0,5098	0,5683	0,5922	0,6014	0,6048	0,6061	0,6066	0,6067	0,6068
D25	=	0,4000	0,3056	0,2500	0,3726	0,4228	0,4420	0,4493	0,4521	0,4529	0,4533	0,4535
DE25	=	0,4000	0,3090	0,2500	0,2217	0,2101	0,2057	0,2040	0,2034	0,2032	0,2031	0,2031
D34	=	0,0700	0,1458	0,0301	0,0226	0,0195	0,0183	0,0178	0,0177	0,0177	0,0177	0,0177

CASE 7

INITIAL INDEX VALUES		EQUATIONS FOR EACH INDEX
W(1,1)=,2050	W(1,11)=,2000	W=-0,007TANH(T)+,2050
W(2,1)=,1050	W(2,11)=,1100	W= 0,007TANH(T)+,1050
W(3,1)=,3500	W(3,11)=,3200	W=-0,066TANH(T)+,3500
W(4,1)=,3500	W(4,11)=,3550	W= 0,007TANH(T)+,3500
W(5,1)=,4800	W(5,11)=,5900	W= 0,144TANH(T)+,4800

EQUATIONS

D12=-0,0129TANH(T)+,1000	1SHA 2
D13=-0,0590TANH(T)+,1450	1SHA 3
D14= 0,0129TANH(T)+,1450	1CSHA4
D15= 0,1558TANH(T)+,2750	CEF
D23=-0,0720TANH(T)+,2450	CEF
D24= 0,0000TANH(T)+,2450	CEF
D25= 0,1378TANH(T)+,3750	2CSHA5
D34= 0,0720TANH(T)+,0000	CEF
D35= 0,2099TANH(T)+,1330	CEF
D45= 0,1378TANH(T)+,1350	4CSHA5

EXPECTED VALUES

TIME		0,0000	0,5000	1,0000	1,5000	2,0000	2,5000	3,0000	3,5000	4,0000	4,5000	5,0000
W1	=	0,2749	0,2739	0,2184	0,1991	0,1987	0,1985	0,1985	0,1985	0,1985	0,1985	0,1985
W2	=	0,1049	[illegible]	0,1099	0,1108	0,1112	0,1114	0,1113	0,1114	0,1114	0,1114	0,1114
W3	=	0,3499	0,3196	0,3002	0,2906	0,2867	0,2852	0,2847	0,2845	0,2844	0,2844	0,2844
W4	=	0,3499	0,3539	0,3549	0,3558	0,3562	0,3564	0,3564	0,3564	0,3564	0,3564	0,3564
W5	=	0,4799	0,5467	0,5899	0,6107	0,6192	0,6224	0,6236	0,6241	0,6243	0,6245	0,6245
D12	=	0,1000	0,0939	0,0901	0,0883	0,0875	0,0871	0,0871	0,0871	0,0871	0,0871	0,0871
DE12	=	0,0999	0,0922	0,0901	0,0883	0,0875	0,0872	0,0871	0,0871	0,0871	0,0871	0,0871
D13	=	0,1450	0,1177	0,1009	0,0915	0,0880	0,0867	0,0862	0,0860	0,0859	0,0859	0,0859
DE13	=	0,1449	0,1177	0,1001	0,0915	0,0891	0,0867	0,0862	0,0861	0,0860	0,0860	0,0860
D14	=	0,1450	0,1511	0,1549	0,1567	0,1575	0,1579	0,1579	0,1579	0,1579	0,1579	0,1579
DE14	=	0,1449	0,1509	0,1548	0,1566	0,1574	0,1577	0,1578	0,1578	0,1578	0,1578	0,1578
D15	=	0,2750	0,3448	0,3899	0,4116	0,4205	0,4239	0,4251	0,4256	0,4258	0,4258	0,4258
DE15	=	0,2749	0,3446	0,3898	0,4119	0,4203	0,4237	0,4250	0,4255	0,4256	0,4257	0,4257
D23	=	0,2450	0,2116	0,1911	0,1798	0,1755	0,1738	0,1733	0,1731	0,1730	0,1730	0,1730
DE23	=	0,2449	0,2117	0,1901	0,1799	0,1755	0,1739	0,1733	0,1731	0,1731	0,1732	0,1730
D24	=	0,2450	0,2450	0,2450	0,2450	0,2450	0,2450	0,2450	0,2450	0,2450	0,2450	0,2450
DE24	=	0,2449	0,2449	0,2449	0,2449	0,2449	0,2449	0,2449	0,2449	0,2449	0,2449	0,2449
D25	=	0,3750	0,4387	0,4800	0,4999	0,5080	0,5110	0,5122	0,5127	0,5129	0,5129	0,5129
DE25	=	0,3750	0,4386	0,4799	0,4997	0,5078	0,5109	0,5121	0,5125	0,5127	0,5127	0,5127
D34	=	0,0000	0,0334	0,0529	0,0652	0,0695	0,0712	0,0717	0,0719	0,0720	0,0720	0,0720
DE34	=	0,0000	0,0332	0,0560	0,0651	0,0694	0,0710	0,0716	0,0715	0,0719	0,0719	0,0719
D35	=	0,1330	0,2271	0,2899	0,3221	0,3325	0,3372	0,3389	0,3396	0,3399	0,3399	0,3399
DE35	=	0,1299	0,2269	0,2898	0,3199	0,3323	0,3370	0,3388	0,3395	0,3397	0,3394	0,3398
D45	=	0,1350	0,1937	0,2350	0,2549	0,2639	0,2660	0,2672	0,2677	0,2679	0,2677	0,2679

CASE 8

INITIAL INDEX VALUES

W(1,1)=.1234   W(1,11)=.3241
W(2,1)=.0000   W(2,11)=.0560
W(3,1)=.4789   W(3,11)=.3521
W(4,1)=.0000   W(4,11)=.0000
W(5,1)=.6000   W(5,11)=.6500

EQUATIONS FOR EACH INDEX

W= 0.264TANH(T)+.1234
W= 0.074TANH(T)+.0000
W=-0.166TANH(T)+.4769
W= 0.000TANH(T)+.0000
W= 0.066TANH(T)+.6000

EQUATIONS

D12=-0.1901TANH(T)+.1233   2CSHAT
D13=MODEL DOES NOT FIT
D13=-0.4298TANH(T)+.3555   MEF
D14= 0.2635TANH(T)+.1233   4CSHA1
D15=-0.1978TANH(T)+.4766   5SHA 1
D23=-0.2597TANH(T)+.4788   MEF
D24= 0.0733TANH(T)+.0000   4CSHA2
D25=-0.0077TANH(T)+.5999   5SHA 2
D34=-0.1663TANH(T)+.4788   4SHA 3
D35= 0.2320TANH(T)+.1211   CMEF
D45= 0.0656TANH(T)+.5999   4CSHA5

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.1233	0.2451	0.3240	0.3619	0.3774	0.3833	0.3855	0.3864	0.3867	0.3868	0.3868
W2	=	0.0000	0.0339	0.0559	0.0665	0.0708	0.0725	0.0731	0.0733	0.0734	0.0734	0.0734
W3	=	0.4788	0.4020	0.3521	0.3282	0.3184	0.3147	0.3133	0.3128	0.3126	0.3125	0.3125
W4	=	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
W5	=	0.5999	0.6303	0.6499	0.6593	0.6652	0.6647	0.6652	0.6654	0.6655	0.6655	0.6655
D12	=	0.1233	0.2112	0.2681	0.2954	0.3066	0.3108	0.3124	0.3131	0.3133	0.3134	0.3134
DE12	=	0.1232	0.2111	0.2680	0.2953	0.3065	0.3108	0.3124	0.3130	0.3132	0.3133	0.3133
D13	=	0.3555	0.1569	0.0281	0.0337	0.0590	0.0686	0.0722	0.0736	0.0741	0.0743	0.0743
DE13	=	0.3554	0.1568	0.0281	-0.0335	-0.0588	-0.0685	-0.0721	-0.0735	-0.0740	-0.0741	-0.0742
D14	=	0.1233	0.2451	0.3240	0.3619	0.3774	0.3833	0.3855	0.3864	0.3867	0.3868	0.3868
DE14	=	0.1232	0.2450	0.3239	0.3618	0.3773	0.3832	0.3854	0.3865	0.3866	0.3867	0.3867
D15	=	0.4766	0.3452	0.3259	0.2974	0.2858	0.2814	0.2797	0.2790	0.2788	0.2787	0.2787
DE15	=	0.4765	0.3451	0.3259	0.2975	0.2859	0.2814	0.2797	0.2791	0.2789	0.2788	0.2788
D23	=	0.4788	0.3661	0.2962	0.2617	0.2476	0.2422	0.2402	0.2395	0.2392	0.2391	0.2391
DE23	=	0.4787	0.3660	0.2962	0.2618	0.2477	0.2423	0.2402	0.2395	0.2392	0.2391	0.2391
D24	=	0.0000	0.0339	0.0559	0.0665	0.0708	0.0725	0.0731	0.0733	0.0734	0.0734	0.0734
DE24	=	0.0000	0.0338	0.0558	0.0665	0.0706	0.0725	0.0729	0.0731	0.0732	0.0732	0.0732
D25	=	0.5999	0.5960	0.5940	0.5928	0.5924	0.5922	0.5921	0.5921	0.5921	0.5921	0.5921
DE25	=	0.5994	0.5963	0.5940	0.5929	0.5924	0.5923	0.5922	0.5922	0.5922	0.5922	0.5922
D34	=	0.4788	0.4020	0.3521	0.3282	0.3184	0.3147	0.3133	0.3128	0.3126	0.3125	0.3125
DE34	=	0.4787	0.4019	0.3521	0.3282	0.3184	0.3147	0.3133	0.3128	0.3126	0.3125	0.3125
D35	=	0.1211	0.2283	0.2978	0.3311	0.3446	0.3500	0.3519	0.3526	0.3529	0.3530	0.3530
DE35	=	0.1210	0.2283	0.2977	0.3310	0.3447	0.3499	0.3519	0.3526	0.3529	0.3530	0.3530

CASE 9

```
      INITIAL INDEX VALUES                          EQUATIONS FOR EACH INDEX
W(1,1)=.0123      W(1,11)=.3456                       W= 0.438TANH(T)+.0123
W(2,1)=.2022      W(2,11)=.4500                       W= 0.325TANH(T)+.2022
W(3,1)=.3000      W(3,11)=.3500                       W= 0.066TANH(T)+.3000
W(4,1)=.4500      W(4,11)=.4650                       W= 0.013TANH(T)+.4500
W(5,1)=.3568      W(5,11)=.4000                       W= 0.054TANH(T)+.3568

      EQUATIONS
D12=-0.1122TANH(T)+.1899      2SHA 1
D13=MODEL DOES NOT FIT
D13=-0.3719TANH(T)+.2877      3SHA 1
D14=-0.4245TANH(T)+.4377      4SHA 1
D15=MODEL DOES NOT FIT
D15=-0.3835TANH(T)+.3665      5SHA 1
D23=MODEL DOES NOT FIT
D23= 0.0628TANH(T)+.0978      3CSHA2
D24=MODEL DOES NOT FIT
D24=-0.3122TANH(T)+.2476      4SHA 2
D25=MODEL DOES NOT FIT
D25=-0.1399TANH(T)+.1566      5SHA 2
D34=-0.0525TANH(T)+.1560      4SHA 3
D35=-0.0115TANH(T)+.0586      5SHA 3
D45=-0.0409TANH(T)+.0912      4SHA 5
```

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.0122	0.2145	0.3455	0.4083	0.4341	0.4440	0.4477	0.4491	0.4496	0.4497	0.4498
W2	=	0.2021	0.3525	0.4499	0.4966	0.5157	0.5231	0.5258	0.5269	0.5272	0.5273	0.5274
W3	=	0.2999	0.3513	0.3499	0.3593	0.3632	0.3647	0.3652	0.3654	0.3655	0.3655	0.3655
W4	=	0.4499	0.4551	0.4599	0.4618	0.4626	0.4629	0.4630	0.4630	0.4630	0.4630	0.4630
W5	=	0.3587	0.3837	0.3999	0.4076	0.4108	0.4120	0.4125	0.4127	0.4127	0.4127	0.4127
D12	=	0.1899	0.1380	0.1044	0.0883	0.0816	0.0791	0.0781	0.0778	0.0776	0.0777	0.0776
DE12	=	0.1898	0.1380	0.1044	0.0883	0.0817	0.0792	0.0782	0.0779	0.0777	0.0777	0.0777
D13	=	0.2877	0.1158	0.0344	0.0490	0.0739	0.0793	0.0825	0.0837	0.0841	0.0842	0.0843
DE13	=	0.2876	0.1159	0.0344	-0.0489	-0.0708	-0.0792	-0.0823	-0.0835	-0.0839	-0.0841	-0.0841
D14	=	0.4377	0.2415	0.1144	0.0535	0.0285	0.0189	0.0153	0.0139	0.0134	0.0133	0.0132
DE14	=	0.4376	0.2415	0.1144	0.0534	0.0284	0.0188	0.0152	0.0139	0.0134	0.0133	0.0132
D15	=	0.3965	0.1692	0.0544	0.0007	0.0233	0.0320	0.0352	0.0364	0.0369	0.0372	0.0371
DE15	=	0.3964	0.1692	0.0544	-0.0006	-0.0232	-0.0318	-0.0351	-0.0363	-0.0367	-0.0369	-0.0369
D23	=	0.0978	0.0222	0.1000	0.1373	0.1525	0.1584	0.1606	0.1615	0.1617	0.1619	0.1619
DE23	=	0.0977	0.0997	0.0999	0.1003	0.1004	0.1005	0.1005	0.1005	0.1005	0.1005	0.1005
D24	=	0.2479	0.1135	0.0163	0.0348	0.0531	0.0602	0.0626	0.0639	0.0642	0.0644	0.0644
DE24	=	0.2477	0.1135	0.0160	-0.0347	-0.0531	-0.0602	-0.0628	-0.0638	-0.0643	-0.0643	-0.0643
D25	=	0.1566	0.0512	0.0500	0.0890	0.1049	0.1111	0.1133	0.1142	0.1145	0.1147	0.1147
DE25	=	0.1565	0.0419	0.0500	0.0299	0.0217	0.0185	0.0173	0.0169	0.0167	0.0167	0.0167

CASE 10

INITIAL INDEX VALUES		EQUATIONS FOR EACH INDEX
W(1,1)=.2050	W(1,11)=.2000	W=-0.007TANH(T)+.2050
W(2,1)=.1110	W(2,11)=.1100	W=-0.001TANH(T)+.1110
W(3,1)=.3500	W(3,11)=.3000	W=-0.066TANH(T)+.3500
W(4,1)=.3550	W(4,11)=.3550	W= 0.000TANH(T)+.3550
W(5,1)=.4800	W(5,11)=.3000	W=-0.236TANH(T)+.4800

EQUATIONS

D12=-0.0052TANH(T)+.0940 2SHA 1
D13=-.0590TANH(T)+.1050 1SHA 3
D14= 0.0064TANH(T)+.1500 4CSHA1
D15=-.2297TANH(T)+.2750 1SHA 5
D23=-0.0643TANH(T)+.2390 2SHA 3
D24= 0.0011TANH(T)+.2440 4CSHA2
D25=-0.2350TANH(T)+.3600 2SHA 5
D34= 0.0655TANH(T)+.0050 4CSHA3
D35=MODEL DOES NOT FIT
D35=-0.1706TANH(T)+.1300 3SHA 5
D45=MODEL DOES NOT FIT
D45=-0.0920TANH(T)+.1250 4SHA 5

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.2049	0.2019	[illegible]	0.1991	0.1987	0.1985	0.1985	0.1965	0.1985	0.1965	0.1985
W2	=	0.1109	0.1103	0.1100	0.1098	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097	0.1097
W3	=	0.3499	0.3196	0.3000	0.2906	0.2867	0.2852	0.2847	0.2845	0.2844	0.2844	0.2844
W4	=	0.3549	0.3549	0.3549	0.3549	0.3549	0.3549	0.3549	0.3549	0.3549	0.3549	0.3549
W5	=	0.4799	0.3708	0.3000	0.2661	0.2522	0.2468	0.2448	0.2441	0.2438	0.2437	0.2437
D12	=	0.0940	0.0916	0.0900	0.0893	0.0890	0.0885	0.0888	0.0888	0.0888	0.0888	0.0888
DE12	=	0.0939	0.0915	0.0900	0.0892	0.0889	0.0888	0.0888	0.0888	0.0888	0.0888	0.0888
D13	=	0.1455	0.1177	0.1000	0.0915	0.0880	0.0867	0.0862	0.0860	0.0859	0.0859	0.0859
DE13	=	0.1449	0.1177	0.1009	0.0915	0.0881	0.0867	0.0862	0.0861	0.0860	0.0860	0.0860
D14	=	0.1500	0.1534	0.1549	0.1558	0.1562	0.1564	0.1564	0.1564	0.1564	0.1564	0.1564
DE14	=	0.1499	0.1529	0.1548	0.1557	0.1561	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563
D15	=	0.2751	0.1669	0.1000	0.0670	0.0535	0.0485	0.0465	0.0456	0.0453	0.0452	0.0452
DE15	=	0.2749	0.1658	0.1009	0.0679	0.0535	0.0483	0.0464	0.0457	0.0454	0.0453	0.0453
D23	=	0.2390	0.2093	0.1900	0.1808	0.1770	0.1755	0.1753	0.1748	0.1747	0.1747	0.1747
DE23	=	0.2389	0.2092	0.1930	0.1807	0.1770	0.1755	0.1751	0.1748	0.1747	0.1747	0.1747
D24	=	0.2440	0.2446	0.2449	0.2451	0.2452	0.2452	0.2452	0.2452	0.2452	0.2452	0.2452
DE24	=	0.2439	0.2445	0.2448	0.2449	0.2450	0.2450	0.2450	0.2450	0.2450	0.2450	0.2450
D25	=	0.3600	0.2605	0.1900	0.1563	0.1425	0.1371	0.1351	0.1344	0.1341	0.1340	0.1340
DE25	=	0.3599	0.2600	0.1900	0.1552	0.1424	0.1371	0.1351	0.1344	0.1341	0.1341	0.1340
D34	=	0.0050	0.0353	0.0549	0.0643	0.0682	0.0697	0.0702	0.0704	0.0705	0.0705	0.0705
DE34	=	0.0049	0.0352	0.0548	0.0642	0.0661	0.0696	0.0701	0.0703	0.0704	0.0704	0.0704
D35	=	0.1300	0.0512	0.0000	-0.0245	0.0345	0.0384	0.0399	0.0404	0.0406	0.0407	0.0407
DE35	=	0.1299	0.0511	0.0006	-0.0240	-0.0340	-0.0383	-0.0397	-0.0402	-0.0404	-0.0405	-0.0405
D45	=	0.1250	0.0154	0.0549	0.0886	0.1027	0.1081	0.1101	0.1106	0.1111	0.1112	0.1112
DE45	=	0.1250	0.0826	0.0549	0.0417	0.0365	0.0342	0.0334	0.0331	0.0330	0.0330	0.0330

CASE 11

INITIAL INDEX VALUES		EQUATIONS FOR EACH INDEX
W(1,1)=.1616	W(1,11)=.1919	W= 0.040TANH(T)+.1616
W(2,1)=.1616	W(2,11)=.3000	W= 0.182TANH(T)+.1616
W(3,1)=.4000	W(3,11)=.3995	W=-0.005TANH(T)+.4000
W(4,1)=.3000	W(4,11)=.3435	W= 0.053TANH(T)+.3000
W(5,1)=.0000	W(5,11)=.0000	W= 0.000TANH(T)+.0000

EQUATIONS

D12= 0.1419TANH(T)+.0000	1CSHA2
D13=-0.0399TANH(T)+.2384	3SHA 1
D14= 0.0127TANH(T)+.1384	1CSHA4
D15= 0.0397TANH(T)+.1615	5CSHAT
D23=-0.1818TANH(T)+.2384	3SHA 2
D24=-0.1292TANH(T)+.1384	4SHA 2
D25= 0.1817TANH(T)+.1615	5CSHA2
D34=-0.0526TANH(T)+.1000	3SHA 4
D35=-0.0001TANH(T)+.3999	MFF
D45= 0.0525TANH(T)+.2999	5CSHA4

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
W1	=	0.1615	0.1799	0.1918	0.1975	0.1998	0.2007	0.2011	0.2012	0.2012	0.2012	0.2012
W2	=	0.1615	0.2655	0.2999	0.3260	0.3367	0.3408	0.3424	0.3429	0.3431	0.3432	0.3432
W3	=	0.3999	0.3999	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998
W4	=	0.2999	0.3242	0.3399	0.3475	0.3506	0.3517	0.3522	0.3524	0.3524	0.3524	0.3524
W5	=	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
D12	=	0.0000	0.0656	0.1081	0.1285	0.1369	0.1401	0.1413	0.1417	0.1419	0.1420	0.1420
DE12	=	0.0002	0.0655	0.1080	0.1284	0.1367	0.1400	0.1411	0.1416	0.1418	0.1418	0.1418
D13	=	0.2384	0.2200	0.2100	0.2023	0.2000	0.1991	0.1967	0.1966	0.1966	0.1966	0.1966
DE13	=	0.2383	0.2199	0.2080	0.2022	0.1999	0.1990	0.1966	0.1985	0.1985	0.1985	0.1985
D14	=	0.1384	0.1443	0.1481	0.1500	0.1508	0.1510	0.1511	0.1512	0.1512	0.1512	0.1512
DE14	=	0.1383	0.1442	0.1480	0.1498	0.1506	0.1509	0.1510	0.1510	0.1510	0.1510	0.1510
D15	=	0.1615	0.1799	0.1918	0.1975	0.1998	0.2007	0.2011	0.2012	0.2012	0.2012	0.2012
DE15	=	0.1614	0.1798	0.1917	0.1974	0.1997	0.2006	0.2010	0.2011	0.2011	0.2011	0.2011
D23	=	0.2384	0.1544	0.0999	0.0738	0.0631	0.0590	0.0574	0.0569	0.0567	0.0566	0.0566
DE23	=	0.2383	0.1543	0.0999	0.0738	0.0631	0.0590	0.0574	0.0569	0.0567	0.0566	0.0566
D24	=	0.1384	0.0787	0.0400	0.0215	0.0139	0.0109	0.0098	0.0095	0.0093	0.0092	0.0092
DE24	=	0.1383	0.0786	0.0400	0.0214	0.0138	0.0109	0.0098	0.0094	0.0092	0.0092	0.0092
D25	=	0.1615	0.2455	0.2999	0.3260	0.3367	0.3408	0.3424	0.3429	0.3431	0.3432	0.3432
DE25	=	0.1614	0.2454	0.2998	0.3259	0.3366	0.3407	0.3423	0.3428	0.3430	0.3431	0.3431
D34	=	0.1000	0.0757	0.0599	0.0523	0.0492	0.0481	0.0476	0.0474	0.0474	0.0474	0.0474
DE34	=	0.0999	0.0756	0.0599	0.0523	0.0492	0.0481	0.0476	0.0474	0.0474	0.0474	0.0474
D35	=	0.3999	0.3999	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998
DE35	=	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998	0.3998
D45	=	0.2999	0.3242	0.3399	0.3475	0.3506	0.3517	0.3522	0.3524	0.3524	0.3524	0.3524
DE45	=	0.2998	0.3241	0.3398	0.3474	0.3505	0.3516	0.3521	0.3523	0.3523	0.3523	0.3523

CASE 12

INITIAL INDEX VALUES		EQUATIONS FOR EACH INDEX
W(1,1)=,0000	W(1,11)=,1000	W= 0,131TANH(T)+,0000
W(2,1)=,1000	W(2,11)=,1500	W= 0,066TANH(T)+,1000
W(3,1)=,2000	W(3,11)=,2000	W= 0,000TANH(T)+,2000
W(4,1)=,2500	W(4,11)=,3500	W= 0,131TANH(T)+,2500
W(5,1)=,4000	W(5,11)=,3000	W=-0,131TANH(T)+,4000

EQUATIONS

D12=-0,0655TANH(T)+,0999	2SHA 1
D13=-0,1311TANH(T)+,1999	3SHA 1
D14= 0,0000TANH(T)+,2500	MEF
D15=-0,2625TANH(T)+,3999	MEF
D23=-0,0656TANH(T)+,1000	3SHA 2
D24= 0,0655TANH(T)+,1501	2CSHA4
D25=-0,1968TANH(T)+,3000	MEF
D34= 0,1311TANH(T)+,0501	3CSHA4
D35=-0,1311TANH(T)+,2000	3SHA 5
D45=MODEL DOES NOT FIT	
D45=-0,1313TANH(T)+,1499	MEF

EXPECTED VALUES

TIME		0,0000	0,5000	1,0000	1,5000	2,0000	2,5000	3,0000	3,5000	4,0000	4,5000	5,0000
W1	=	0,0000	0,0616	0,0999	0,1188	0,1265	0,1295	0,1306	0,1310	0,1312	0,1312	0,1312
W2	=	0,0999	0,1303	0,1499	0,1593	0,1632	0,1647	0,1652	0,1654	0,1655	0,1655	0,1655
W3	=	0,1999	0,1999	0,1999	0,1999	0,1999	0,1999	0,1999	0,1999	0,1999	0,1999	0,1999
W4	=	0,2500	0,3106	0,3499	0,3688	0,3765	0,3795	0,3806	0,3810	0,3812	0,3812	0,3812
W5	=	0,3999	0,3393	0,3000	0,2811	0,2734	0,2704	0,2693	0,2689	0,2687	0,2687	0,2687
D12	=	0,0999	0,0697	0,0500	0,0405	0,0367	0,0352	0,0346	0,0344	0,0345	0,0343	0,0343
DE12	=	0,0998	0,0696	0,0500	0,0406	0,0367	0,0352	0,0347	0,0345	0,0344	0,0344	0,0344
D13	=	0,1999	0,1393	0,1000	0,0811	0,0734	0,0704	0,0693	0,0689	0,0687	0,0687	0,0687
DE13	=	0,1998	0,1393	0,1000	0,0812	0,0735	0,0705	0,0694	0,0690	0,0688	0,0688	0,0688
D14	=	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500
DE14	=	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500	0,2500
D15	=	0,3999	0,2787	0,2001	0,1623	0,1469	0,1409	0,1387	0,1379	0,1375	0,1375	0,1375
DE15	=	0,3998	0,2786	0,2001	0,1624	0,1470	0,1411	0,1388	0,1380	0,1377	0,1376	0,1375
D23	=	0,1000	0,0696	0,0500	0,0405	0,0367	0,0352	0,0347	0,0345	0,0344	0,0344	0,0344
DE23	=	0,0999	0,0696	0,0500	0,0406	0,0367	0,0352	0,0347	0,0345	0,0344	0,0344	0,0344
D24	=	0,1501	0,1803	0,2000	0,2095	0,2133	0,2148	0,2154	0,2156	0,2157	0,2157	0,2157
DE24	=	0,1500	0,1803	0,1999	0,2093	0,2132	0,2147	0,2152	0,2154	0,2155	0,2155	0,2155
D25	=	0,3000	0,2090	0,1501	0,1218	0,1102	0,1057	0,1041	0,1035	0,1032	0,1032	0,1032
DE25	=	0,2999	0,2091	0,1501	0,1218	0,1102	0,1058	0,1041	0,1035	0,1033	0,1032	0,1032
D34	=	0,0501	0,1107	0,1500	0,1689	0,1766	0,1796	0,1807	0,1811	0,1813	0,1813	0,1813
DE34	=	0,0500	0,1106	0,1499	0,1687	0,1764	0,1794	0,1805	0,1809	0,1811	0,1811	0,1811
D35	=	0,2500	0,1394	0,1001	0,0812	0,0735	0,0705	0,0694	0,0690	0,0688	0,0688	0,0688
DE35	=	0,1999	0,1394	0,1001	0,0813	0,0736	0,0706	0,0695	0,0691	0,0689	0,0689	0,0689
D45	=	0,1499	0,0287	0,0499	0,0677	0,1031	0,1091	0,1113	0,1121	0,1125	0,1125	0,1125
DE45	=	0,1498	0,0492	0,0499	0,0310	0,0233	0,0203	0,0192	0,0186	0,0186	0,0186	0,0186

12 INITIAL ICOMB VALLES

1COMB3	0.1998	24
2COMB4	0.2500	
3COMB5	0.3998	
4COMB12	0.0499	

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EQUATIONS FOR EACH ICOMB

M= 0.000TANH(T)+.1998
M= 0.131TANH(T)+.2500
M=-0.131TANH(T)+.3998
M= 0.098TANH(T)+.0499

EQUATIONS

D12=-0.1309TANH(T)+.0503 MEF
D13=-0.1310TANH(T)+.2000 1SHA 3
D14=-0.0982TANH(T)+.1499 1SHA 4
D23=MODEL DOES NOT FIT
D23=-0.1311TANH(T)+.1497 MEF
D24= 0.0326TANH(T)+.2002 4CSHA2
D34=-0.2292TANH(T)+.3494 MEF

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
M1	=	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997
M2	=	0.2500	0.3105	0.3497	0.3685	0.3762	0.3792	0.3803	0.3807	0.3809	0.3809	0.3809
M3	=	0.3997	0.3392	0.2999	0.2811	0.2754	0.2704	0.2695	0.2689	0.2687	0.2687	0.2687
M4	=	0.0494	0.0952	0.1244	0.1387	0.1445	0.1467	0.1476	0.1479	0.1480	0.1480	0.1480
D12	=	0.0503	0.1108	0.1500	0.1688	0.1765	0.1795	0.1806	0.1810	0.1812	0.1812	0.1812
DE12	=	0.0502	0.1107	0.1499	0.1687	0.1764	0.1794	0.1805	0.1809	0.1811	0.1811	0.1811
D13	=	0.2000	0.1335	0.1002	0.0814	0.0737	0.0707	0.0696	0.0692	0.0690	0.0690	0.0690
DE13	=	0.1999	0.1394	0.1002	0.0814	0.0737	0.0707	0.0696	0.0692	0.0690	0.0690	0.0690
D14	=	0.1499	0.1045	0.0751	0.0610	0.0552	0.0530	0.0521	0.0518	0.0517	0.0517	0.0517
DE14	=	0.1494	0.1045	0.0751	0.0610	0.0552	0.0530	0.0521	0.0518	0.0517	0.0517	0.0517
D23	=	0.1497	0.0267	0.0498	0.0874	0.1028	0.1088	0.1110	0.1116	0.1122	0.1122	0.1122
DE23	=	0.1496	0.0891	0.0498	0.0310	0.0233	0.0203	0.0192	0.0188	0.0186	0.0186	0.0186
D24	=	0.2002	0.2153	0.2251	0.2298	0.2317	0.2325	0.2327	0.2326	0.2329	0.2329	0.2329
DE24	=	0.2001	0.2152	0.2250	0.2297	0.2310	0.2323	0.2326	0.2327	0.2327	0.2327	0.2327
D34	=	0.3499	0.2440	0.1753	0.1424	0.1289	0.1237	0.1217	0.1210	0.1207	0.1207	0.1207
DE34	=	0.3494	0.2439	0.1753	0.1424	0.1289	0.1237	0.1218	0.1211	0.1208	0.1207	0.1207

INITIAL ICOMB VALUES		EQUATIONS FOR EACH ICOMB
1COMB2	0.0998	M= 0.066TANH(T)+.0998
2COMB4	0.2500	M= 0.131TANH(T)+.2500
3COMB5	0.3998	M=-0.131TANH(T)+.3998
4COMB13	0.0999	M= 0.066TANH(T)+.0999

EQUATIONS

```
D12= 0.0652TANH(T)+.1503     ICSHA2
D13=-0.1966TANH(T)+.3000     MFF
D14=-0.0001TANH(T)+.0001     MFF
D23=MODEL DOES NOT FIT
D23=-0.1311TANH(T)+.1497     MFF
D24= 0.0653TANH(T)+.1502     4CSHA2
D34=-0.1965TANH(T)+.2999     MFF
```

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
M1	=	0.0997	0.1301	0.1497	0.1591	0.1631	0.1645	0.1650	0.1652	0.1653	0.1653	0.1653
M2	=	0.2500	0.3125	0.3497	0.3685	0.3762	0.3792	0.3803	0.3807	0.3809	0.3809	0.3809
M3	=	0.3997	0.3392	0.2999	0.2811	0.2734	0.2704	0.2693	0.2689	0.2687	0.2687	0.2687
M4	=	0.0998	0.1301	0.1497	0.1591	0.1631	0.1645	0.1650	0.1652	0.1653	0.1653	0.1653
D12	=	0.1503	0.1804	0.2000	0.2094	0.2132	0.2147	0.2153	0.2155	0.2156	0.2156	0.2156
DE12	=	0.1502	0.1806	0.1999	0.2093	0.2131	0.2146	0.2151	0.2153	0.2154	0.2154	0.2154
D13	=	0.3000	0.2291	0.1502	0.1220	0.1104	0.1059	0.1043	0.1037	0.1034	0.1034	0.1034
DE13	=	0.2999	0.2091	0.1502	0.1220	0.1104	0.1060	0.1043	0.1037	0.1035	0.1034	0.1034
D14	=	0.0001	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
DE14	=	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
D23	=	0.1497	0.0287	0.0496	0.0874	0.1021	0.1088	0.1110	0.1118	0.1122	0.1122	0.1122
DE23	=	0.1496	0.0591	0.0494	0.0310	0.0235	0.0203	0.0192	0.0188	0.0186	0.0186	0.0186
D24	=	0.1502	0.1804	0.2000	0.2094	0.2132	0.2147	0.2153	0.2155	0.2156	0.2156	0.2156
DE24	=	0.1501	0.1803	0.1999	0.2093	0.213.	0.2146	0.2151	0.2153	0.2154	0.2154	0.2154
D34	=	0.2999	0.2091	0.1502	0.1220	0.1104	0.1059	0.1043	0.1037	0.1034	0.1034	0.1034
DE34	=	0.2998	0.2090	0.1502	0.1220	0.1104	0.1060	0.1043	0.1037	0.1035	0.1034	0.1034

INITIAL ICOMB VALUES		EQUATIONS FOR EACH ICOMB
1COMB1	0.0000	M= 0.131TANH(T)+.0000
2COMB3	0.1998	M= 0.000TANH(T)+.1998
3COMB5	0.3998	M=-0.131TANH(T)+.3998
4COMB24	0.1748	M= 0.098TANH(T)+.1748

EQUATIONS

D12=-0.1309TANH(T)+.1997 2SHA 1
D13=-0.2619TANH(T)+.3997 MEF
D14=-0.0324TANH(T)+.1747 4SHA 1
D23=-0.1310TANH(T)+.2000 2SHA 3
D24=MODEL DOES NOT FIT
D24= 0.0328TANH(T)+.0250 2SHA 4
D34=MODEL DOES NOT FIT
D34=-0.2295TANH(T)+.2250 MEF

EXPECTED VALUES.

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
M1	=	0.0000	[illegible]	0.0997	0.1185	0.1262	0.1292	0.1303	0.1307	0.1309	0.1309	0.1309
M2	=	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997	0.1997
M3	=	0.3997	0.3392	0.2999	0.2811	0.2734	0.2704	0.2693	0.2689	0.2687	0.2687	0.2687
M4	=	0.1747	0.2202	0.2497	0.2638	0.2696	0.2718	0.2727	0.2730	0.2731	0.2731	0.2731
D12	=	0.1997	0.1392	0.1000	0.0812	0.0735	0.0705	0.0694	0.0690	0.0689	0.0688	0.0688
DE12	=	0.1996	0.1392	0.1000	0.0812	0.0735	0.0705	0.0694	0.0690	0.0688	0.0688	0.0689
D13	=	0.3997	0.2787	0.2002	0.1626	0.1472	0.1412	0.1390	0.1382	0.1378	0.1378	0.1378
DE13	=	0.3996	0.2786	0.2002	0.1626	0.1472	0.1413	0.1390	0.1382	0.1379	0.1378	0.1378
D14	=	0.1747	0.1597	0.1500	0.1453	0.1434	0.1426	0.1424	0.1423	0.1422	0.1422	0.1422
DE14	=	0.1746	0.1597	0.1503	0.1453	0.1434	0.1427	0.1424	0.1423	0.1423	0.1423	0.1423
D23	=	0.2000	0.1395	0.1002	0.0814	0.0737	0.0707	0.0696	0.0692	0.0690	0.0693	0.0690
DE23	=	0.1999	0.1394	0.1002	0.0814	0.0737	0.0707	0.0696	0.0692	0.0690	0.0690	0.0690
D24	=	0.0250	0.0295	0.0500	0.0641	0.0699	0.0721	0.0730	0.0733	0.0734	0.0734	0.0734
DE24	=	0.0249	[illegible]	0.0499	0.0546	0.0560	0.0573	0.0576	0.0577	0.0577	0.0577	0.0577
D34	=	0.2250	0.1190	0.0502	0.0173	0.0038	0.0014	0.0034	0.0041	0.0044	0.0044	0.0044
DE34	=	0.2249	0.1189	0.0562	0.0172	0.0037	-0.0014	-0.0035	-0.0040	-0.0043	-0.0044	-0.0044

INITIAL ICOMB VALUES

1COMP12 0,0499

2COMB345 0,2831

EQUATIONS FOR EACH ICOMB

M= 0,098TANH(T)+,0499

M= 0,000TANH(T)+,2831

EQUATIONS

D12=-0,0982TANH(T)+,2332 25HA-1

EXPECTED VALUES

TIME		0,0000	0,5000	1,0000	1,5000	2,0000	2,5000	3,0000	3,5000	4,0000	4,5000	5,0000
M1	=	0,0498	0,0952	0,1246	0,1387	0,1445	0,1467	0,1479	0,1479	0,1480	0,1460	0,1480
M2	=	0,2830	0,2850	0,2850	0,2830	0,2830	0,2830	0,2830	0,2830	0,2830	0,2850	0,2830
D12	=	0,2332	0,1878	0,1584	0,1443	0,1385	0,1363	0,1354	0,1351	0,1350	0,1350	0,1350
DE12	=	0,2331	0,1878	0,1584	0,1443	0,1385	0,1363	0,1354	0,1351	0,1350	0,1350	0,1350

INITIAL ICOMB VALUES

1COMB13 0.0999
2COMB245 0.2496

EQUATIONS FOR EACH ICOMB

M= 0.066TANH(T)+.0999
M= 0.022TANH(T)+.2496

EQUATIONS

D12=-0.0435TANH(T)+.1497 2SHA 1

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
M1	=	0.0998	0.1501	0.1497	0.1591	0.1650	0.1645	0.1650	0.1652	0.1653	0.1653	0.1653
M2	=	0.2495	0.2597	0.2662	0.2694	0.2707	0.2712	0.2713	0.2714	0.2714	0.2714	0.2714
D12	=	0.1497	0.1296	0.1165	0.1103	0.1077	0.1067	0.1063	0.1062	0.1061	0.1061	0.1061
DE12	=	0.1496	0.1295	0.1165	0.1103	0.1077	0.1067	0.1064	0.1062	0.1062	0.1062	0.1062

INITIAL ICOMB VALUES

ICOMB14 0.1250
2COMB235 0.2329

EQUATIONS FOR EACH ICOMB

M= 0.131TANH(T)+.1250
M=-0.022TANH(T)+.2329

EQUATIONS

D12=MODEL DOES NOT FIT
D12=-0.1306TANH(T)+.1078 MEF

EXPECTED VALUES

TIME		0.0000	0.5000	1.0000	1.5000	2.0000	2.5000	3.0000	3.5000	4.0000	4.5000	5.0000
M1	=	0.1250	0.1854	0.2246	0.2434	0.2511	0.2541	0.2552	0.2556	0.2558	0.2558	0.2558
M2	=	0.2328	0.2228	0.2163	0.2132	0.2119	0.2114	0.2113	0.2112	0.2112	0.2112	0.2112
D12	=	0.1078	0.0374	0.0083	0.0302	0.0392	0.0427	0.0439	0.0444	0.0446	0.0446	0.0446
DE12	=	0.1077	0.0474	0.0083	-0.0104	-0.0181	-0.0210	-0.0221	-0.0225	-0.0227	-0.0227	-0.0227

INITIAL ICOMB VALUES
1COMB45 0,3249
2COMBT23 0,0997

EQUATIONS FOR EACH ICOMB
M=-0,000TANH(T)+,3249
M= 0,065TANH(T)+,0997

EQUATIONS
D12=-0,0653TANH(T)+,2252 ISHA 2

EXPECTED VALUES

TIME		0,0000	0,5000	1,0000	1,5000	2,0000	2,5000	3,0000	3,5000	4,0000	4,5000	5,0000
M1	=	0,3248	0,3248	0,3248	0,3248	0,3248	0,3248	0,3248	0,3248	0,3248	0,3248	0,3248
M2	=	0,0996	0,1298	0,1494	0,1588	0,1626	0,1641	0,1646	0,1648	0,1649	0,1649	0,1649
D12	=	0,2252	0,1950	0,1754	0,1660	0,1622	0,1607	0,1602	0,1600	0,1599	0,1599	0,1599
DE12	=	0,2251	0,1950	0,1754	0,1660	0,1622	0,1607	0,1602	0,1600	0,1599	0,1599	0,1599