INFORMATION THEORY AND KINSHIP

PRELIMINARY CONSIDERATIONS IN THE APPLICATION OF INFORMATION THEORY TO KINSHIP

BY

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SCOPE AND CONTENTS: This thesis explores uses of information theory as a basis for comparison of kinship terminologies. The relevance of this approach to anthropological problems is discussed with reference to the inherent characteristics of information theory and the techniques of componential analysis. Some hypotheses concerning the relationship between sibling terms and quantities of information are considered. It is shown, with respect to a limited sample of Polynesian societies, that the information 'content' of sibling terminologies tends to vary with both population densities and indices of social stratification. The paper concludes with the formulation of a similarity metric for sibling terminologies, using shared information values, and an application of the similarity metric to Athapaskan kinship.

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CHAPTER I

INTRODUCTION AND CONSPECTUS

The idea that information was something that could be measured in precise terms, or indeed, quantified at all, began with the publication of The Mathematical Theory of Communication by Claude Shannon and Warren Weaver in 1949.

Shannon's information measure was originally formulated to improve the flow of messages in communication channels, but it has been applied to more extensive fields of inquiry, such as physics, biology, psychology, and more recently, anthropology.

One of the interesting aspects of this information measure is that the content of a message is invariant to its form. It does not matter whether the message is sent in the form of words, signs, or morse code. The quantity of information remains unchanged. As such, information theory provides a conceptual framework and a set of measures that can be used in the analysis of a number of diverse situations.

One fundamental principle of the theory is that the processes which are said to convey information are relational selection processes, e.g., one makes decisions with respect to a known set of alternatives. The concept of information only has meaning in relation to a well-defined system. A second fundamental property of information measures is that probabilities can be assigned to the set of outcomes.

Componential analysis, as a method of semantic investigation (useful references on componential analysis include Frake 1962; Lounsbury 1964; Sturtevant 1964; Wallace and Atkins 1960), also consists of procedures for the identification of mutually exclusive features of a well-defined set, often a set of kin-type designations. Since information theory can be regarded, in part, as an extension of correlation theory, one is able (theoretically) to compare quantitatively the meaning (e.g., <u>significatum</u>, see Scheffler and Lounsbury 1971: 3-12) of terms in taxonomic lexicons.

A.F.C. Wallace (1961), in a paper presented to a symposium on the problems of crowding and stress, was the first anthropologist to use the information metric as a measure of the "semantic complexity" of kinship terminologies.

Wallace (1961: 459-460) found that by counting the number of cells occupied by a term (in a componential paradigm), and dividing that number by the number of cells in the taxonomic space, one has a probability measure that is analogous to Shannon's information measure. He then used this measure to test the hypothesis that "human cultures have become more complex in the course of their evolution from paleolithic to modern industrial levels of oganization" (Wallace 1961: 458). "Complexity" was seen as the number of binary discriminations that are necessary to specify every term in the lexicon.

Boyd *et al.* (1973) also recognized that the information measure is additive functions of probability spaces, and they formulated a normalized information similarity measure. This measure generates patterns of similarity which were used in the construction of hierarchical clusterings (e.g., taxonomies, see Johnson 1967) of Polynesian kinship terminologies. This analysis aided these researchers in their attempts to formulate questions of social and historical processes--phylogenetic questions--since a taxonomy of kinship systems could be compared with taxonomies of languages as provided by glottochronological techniques.

Since the papers by Wallace and Boyd *et al.* are, as far as I am able to determine, the only accounts of applications of information theory to problems associated with the study of kinship, I thought that it would be of some theoretical value to investigate the wider implications of kinship terminologies as information systems.

In chapter two I examine briefly the formal properties of information theory, relate the notion of probability to sets of alternate messages, and develop the formula for the Shannon measure of information.

Chapter three is an examination of the problem of boundary placement on sets of kin-type components and in this chapter I discuss the relevance of defining behaviour, which is characteristically infinite in variation, in terms of finite sets.

Some criticisms of componential analysis (e.g., Burling 1962; 1964) are considered which relate to the problems of kinship variation and indeterminate "solutions". The contents of this chapter are then discussed in light of a summary of psychological experiments--treated with appropriate skepticism--which indicate that our capacity for processing information, and hence, for constructing taxonomies, is significantly limited.

Chapter four is a discussion of the techniques of componential analysis as they relate to the placement of boundaries or constraints on the range of kin-type "meanings". The application of information theory is not possible unless one has a precise knowledge of the range of possible alternatives. Since information is conveyed in the form of messages or signal elements, the distinctive features or components of kin terms are seen as equivalent to these signal elements.

In chapter five I elaborate on the problem of kinship variation and suggest a functional hypothesis which restricts sibling terminologies to two varieties (e.g., terminologies with one or two terms) in terms of maxima information values. The hypothesis is given preliminary consideration by testing it against a sample of five hundred societies. This section concludes with a look at the relationship between quantities of information in sibling terminologies (Polynesian), and the independent variables of social differentiation and population densities.

In chapter six I relate discussions in the previous chapters to an empirical example, to wit, Athapaskan kinship systems. This example is organized about the testing of an hypothesis, proposed by Murdock (1968), concerning the relationship between patterns of sibling terminology and linguistic groupings.

CHAPTER II

INFORMATION AND MESSAGES

Science has given precise definition to our intuitive understanding of such terms as "acceleration", "work", and "information". When a technical concept is designated by a common word, the word consequently acquires a new meaning. Before a term can be used in a technical context, its new meaning must be defined. Since the fundamentals of information theory are not generally well known, the information theorist's definition of information will now be defined.

The concept of information, as used in this thesis, is a refinement of the everyday usage of the term. Information can be thought of as that which removes or reduces our uncertainty about the outcome of a particular event. (Attneave 1959: 1). The more information that we have at our disposal, the more certain we are about making decisions or choosing between alternatives. The technical meaning of information is simply more precise than the lay usage.

The reader will find the following "checkerboard" example illustrative, more embellished variations of which can be found in Attneave (1959: 2-4), and DeFleur and

Larson (1958: 261-263).

If one were asked to determine the location of one square of the checkerboard, what is the minimum number of questions, which elicit yes-no answers, that can be asked in order to always arrive at the correct solution? Since yes-no responses are the only ones admissible, the task must be accomplished by the successive binary partitioning of the board. The first question reduces the number of alternatives from 64 - 32, the second to 16, and so on, until one is certain of the location of the correct square. The number of alternate questions is six, all of which are not only necessary, but sufficient when properly asked, to identify the appropriate square.

An interesting aspect of this process is that $2^6=64$. Put another way, the minimum number of questions required to arrive at the correct solution is the power to which 2 must be raised in order to equal the number of available alternatives.

This equation (e.g. $64=2^6$) can be generalized to the form $m=2^H$ or $\log_2 m=H$, since logarithms are easier to manipulate. "m" is the number of equally likely alternatives from which a choice is made, and "H" is the amount of uncertainty or information, expressed in binary digits (contracted to "bits"). The unit for measurement of information is one binary digit (Attneave 1959: 4).[1]

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[1] It should be noted that information theory does not necessarily require "binary digits". Information could be calculated using bases other than 2.

One bit is the maximum amount of information contained in any yes-no answer. This maximum is only achieved when the number of possibilities is reduced exactly in half. As with the squares of the checkerboard where all alternatives are equiprobable, H represents the minimum number of binary digits into which an event may be encoded (ibid: 9).

The ascertainment of a particular square on a checkerboard is an example of gradual uncertainty-reduction. The number of alternatives, and our uncertainty, are progressively reduced to the point where we are certain of the location of a square. Six binary digits are needed to specify one alternative out of sixty-four. This is another way of saying that the number of bits is the logarithm, to the base 2, of the number of alternatives (when the alternatives are equiprobable).

In the example above, every square of the checkerboard has an equal chance of selection. But one must also allow for situations where a choice must be made from a set of alternatives which are not all equiprobable.

A weighted average can be utilized to rectify this problem (ibid: 7). That is, the probability of occurrence is multiplied by each of the likely alternatives.

To illustrate this procedure, imagine two events where the outcomes are divided into two groups, n_1 and n_2 (Raisbeck 1964: 8-10).

One group has probability $p_1 = \frac{n_1}{n_1 + n_2}$,

and the other has probability $p_2 = \frac{n_2}{n_1 + n_2}$.

Since the information associated with n equally likely alternatives is;

$$\log_2 n,$$

the information associated with a two-event space of events is $\log_2 n_1$ and $\log_2 n_2$.

We then get; $H = \log_2 n - \frac{n_1}{n} \cdot \log_2 n_1 - \frac{n_2}{n} \cdot \log_2 n_2$

$$= -p_1 \cdot \log_2 p_1 - p_2 \cdot \log_2 p_2 .$$

For the general form of a message having "n" alternatives (not equiprobable), let the various outcomes have probabilities: $p_1, p_2, \ldots, p_n$. In this case, the amount of information associated with a message, X, is:

$$H(X) = -p_1 \cdot \log_2 p_1 - p_2 \cdot \log_2 p_2 - \ldots - p_n \cdot \log_2 n.$$

$$= -\sum_{i=1}^{n} p_i \cdot \log_2 p_i \qquad 0 \leqslant p_i \leqslant 1, \text{ for all } i.$$

This final equation is often called the Shannon measure of information (Shannon and Weaver 1949: 20).

Each value, then, is weighted by its probability. The average information of an event is equal to the sum of the information values for each alternative, multiplied by its probability as a weighting factor (Attneave 1959: 7-8).

As the Shannon measure implies, information theory is founded on concepts of probability, where a state of knowledge is assigned a numerical code. If one knows everything about a question, all possible answers (except one) have zero probability ($p=0$) of occurrence. As such, when an answer is assigned unit probability ($p=1$), no more knowledge can be gleaned about the question. Knowledge can thus be encoded on a probability distribution, and information can be defined as "anything that causes an adjustment in a probability assignment" (Tribus and McIrvine 1971: 179).

CHAPTER III

INFINITE VARIATION: A CONCEPTUAL PROBLEM

Information theory is founded on the exploitation of one rather simple principle, namely, any message is itself a sequence of events (Neisser 1968: 355). Information processing could be considered in the context of the alternate events that might occur, within existing parameters or constraints. If one accepts this premise, every utterance is basically a choice, or a series of choices, among possibilities.

Information theory is fundamentally a theory of selection, but the selection must take place within the constraints of a well-defined set or from a specific set of alternatives. Such a selection process is basically statistical in the sense that it involves probability considerations.

As such, Frick (1968: 182) argued that behaviour is not a simple matter of distinct stimulus and response events, but of sets of possible alternatives or potential stimuli and responses from which choices must be made. Speech, for example, can be regarded as a sequence of selections from a number of possible choices i. e., the morphemes of a language. Consequently, we need information only when we are faced with a choice of some sort.

In information theory, the source of the information must be a discrete source (see Raisbeck 1964: 4-5); the number of possible alternate messages must constitute a finite set of distinct entities. This theory rests squarely on the definition of a "sample space", e.g., an explicit listing of the range of events over which the probability measure is to be defined (Rapoport 1956: 309).

The conceptualization of finite sets of behaviour raises a problem which questions the determinancy of componential analyses and, in a sense, is fundamental in applications of mathematical tool kits. The problem is this: since the classes of all numbers of behaviour events is infinite, an infinite amount of information must be involved in the specification of any number, which is an "impossible" task.

One must admit that behaviour is <u>potentially</u> infinite in variation and coding systems are, by definition, finite. Keesing aptly remarks (1971: 80); "Codes have sharp edges and neat rules, while behaviour has fuzzy edges and only statistical regularities". But one might ask if it is useful, or will it facilitate our understanding of behavioural phenomena, to view them in terms of infinite variation.

A noted scientist, Leon Brillouin, reminds us that because of this problem of infinite variation; "<u>Experimental errors are inevitable</u>, and it is unscientific to think of infinite accuracy in any measurement" (1962: 320).

In fact Burling's criticism of componential analysis was that indeterminate solutions were inevitable because of the infinite variability of empirical data; "Homonymy, empty spaces, non-binary distinctions, parallel components, and redundant solutions all add considerable complexity to the possibilities for analysis of a set of terms. In principle, the number of possible analyses becomes infinite" (1964: 24).

Burling (1962) also noted that a restatement of Njamal kinship terminology was possible and that anthropologists should expect alternate solutions in their componential analyses. He then proceeded to demonstrate (1964), (a), the complexity involved in the very large number of componential analyses possible for even a small number of items, and (b), that many alternate arrangements are often logically possible.

These observations obviously complicate the problem of indeterminancy for semantic analysis. Componential analysis is a process whereby a set of terms (from a culturally relevant domain) are apportioned or partitioned into contrasting subsets. And there are alternate ways to arrive at these subsets.

Burling further questioned Frake's (1961) analysis of disease terms in Subanun, a language of Mindanao:

> I cannot help wondering if he does not convey an unjustified certainty in the particular analysis he offers. I will not be convinced that there are not dozens or hundreds of possible analyses of Subanun disease terms (Burling 1964: 26).

Even though the number of possible analyses rapidly approaches infinity the more one adds dimensions and subpartitions a set, the fact remains that all theoretical possibilities do not have an equal chance of occurrence. Are there a priori grounds for assuming that some possibilities have a greater chance of occurrence than do others?

In a rejoiner, Hymes (1964), argued that independently elicited information on the informants' principles of "sorting" can eliminate from consideration many logical possibilities. Hymes (1964: 116) further reiterates; "The main thing is to observe that the total number of logical possibilities is fully pertinent only if all solutions have an equal chance of being arrived at".

Since Burling's contribution, a number of anthropologists, especially those dealing with kinship systems, have given this problem of indeterminancy serious consideration. Nerlove and Romney (1967), for example, have postulated some basic terminological principles that make the occurrence of certain types of sibling terminology exceedingly unlikely in practice. One such principle is that classification systems utilize only conjuctive and relational categories. Disjunctive categories have but a rare and improbable chance of occurrence.

Muriel Hammer (1966) also regarded the distinction between open and closed systems as a central issue in anthropoligical theory, especially in the formal analysis of grammatical and semantic systems. She pointed out that no natural system--physical, biological, or cultural-- is a closed system. Therefore the demand for a finite set of rules which govern the operation of a system, particularly if formulated in absolute terms, should be rejected as inapplicable. As such, Hammer considered that Chomsky's criteria of grammar as finite sets was objectionable;

> ...the rules involved in linguistic behavior are not a finite set because natural languages are not closed systems, and that the speakers of the language are not an appropriate source of evaluative criteria for a formal, finite grammar (Hammer 1966: 366).

Because of this "open" characteristic of languages, Hammer called for analyses which involved two connected grammars. One would deal with general sets of rules and could specify a maximal range, while another grammer would specify a minimal range and add those restrictions which are necessary for the production of only those sentences which are always formally acceptable (1966: 365-366).

The reasons that Hammer gave for a set of maximum and minimum range grammars are that formal grammars, such as that posited by Chomsky, do not allow for, (a), disagreement among native speakers, and (b), errors of judgement (1966: 364). But the fact remains that the linguist must still account for communication, even though an individual may use different sets of grammatical rules depending upon the situation.

This concept of minimal and maximal ranges as a method of coping with infinite sets is suggested, albeit in different terms, by other anthropologists.

Keesing (1971: 329) recognized that the precise arrangements of human behaviour are potentially infinite in variability, but qualified this position by noting that the mode of arrangement, the structure of the designs, is repeated over and over throughout the cultures of the world.

Some areas of culture, such as house types, dress, and so on, show wide variation from society to society. But there is less variation in some areas, such as principles of kin classification, where the same themes keep reappearing. Once it is recognized that all the societies that anthropologists have yet encountered attribute some importance to kinship, and have some form of marriage, the range of variation is already greatly narrowed.

However Keesing found this observation somewhat less than profound, given the limitations of human biology;

> We find over and over again variation on the same themes, different combinations of familiar elements. This should not surprise us. Even human imagination can devise only so

> many ways of assigning parentage, tracing descent, classifying relatives, transmitting rights across generations, forming groups, and regulating mating. Given the common elements of human biology, the range of possibility is distinctly limited (Keesing 1971: 152-153).

The French anthropologist, Claude Levi-Strauss, has devoted a considerable amount of attention to the exploration of universal patterns which he believes are imposed by the constraints of human thinking. Levi-Strauss' argument is that the logic of our thinking closely resembles the workings of a computer in that it is digital and binary--that is, it is based on sets of two way contrasts (Keesing 1971: 329).

Levi-Strauss seeks to demonstrate that in cultural structure and symbolism, symbolic oppositions, e.g., the dualistic contrast of polarities: Left: right, moon: sun, female: male, and so on, are similar modes of thinking that can be found in various parts of the globe. Such symbolic polarities as culture versus nature, sacred versus profane, and other formal arrangements of contrast, can be found both within the same culture, and from culture to culture. But Levi-Strauss is quick to emphasize that it is the <u>design</u> which is replicated or transformed (1962: 95). Cultural differences are found in the area of <u>content</u>.

Greenberg's (1963) search for linguistic universals and recurrent patterns is analogous to Levi-Strauss' endevours. Greenberg argues that grammars often utilize systems of binary contrast where one feature is "marked" and the contrasting one is "unmarked". These features are a recurrent theme in the semantics, phonology, and syntax of many languages.

Following Greenberg's earlier work, Lounsbury attempted to demonstrate that dimensions of kinship systems represent a dichotomous opposition of just two features where a distinction is made between a "marked" and an "unmarked" member of every opposition. For example, the first term of each of the following oppositions is regarded as the "marked" member (Lounsbury 1969: 204);

POLARITY: senior, vs. junior

SEX: male, vs. female

BIFURCATION: cross, vs. parallel.

Although one might be concerned with the question as to whether Levi-Strauss is actually discovering structure, or creating it, Keesing feels that these recurrent themes of contrasting symbolic oppositions possibly are a characteristic of human modes of thinking:

> The patterns of thinking imposed by the brain, applied to the common perceptual features of men's environment and universal elements of human experience, must also limit cultural possibility (keesing 1971: 329).

If these explanations of cognitive patterning appear much too simplistic, recent neurophysiological research has led one writer to remark:

> It seems that the language of the brain is logically much 'simpler' than any we have been able to devise so far. This is why the next significant advance in the production of brain 'models' will depend on the discovery of a new much more profound and subtle melange of logic, mathematics, neurophysiology, molecular biology, biophysics, biochemistry, electronics, engineering, and so forth, than any we have already (Singh 1966: 327).

The first step is to discover the primary logico-mathematical language actually used by the brain. Singh uses the word "simpler", not because it will be easier to learn, but because the number of successive steps required to complete an operation in a net of live neurons are fewer than that found in vacuum tubes or transistors. The invention of novel systems, which will replicate patterns of human thinking, appears as a necessary precondition.

There is other evidence, primarily psychological, which tends to restrict the limits of human variation. Granting these restrictions, the goal of complete analyses in ethnographic studies appears less impracticable. Goodenough (1965) points out in his examination of the concepts 'status' and 'role' in Truk, that since people manage to learn the various duties, status dimensions, and identity relationships in the normal course of their lives, they are not likely "to be so complicated as to defy analysis".

George Miller (1956) in his studies in the psychology of cognition, finds that an individual's ability to class stimuli on unidimensional scales is remarkabley limited. The maximum number of discriminations that one can make on one dimension appears to be about seven (plus or minus two). This is another way of saying that the channel capacities, measured for unidimensional variables, ranges from 2.3 to 3.2 bits of information.

This is the range for an unidimensional variable, but what could be the range for multidimensional variables? Wallace (1961) calls attention to evidence which suggests that if too many dimensions are involved, one might have difficulty in making several successive judgements because the process becomes cumbersome and cognitively difficult. Wallace (1961: 463) then suggests "the numerical value of 2^6 for maximum size of folk taxonomies".

When one considers the wide variety of different possible variables, these ranges are surprisingly narrow. Miller hypothesizes that these restricted ranges are possibly a function, not of a psychic unity, but of the restricted range of our anatomical and physiological characteristics.

He notes:

> There seems to be some limitation built into us either by learning or by the design of our nervous systems, a limit that keeps our channel capacities in this general range. On the basis of the present evidence it seems safe to say that we possess a finite and rather

> small capacity for making such unidimensional judgements and that this capacity does not vary a great deal from one simple sensory attribute to another (Miller 1956: 86).

Wallace and Atkins state that one of the major sources of indeterminancy, or multiplicity of solutions, in semantic analyses of kinship systems is "the fact that the set of all kin-type denotata has no finite boundaries" (1960: 76). This problem, they believe, raises basic theorectical issues which tend to question; (a), the purposes of componential analysis, (b), the nature of model-building in anthropology, and (c), the constraints on purpose imposed by the technical demands of a convenient model (ibid: 64).

I have attempted to demonstrate, in this chapter, that a number of social scientists are concerned with the infinite nature of human variation, as it relates to componential analysis, cognitive processes, and linguistic universals. This problem is often seen as a major difficulty with studies in the realm of 'social systems', e.g., closed ones in Hammer's (1966) sense.

Since information theory developed with the realization that the processes which might be said to convey information are basically processes of selection (Frick 1968: 182), and in order to examine the selection process it is essential to be able to examine the set in finite terms (Rapoport 1956: 306), applications of information theory can be said to be subject to the same criticisms as levied above by Wallace and Atkins.

But one might question whether the fact that the possible variations of human behaviour are potentially infinite, precludes analyses in terms of finite sets. Hammer (1966: 371) reminds us that; "...componential analyses, like grammars of a language, are finite and formal, and, thereby, unlike the behaviors utilized in their derivation". These same problems are much the same as those faced in the 'physical' sciences. But in these fields, infinite quantities are not usually a major concern.

Euclidean geometry may be infinite, but its rules are a finite set. One need not find any logical difficulty in a finite set of rules governing the production of a nonfinite set, or sequence of events (ibid: 363).

A geometrical line, for example, is composed of an infinite number of points, and an infinite amount of information would be required to specify one of these points. But since the position of a point can never be determined without some degree of error, the number of specifiable numbers is not infinite (Attneave 1959: 5).

This error of measurement, in effect, allows us to divide a continuum into a limited number of alternate categories which can be distinguished from one another. Attneave (1959: 5) finds a solution to the problem of an infinite sequence of events by suggesting;

> In general, whenever it appears that we are able to deal with infinite quantities of information, we find that we have overlooked some limiting factor which reduces the number of practical alternatives in the solution to a finite level.

In much the same manner, anthropologists and linguists such as Murdock, Kroeber, Levi-Strauss, and Greenberg have been able to deal with the potentially infinite variation of human behaviour by utilizing such 'limiting factors' as residence rules, historical influences, psychological processes, and principles of kinship classification.

CHAPTER IV

SEMANTIC COMPONENTS AS PARAMETERS IN KINSHIP ANALYSIS

In this chapter I examine variations in principles of kinship classification in order to establish parameters or boundaries on this special lexical domain. Although little research has been conducted into establishing "universals" of kinship variation (for exceptions see Kroeber 1909; Murdock 1949; 1968; 1970; Nerlove and Romney 1967), this task is seen as essential, and necessary, in applications of information theory. Without a precise definition of the particular constraints or parameters involved, one would have only a vague understanding of available alternatives and, hence, be unable to define the appropriate probability space. The lack of probability considerations precludes the application of an information measure.

Anthropologists have been aware for some time that kinship systems function as signal units to discriminate among certain social positions or kinship roles. Every society has a kinship system and accompaning kinship terminology. As such, kinship systems can be considered as 'common denominators' or universal aspects of man's societies and cultures (Epling 1961: 152).

Some years ago Kroeber (1909) demonstrated that the kinship systems of many cultures share the same structural features, although each terminology can be viewed as a more or less discrete system. But the fact remains that kin terminologies are based on a limited number of recognized kin 'categories' or dimensions of difference between kinsmen.

Also, since sets of kin terms function mainly as signal systems used to discriminate among kinsmen, one's position in a kin network is "defined" by dimensions of kinship differences. In turn, these dimensions are signalled, and defined, by various linguistic structures which are centered about kinship terms, the irreducible forms associated with their own particular "meanings".

Frake (1962: 76-78) sees these kin categories in terms of what he calls segregates, which are "a terminologically distinguished array of objects". When a contrast set makes distinctive alternatives available, this set forms a series of terminologically contrasted segregates (ibid: 78-79). When one makes a decision about category membership, he is selecting a term from a set of alternatives, each of which is important in a classificatory sense.

In the Euro-Canadian kinship terminology, such categories as mother, brother, son, and father are all segregates, only the opposition of mother: father categories would form a contrast set.

The definition as to what constitutes a contrast set is still not entirely clear. The terms of the set: mother, son, father, differ along two dimensions; sex and generation. The contrast set: mother-father, differs only on the component of relative sex, while the contrast set: mother-son differs on two components, sex and generation.

Kay (1969: 87) provides a somewhat less ambiguous definition of "contrast set". "The taxa are in the same contrast set if and only if they are immediately dominated by the same taxon" (ibid).

Consider the taxonomy in figure 1. All contrast sets are represented by the pairs of taxa (X,Y), (P,Q), and (R,S). The set of taxa (P,Q,R,S) is not a contrast set.

The composition of contrast sets is an important fundamental distinction. Kinship systems, considered in a taxonomic sense, are characteristically composed of various contrast sets. But it is a different matter to specify, in different cultural settings, the alternatives which constitute culturally relevant contrast sets. At any rate, taxonomies, such as those made up of networks of kin terms, "make possible a regulation of the amount of information communicated about an object in a given situation" (Frake 1962: 80).

As pointed out above, one of the interesting aspects of kinship terminologies is that discriminations are usually made between two classes or sets of features, e.g., male and female, cross and parallel, and, elder and younger.

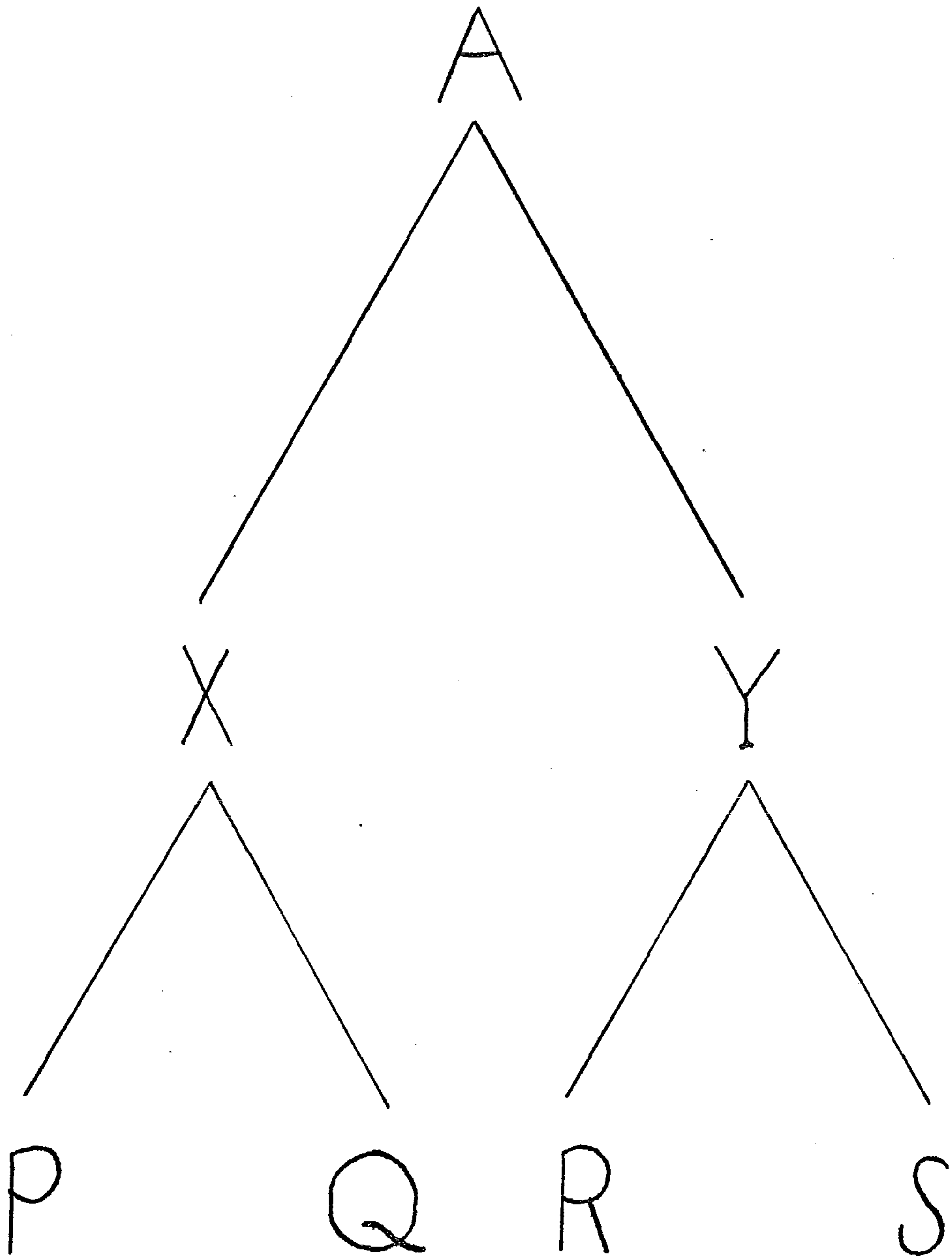

Figure 1. A Tree Arrangement Depiciting Levels of Contrast (Adapted from Kay 1969: 87).

Such binary oppositions as these are the building blocks of information theory. One might speculate that future researchers may discover that decisions of a binary nature are fundamental to human cognitive processes. Nevertheless, the fact that binary discriminations appear to be a universal principle of kin term differences, makes kinship systems an intriguing aspect of analyses of an "informational" nature.

In much the same vein, Lounsbury, in his study of the Iroquois kinship system found it instructive to reduce the sets of terms to binary discriminations, or, as he phrases it, "dichotomous oppositions". Lounsbury (1969: 203) remarks further on the reciprocal characteristic of sets of Iroquois kin terms; "It will be noted that, the four dimensions employed in the analysis of the consanguineal system, three of them--sex, bifurcation [cross vs. parallel], and relative age--were dimensions representing a dichotomous opposition of just two features".

In 1909, Kroeber enumerated eight categories or principles found in kinship systems around the world.

Kroeber wrote;

> It is apparent that what we should try to deal with is not the hundreds or thousands of slightly varying relationships that are expressed or can be expressed by the various languages of man, but the principles or categories of relationship which underlie these. Eightsuch categories are discernible (Kroeber 1909: 78).

These eight kinds of differences between kinsmen are: (1) the difference between persons of the same and of separate generations; (2) the difference between lineal and collateral relationship; (3) difference of age within one generation; (4) the sex of the relative; (5) the sex of the speaker; (6) the sex of the person through whom relationship exists; (7) the distinction of blood relatives from connections by marriage; and (8) the conditions of life of the person through whom relationship exists.

Kroeber's attempts to delimit, in explicit terms, the principles of kinship organization will be utilized in my efforts to determine maximum probability spaces that one could encounter, and still be empirically plausible, in the kinship systems (here restricted to sibling terminologies) of the world.

These criteria have an empirical, as well as a logical basis; various combinations of which include all the principles employed by different societies to classify and differentiate their kinsmen (Murdock 1949: 101). The linguistic recognition of these criteria makes a classificatory term less inclusive, and a descriptive or denotative term more specific.

1. Criterion of generation. This kinship principle rests on a recognition given differential reproduction. When people are born, they are automatically aligned in different generations.

2. Criterion of sex. This principle rests on the biological difference between males and females, and is commonly found at all generational levels although there is a tendency to ignore this distinction in the second descending and second ascending generations.

3. Criterion of relative age. This distinction is based on the birth order of individuals. Generally it is recognized only within Ego's generation. However, some societies, such as the Yuman tribes of the American Southwest, also differentiate the elder and younger siblings of a parent and children of an elder and younger sibling (Murdock 1949: 105).

4. Criterion of speaker's sex. This kinship principle is based on the biological fact that the speaker, as well as the denoted relative, must be either male or female. Note that this criterion will automatically double the number of kin terms since two terms will be required (usually) for each relative.

5. Criterion of affinity. This distinction rests on the phenomena of marriage and incest taboos. Relatives can be thought of as comprising two groups; the members of one group are related biologically to Ego (consanguines), and Ego can also trace relationships with members of another group through at least one marital line (affines).

In the following discussion only consanguines are taken into consideration, as the inclusion of affines would substantially increase the boundaries of a system and, hence, this analysis. It should be noted however, that among some Australian tribes, e.g., the Kariera and Njamal, the affine-consanguine distinction is not made as such. The distinction between relatives vs, non-relatives is determined with reference to societal boundaries, as opposed to internal kinship structures (cf. Romney and Epling 1958; Epling 1961).

The following terminological analysis will begin with all of the kin-types for which sibling terms can be distinguished. Similar procedures could be utilized to determine probability spaces for other kin categories, e.g., cousin terminologies, categories for terms for children, and so on.

Sibling Terminology

This section of the chapter examines variation in sibling terminology. The analysis is restricted to full siblings, as the extension of terms to cousins, half-siblings, and so on, is not considered. Also, this analysis refers only to terms of reference.

As a preliminary consideration, I assume that any set of words/terms that refer to the same domain may be expressed, as to their primary denotative meaning, as a collection or bundle of "components" (or, as a bundle of values on components).

Any of the myriad of kinds of sibling terminologies can be characterized by means of three dimensions or features: relative age, sex of referent--as opposed to sex of speaker, and parity--same sex sibling (//), or opposite sex sibling (X) (Nerlove and Romney 1967: 179; Murdock 1968: 2; Boyd et al. 1973: 3). The distinction between male and female relatives is designated by "m" or "f". Relative age is distinguished by an "e" for elder sibling, and a "y" for younger sibling.

These three features yield eight possible kin-types: Xem, Xef, Xym, Xyf, //em, //ef, //ym, and //yf. Four of these kin-types (Xem, Xym, //em, and //ym, constitute the same range as the Euro-Canadian term for "brother".

A sibling terminology which utilizes all of the eight distinctions can be diagrammed as in Figure 2. This figure, also, is the sample space of sibling terminology. Notice that there are eight cells or eight distinct concepts and terms shown.

Sibling terminologies often employ these eight distinctions in unequal proportions and, as such, it is necessary to distinguish among "primary", "secondary", and "tertiary" components.

A primary component is one which partitions the eight kin-types into two equal subsets of four kin-types each. All three primary components may occur together (as in figure 2, where only primary components are used).

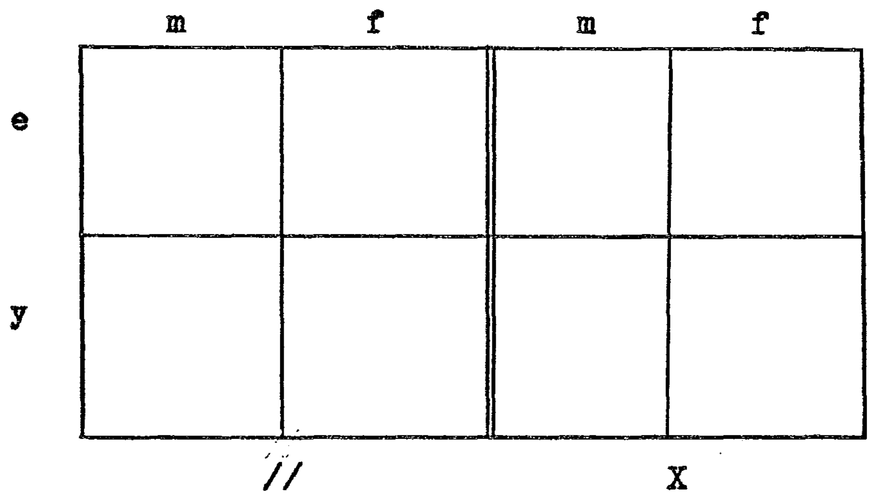

Figure 2. The Set of Eight Possible Conjunctive Sibling Kin-types

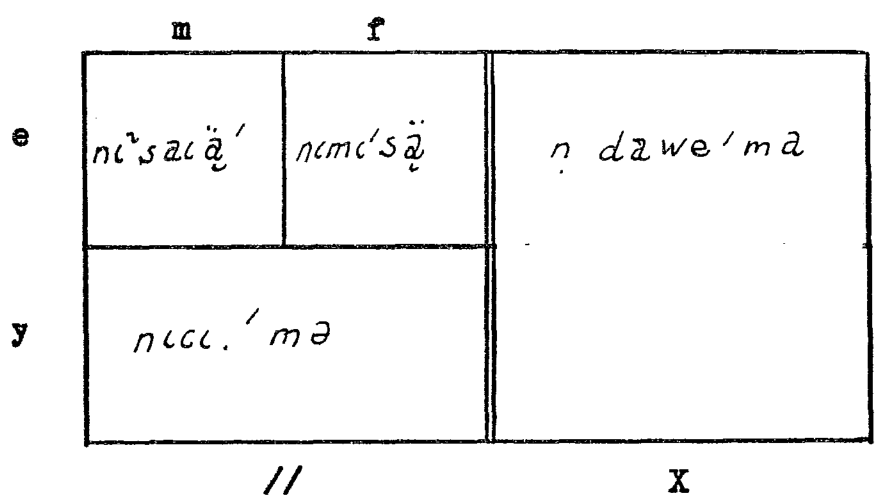

Figure 3. Notations Illustrated for the Ojibwa Sibling Terminology, after Landes, 1937.

A secondary component apportions one of the subsets divided by a primary component. A tertiary component partitions a subset which contains just two kin-types. A tertiary component can be produced by the intersection of two primary components, or, of a primary component and a secondary component (Nerlove and Romney 1967: 183).

Ojibwa sibling terminology, for example, makes use of all three different kinds of components (e.g., primary, secondary, and tertiary). Consider the kin terms and kin-types below (from Landes 1937: 9-10);

ṇdawe'ma ________--sibling of the opposite sex,
nιci.'mə ______ --younger sibling (no sex distinction),
nιˀsaιą̈' _____ --elder brother,
nιmι'są̈ ______ --elder sister.

These four sibling kin-types can be diagrammed as in figure 3, which is an arrangement of these Ojibwa terms in "square" or box notation.

It bears noting, as the Ojibwa case exemplifies, that each term has been so defined, with reference to the components selected, such that; (a), no term over-laps or is included in another, e.g., is conjunctively defined; (b), each term is discriminated by at least one component; and (c), all terms can be displayed in the same paradigm (cf. Wallace and Atkins 1960: 62). This may not be the best presentation, but it can be argued that this paradigm is adequate to define the set of terms chosen. It is also adequate to sufficiently define the probability space of any sibling terminology yet known.

This same process can be utilized in the analysis of other kin-types, besides sibling terms. With respect to parental kin terms, for example, the two dimensions of sex of relative and parity are sufficient to describe terms for parents. These two dimensions yield four kin-types. The dimension of relative age might also conceivably be used in cases of polygamous marriages where a distinction is made between elder and younger "fathers", or elder and younger "mothers".

CHAPTER V

LIMITED COMPLEXITY

A problem allied to the previous discussion of 'limiting factors' of human behavioural variation is, to wit, the role of functional determinants as principles of organization in patterns of behaviour.

I assume here that patterns of classification or taxonomy, such as kinship systems, do not occur haphazardly, but are the result of specific pressures or stimuli, e.g., psychological, social, cultural.

As noted in the preceding chapter, kinship systems 'function' as signal units which discriminate among social positions or kinship roles. In other words, kin terms convey social information which is utilized as a basis for the recognition of differences between relatives or kinship 'categories'. But the problem here is whether these kinship categories are (a), the result of some psychological limiting factors such as Wallace's "2^6 Rule", or (b), the result of functional connections between systems of kinship terminology and aspects of social structure. I will first consider alternative (a).

Conceptual Limitations

Components or semantic features serve both as a basis for the discrimination of kin categories, and as parameters for an analysis of information processing. At this juncture, one might ask if the quantity of information, as defined by the parameters of a kin category, has any relationship to the general classification patterns of kinship systems.

This is essentially a question concerning psychological, as opposed to social, processes. And it should not go unnoted that some theorists have attributed kinship terminology to certain elementary psychological or logical processes. Kroeber (1909: 84), for example, maintained that "terms of relationship reflect psychology, not sociology".

With Kroeber's comment in mind, and Frick's (1968: 184) suggestion that information theory is often helpful in formulating hypotheses regarding the manner in which people process, or organize, the sensory inputs from their environment, I began, as an initial level of enquiry, with a graph (figure 4) of the information measure plotted against numbers of sibling terms (the horizontal axis).

Recall that a sibling terminology, using the three dimensions of contrast--relative age, relative sex, and parity--can have from one to eight terms depending upon the number of discriminations actually employed in the terminology. The vertical axis of the graph corresponds to levels of bits of information, where a sibling terminology can range from 0 to 3 binary discriminations.

This graph is that of a typical logarithmic function, but a number of significant points are discernible. I had originally thought that this curve, and its significant points,[2] could be used as a heuristic device for generating hypotheses concerning sibling terminology.

Notice, on the graph of H(x), that each additional sibling term does not necessarily correspond to constant increases in information. There is an increase, for example, of one unit of information from one to two terms, but the rate of increase from a two to a four term system is one-half a bit, and there is only a one-quarter of a bit increase between four and eight terms.

At two and four terms occur the maximum amount of information with the least number of sibling terms. In terms of 'cognitive economy', it might be hypothesized that sibling terminologies will tend to be composed of either two or four term systems, while five to eight terms appear the least likely to occur, strictly on formal grounds, since there is only a minimal (one-quarter) increase in infor-

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[2] These points, in the language of differential calculus, are <u>inflection points</u>. The function H(x), whose graph is shown in figure 4, is <u>increasing</u> and <u>convex downward</u> on the interval [1,8]. The points (2,1) and (4,2) are said to be inflection points on the graph of the function, H(x), since the convexity changes as the graph passes these points.

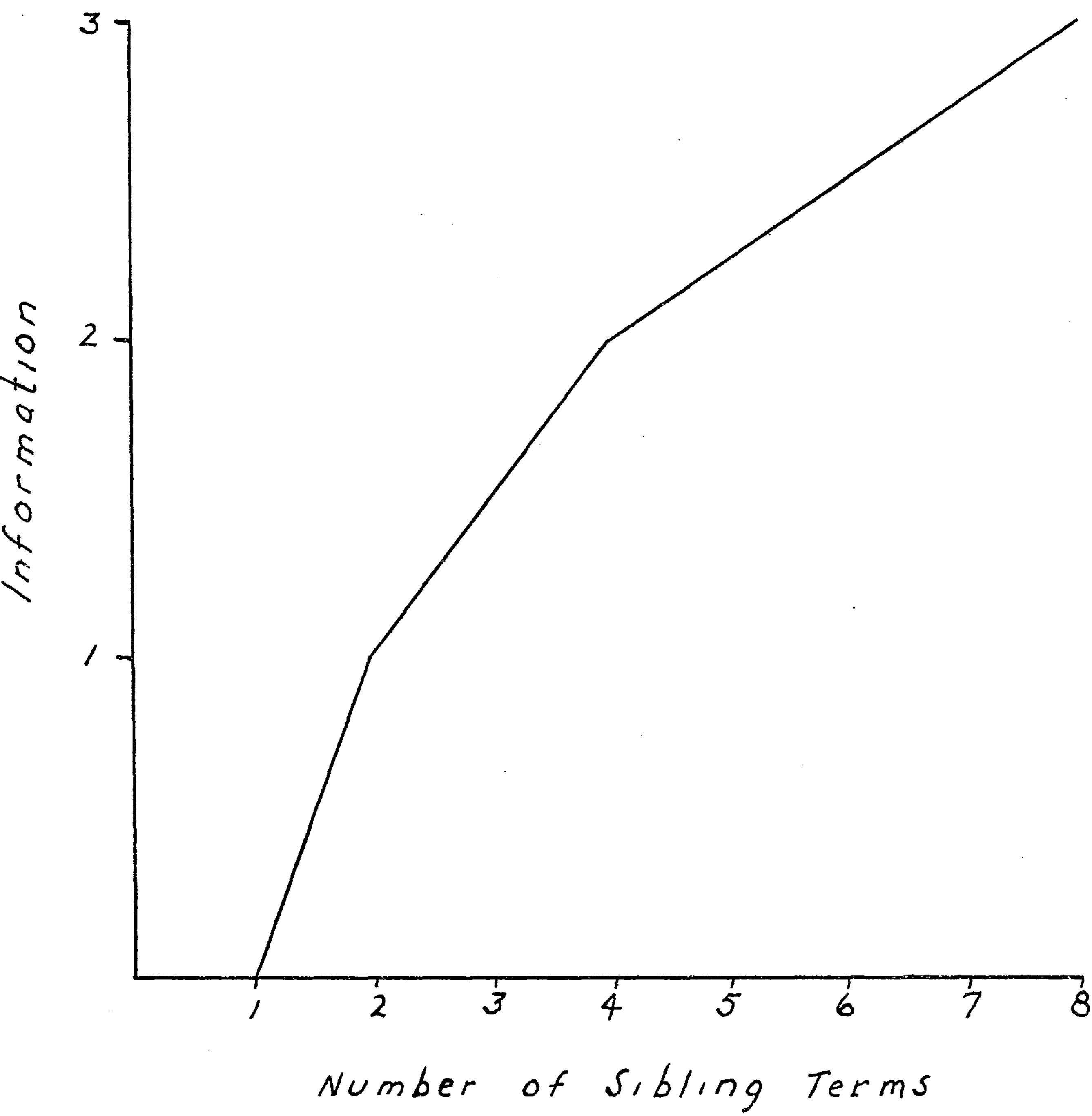
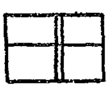
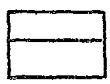
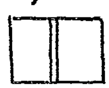


Figure 4. Graph of Sibling Terms as a Function of Quantities of Information.

mation with the addition of each term.

Murdock's latest (1970) ethnographic data on the sibling terminologies of 551 societies allows for a fairly comprehensive 'test' of this hypothesis. Figure 5 is a histogram of the percentages of the sample societies for each of the eight varieties of sibling terminology.

The hypothesis receives some confirmation from the breakdown and analysis of Murdock's sample. As predicted, most (sixty-three percent) of the sibling terminologies have a system with only two or four terms. One-fifth of the sample use a three term terminology, and this form could possibly represent a transitional stage.

The 'paths' of this transition or evolution are depicted in figure 6. This lattice outlines plausible steps that the three varieties of two term systems could go through in arriving at a four term system, where the change is by <u>successive binary partitioning</u> (cf. Boyd <u>et al</u>. 1973: 2-10). But a two term system need not go through the intermediate partition of three terms. Thus, a system such as  may come directly from  or , or vice versa.

It should also be noted with reference to figure 6, that any sequence of binary 'cuts' generates a conjunctive terminology. It may be hypothesized further, that the evolution of a sibling terminology is primarily a process of making binary distinctions and/or removing old ones (Boyd <u>et al</u>. 1973: 10). This notion provides a partial justifi-

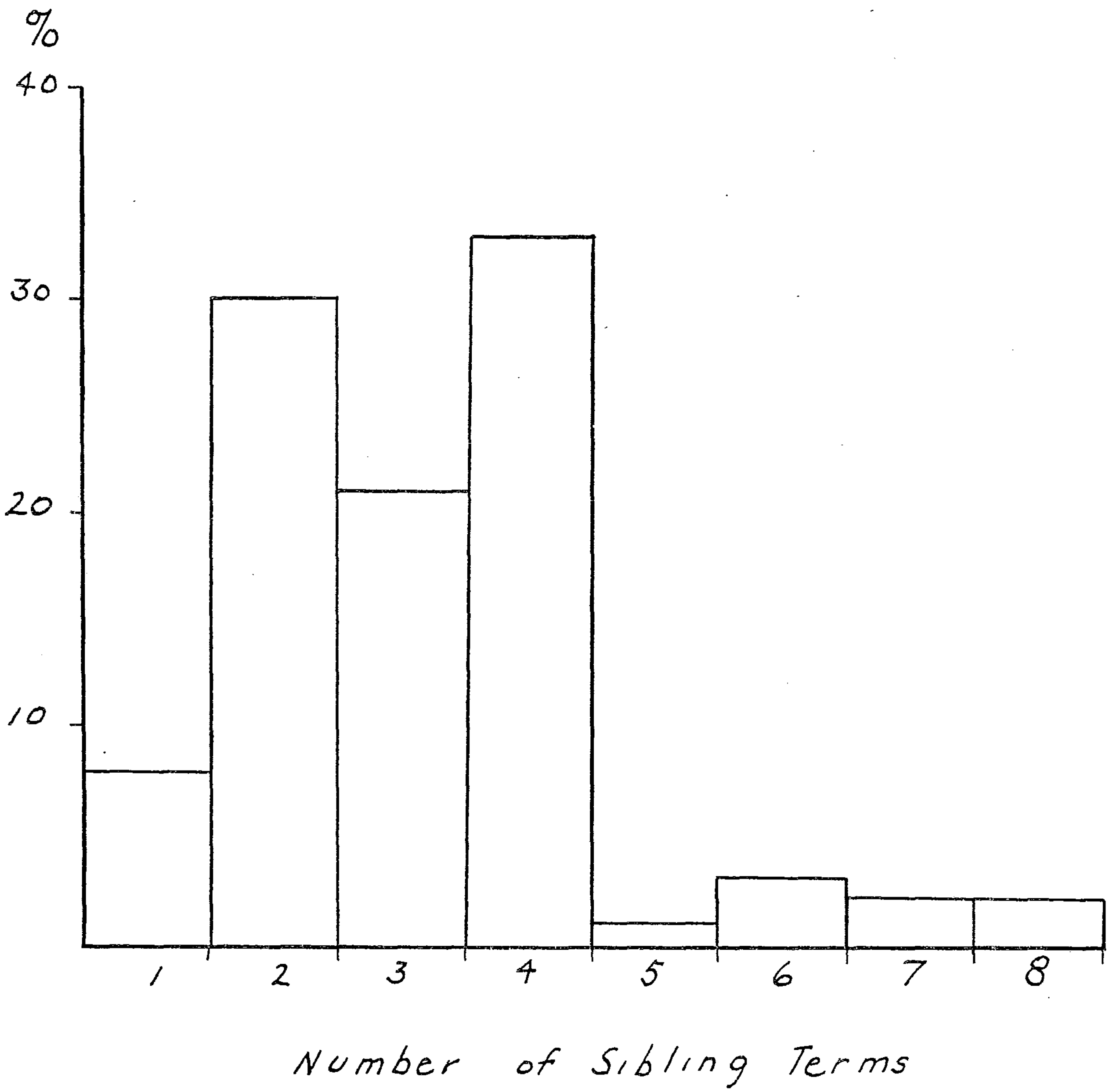


Figure 5. Distribution Histogram of Percentages of Eight Varieties of Kin-types for 551 Societies.

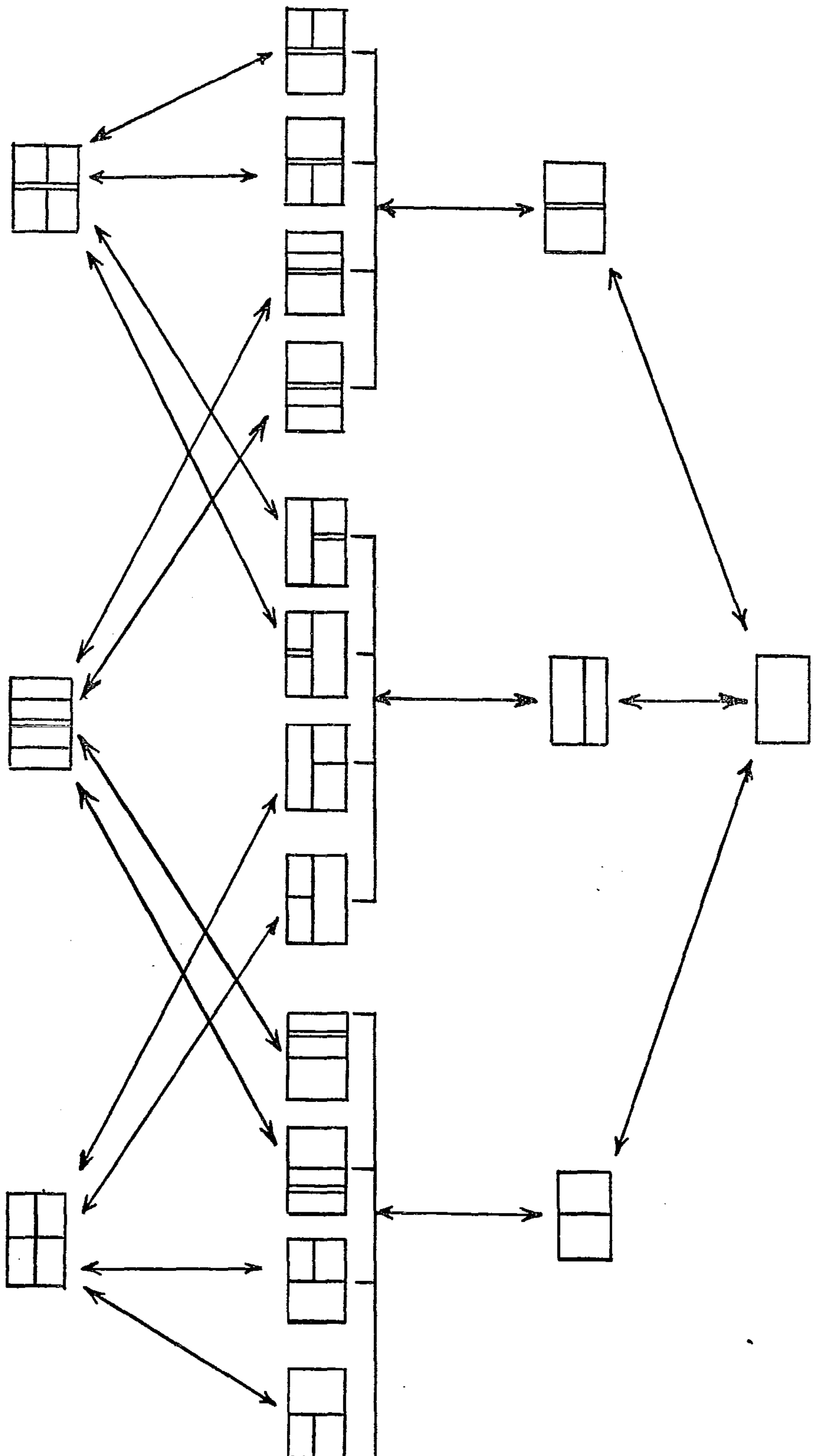


Figure 6.
Lattice of Conjunctive Sibling Kin-types, showing Paths or Chains of Evolution, after Boyd <u>et al</u>. 1973.

cation for restricting sibling terminologies to evolvable partitions.

This process of binary partitioning receives additional support from Murdock's (1949: 197-199) observations that kinship systems, under conditions of contact, tend to change by a process of internal readjustment, as opposed to change by direct diffusion.

Sumner (1913: 5-6) also regarded culture change as essentially an adaptive process, or as he termed it, "a strain toward consistency" which is a trend toward the integration of the elements of a culture. There is a tendency to approach an equilibrium, although this integration need not be regularly achieved because historical events can interrupt processes toward equilibrium, and initiate trends toward a new equilibrium (Murdock 1949: 197-198).

This perceived trend towards "consistency" or equilibrium" is quite similar to the phenomena of "drift" in language change. Such examples of linguistic drift as Grimm's Law exhibit limited possibilities of change where there is a shift from one state of relatively stable equilibrium to another, with <u>consistent</u> internal readjustments (Bloomfield 1933: 347-350).

The proposed hypothesis concerning tendencies toward a sibling terminology with either two or four terms is also consistent with Miller's (1956) review of the information channel capacities of human beings from psychological experiments. As pointed out above, he found that "absolute judgements of unidimensional stimuli" were generally only accurate for seven or fewer stimuli (e.g., between two and three binary discriminations).

These results obtained in the psychologist's laboratory are remarkably close to this analysis of sibling terminology. On the single dimension of "zero" generation, three binary discriminations represent a maximum for sibling kin-types, although in light of Murdock's sample this "rule" might be amended to read: "sibling terminologies will tend toward an equilibrium of one or two binary discrimination".

Besides satisfying one's intuitive notions of 'cognitive economy' or parsimony, this analysis could also have implications for the reconstruction of proto-sibling terminology. When information on the various sibling systems within a genetic unit is incomplete, one might tentatively assume, on an average, a two or four term system. But of course, this assumption will not help the reconstructionist in decisions regarding which linguistic <u>forms</u> are appropriate.

Before terminating this discussion, a few words regarding a possible criticism would not be out of order.. One might be tempted to argue that the percentages in figure 5 simply reflect the skewed frequency-distribution of possible kin-types per term. For example, there are slightly over 1,700 logically possible different kin-types for a four term system, while there is only one possible type of arrangement using one or eight terms.

In a sense this criticism would have some merit, since both bell-curves are somewhat similar, but the censure would not account for the low occurrence of five or six term systems (which comprise only four per cent of Murdock's sample).

Functional Determinants

Besides cognitive aspects, most theorists would agree that there are social and cultural considerations to the study of kinship. Kinship systems are one way by which people map their social worlds and, as such, they have "promised to provide some kind of Rosetta Stone for understanding social organization" (Keesing 1971: 176). But a precise outline of this 'social map' has alluded behavioural scientists.

Murdock (1949: 116) calls attention to the curious paradox that kinship terminology, and forms of social organization, often show resemblances where historical contact is exceedingly unlikely, but differ where historical relationships are not in question.

Consequently, Murdock calls for an analysis of determinants that are not historically limited, and he suggest that economic factors play a significant role in the formation of social structure. One reason for the predominance of economic considerations is that; "the available sources of food and the techniques of procuring it affect the sex division of labor and the relative statuses of the sexes" (Murdock 1949: 137), which in turn, are reflected in the terminological system of kinship. It is also plausible that particular rules of inheritance, which are conditioned by modes of property distribution, are mirrored in elder-younger distinctions, especially in sibling terminology.

In their study of the taxonomy and phylogeny of the sibling terminologies of twenty-three Polynesian societies, Boyd et al. (1973) also find that economic features account for a large proportion of the differential development of this sub-lexicon of kinship categories.

The earliest "ethnographic" reports of Polynesia suggest that by the early part of the nineteenth century many societies, widely dispersed geographically, but belonging to a single genetic unit of language and culture, were organized in terms of hierarchical ordering of social classes.

Sahlins (1958), on the basis of more recent ethnographic reports and an evaluation of the older information, has concluded that there was, and is, a gradient of rank system running throughout Polynesia. He then suggests that there is a positive correlation between "degree of social complexity", or "social differentiation", and the elaborateness of social ranking institutions. These ranking systems, in turn, are apparently related to levels of productivity.

Boyd _et al_. (1973) assume that sibling terminologies have social jobs, in the sense that they convey social information. This assumption provides the basis for the positing of their function hypothesis, namely;

> The amount of information, H, of sibling terminology is positively correlated with the degree of social differentiation and degree (emphasis on) of social ranking (1973: 22).

This hypothesis is given preliminary consideration by comparing the information values for a sample of Polynesian sibling terminologies with Sahlins' data. Marsh's (1967) material is also included as a further check on the indices of social differentiation which is compared with the same information measure.

The problem here is this. The polynesian languages/societies show a rather wide range of type within this genetic unit. Specifically, in the area of kinship terminology, one can treat kinship terminology as a dependent variable, and use a subset of it as an index of this variable: sibling terminology.

The results are shown in Table 1. When the variables of social differentiation and sibling information are dichotomized, Marquesas is the only exception.

Further indirect support is given the hypothesis by correlating the information measure with aboriginal population densities (Table 2) where three cases out of twenty-two are not predicted.

Boyd et al. propose (1973: 24) that throughout a genetic unit, there is an increasing differentiation of sibling distinctions, which also correspond to population growth. They further suggest (ibid: 26) that there is a "unit-wide trend towards greater and greater differentiation of the sibling categories with increasing 'cognitive' complexity and information".

But here I am inclined to argue that the trend is not necessarily towards greater complexity, but rather towards stability or a state of equilibrium.

This notion that human cultures have become increasingly more complex through the passage of time was critically examined by A.F.C. Wallace (1961), the first anthropologist to suggest the application of an information measure to the cultural sub-system of kinship. In a paper bearing the curious title, "On Being Just Complicated Enough", he employed the $\log_2$ function as a "quantitative measurement of semantic complexity" in the analysis of six kinship terminologies of varying levels of complexity.

Wallace concluded that:

Society	Amount of Information	Sahlins' Index of Social Differentiation	Marsh's Index of Social Differentiation	
Hawaii	2.0	1	5	
Tonga	2.0	1	5	
Tahiti	2.0	1	4	
Samoa	1.75	1	4	High
Mangareva	2.0	2	-	Degree
Easter	2.0	2	3	
Uvea	2.0	2	-	
Mangaia	2.0	2	4	
Marquesas	2.0	3	2	
Tokelau	1.5	4	1	Low
Pukapuka	1.5	4	2	Degree
Ontong-Java	1.0	4	2	
Futuna	1.0	3	-	
Tikopia	1.0	3	1	

Table 1. Amounts of Information of Fourteen Polynesian Sibling Terminologies Tabulated Against Indices of Social Stratification, after Sahlins (1958), Marsh (1967), and Boyd _et al._ (1973).

Information of Sibling Terminology

	0.0 - 1.50	1.75 - 2.00
300- over per square mile	Kapinga	Uvea
	Ontong-Java	Tongareva
	Tokelau	
	Tikopia	
	Pukapuka	
	Ellice	
	Nukuora	
	Manahiki	
1-299 per square mile	Futuna	Niue
		Samoa
		Tonga
		Hawaii
		Mangaia
		Marquesas
		Easter
		Rennell
		Mangareva
		Tahiti
		New Zealand

Table 2. Amounts of Information of Twenty-two Polynesian Sibling Terminologies Tabulated Against Estimated Population Densities, AD 1900, after Boyd *et al.* (1973).

> ...first, there is no <u>necessary</u> relation between complexity of the kinship terminology system and the size and technological level of the society; and second, each of the systems can be accommodated by a taxonomic space requiring only six binary dimensions or less (1961: 461).

The implication of Wallace's "2^6 Rule" is that as the size of the population increases, as the population density rises, and as the complexity increases in the technology; new taxonomic systems are added rather than more complex systems developed. If the Kariera and the Euro-Canadian live in conceptual worlds of about the same complexity (e.g., their systems of classification have less than sixty-four mutually exclusive categories), one might question whether there is any valid functional connection between the complexity (information) of a kinship system and sub-systems of social structure (e.g. economy or technology).

Despite the profundity of the hypotheses discussed thus far, one has to admit that the ethnographic evidence required to adequately "test" these hypotheses if far from complete. In the preceding problems, we have been working with a sample of societies/languages. This sample is not random, but is drawn from the universe of all societies and languages on the basis of availability of data, a decidedly poor criteria for samples generally.

However, it might be suggested that the data is a reflection of gross patterns, and thus, could merit future consideration in the formulation of hypotheses concerned with the relationships between functional determinants and kinship systems. But sampling deficiencies must always be a major concern with comparative ethnological studies.

Another concern is with the potential significance of the relationship between functional correlates and kinship systems. One cannot help reading Murdock's (1949) Social Structure without feeling somewhat inundated with his plethora of correlations. When one discovers that patrilineal descent tends to be associated, for example, with an Omaha cousin terminology, he may find that his analysis fails, (a), to account for the absence of Omaha cousin terminology, and (b), to generate new hypotheses.

McKinley (1971), in a stimulating critique of what he terms the "reflectionist theory" of kinship terminology, believes that much of cross-cultural testing relegates a passive role to kinship systems which obscures the effects that these systems can have on social organization. He explains this point by stating (1971: 245);

> I am strongly convinced that kinship nomenclatures are grounded in social life. My point is simply that there is a difference between grounded in social life and being a reflection of social life. Things which are grounded in social life are by nature much more than simple reflections. Once they are produced they become things in their own right and they begin to act back on the social world which first produced them; and

> this action in turn influences the course of their own further development.

Without indulging in a "Whorfian" exegesis, it might not be inappropriate to speculate that in certain instances, aspects of kinship such as sibling terminologies, could influence population growth. In a system with eight sibling terms, there could be a tendency to try and fill these categories. But at this juncture, one cannot say much more without succumbing to tautological explanation.

CHAPTER VI

ATHAPASKAN: AN EMPIRICAL EXAMPLE

In order to relate the previous discussions of information theory to specific ethnographic data, the sibling terminologies of Athapaskan speakers will be analysed. This analysis will permit a modest "test" of an hypothesis recently formulated by Murdock (1968).

Reconstruction of kinship terminology is now relatively common in North American anthropology. Based on comparative linguistic evidence, the reconstructions have run the gamut from Algonkian to Yuman. Hoijer (1956a), for example, has presented a formidable analysis of Athapaskan kinship terminologies based on Kroeber's "tentative reconstruction of primitive Athabascan kinship" (Kroeber 1937: 602). More recently, Proto Central Algonkian has been studied by Hockett (1964).

In this chapter I will focus on the historical reconstruction of Athapaskan sibling terminologies as presented by Hoijer (1956a). The purpose of this focus is to examine several assumptions inherent in this reconstruction, and relate these assumptions to Murdock's (1968) hypothesis concerning the relationship between patterns of sibling terminology and linguistic classification, specifically Athapaskan linguistic groupings.

In this thesis I take as fact the genetic relationship among Athapaskan cultures. All Athapaskan cultures are members of a single cultural genus. Through the passage of time, these cultures have become differentiated to the point they appear as species variations within the genus.

Athapaskan speakers are described as a genetic unit. Sapir (1949) originally suggested this term in 1916, and Romney (1957: 35) later provided the following refinements on the concept;

> The genetic model takes as its segment of cultural history a group of tribes which are set off from all other groups by sharing a common physical type, possessing common systematic patterns, and speaking genetically related languages. It is assumed that correspondence among these three factors indicates a common historical tradition at some time in the past for these tribes. We shall designate this segment of cultural history as the 'genetic unit' and it includes the ancestral group and all intermediate groups, as well as the tribes in the ethnographic present.

The collection of Athapaskan societies constitutes a contemporary example of the "ethnographic present " subset of a genetic unit, in Romney's sense.

Murdock's Hypothesis

In "Patterns of Sibling Terminology", Murdock (1968: 1-24) attempted to establish an exhaustive classification for kinship terms used for siblings. Sibling terms were analysed from all parts of the world for approximately 800 societies.

This study, Murdock (1968: 1) claimed, "generated unexpected insights into problems of linguistic classification". These "insights" provide the basis for his "genetic" hypothesis (1968: 5):

> ... the distribution of types of sibling terminology follows very closely the boundaries of known linguistic divisions, especially language families and sub-families.

And for further clarification Murdock (1968: 11) adds;

> ... the process which governs the development of sibling terminology is most typically the genetic one which also governs the evolution of language itself, so that the patterns tend strongly toward correlation with linguistic groupings.

I will begin with a brief examination of Athapasken sibling terminologies based on Hoijer's substantial review of Athapaskan kinship material.

Kinship data is available for thirty Athapasken societies. Table 3 lists the sample (by accepted name of the language and society) and the sibling terms with their primary denotations for each of the thirty groupings. Figure 7 reduces the data in Table 3 to componential paradigms (box diagrams which show the component structure of each terminology).

Six paradigms are sufficient to characterize all of

1.	Tanaina	onya, em; ?ym; oda, ef; datea, yf.
2.	Anvik	eya, em; teidl, ym; eda, ef; dadze, yf.
3.	Ingalik	eya, em; tcyitl, ym; ota, ef; tadz, yf.
4.	Tena	ura, em; toidl, ym; oda, ef; tadza, yf.
5.	Tanana	ona, em; tcil, ym; ada, ef; tia, yf.
6.	Kitchin	onde, em; tca, ym; edji, ef; djio, yf.
7.	Hare	guntie, em; e-tchile, ym; are, ef; e-die, yf.
8.	Bear Lake	onde, m; taye, f.
9.	Dog Rib	kinte, em; e-tchile, ym; e-dare, ef; dieze, yf.
10.	Kaska	estia, em; tsitle, ym; dada, ef; tatze, yf.
11.	Tahltan	estiuh, em; tshitle, ym; e-tata, ef; tezuh, yf.
12.	Tsetsaut	xudie, em; s-tcee, ym; a, ef; e-de, yf.
13.	Slave	ondie, em; tse, ym; ade, ef; die, yf.
14.	Yellowknife	unaga, em; tchile, yf; dez, ef; are, yf.
15.	Chipewyan	unaya, em; tcile, ym; are, ef; deze, yf.
16.	Sekani	wodege, em; a-sidel, ym; ade, ef; dje, yf.
17.	Beaver	xona, m; ade, ef; die, yf.
18.	Sarci	iniya, em; sitla, ym; da, ef; dadza, yf.
19.	Carrier	anoy, em; tcel, ym; at, ef; dez, yf.
20.	Washington	onaxei, em; loane, ym; wate, ef; deetse, yf.
21.	Tolowa	oniyi, em; tcele, ym; ati, ef; esi, yf.
22.	Hupa	xonwodj, em; kil, ym; at, ef; de, yf.
23.	Kato	ona, em; tcel, ym; at, ef; tesi, yf.
24.	Wailaki	onun, em; tcel, ym; at, ef; te, yf.
25.	Navaho	inai, em; tsili, ym; adi, ef; dezi, yf.

26.	Sancarlos	dage, //e; de, xe; dize, ysib.
27.	Chiricahua;	
	Mescalero	kis, //; ilah, x.
28.	Jicarilla	naa, em; dade, ef; s-dazah, ysib.
29.	Lipan	naa, em; badi, ef; s-da, ysib.
30.	Kiowa	daya, em; tlaa, ym; dada, ef; detca, yf

Table 3. Athapaskan Sibling Terms and Their Primary Denotata, after Hoijer 1956a.

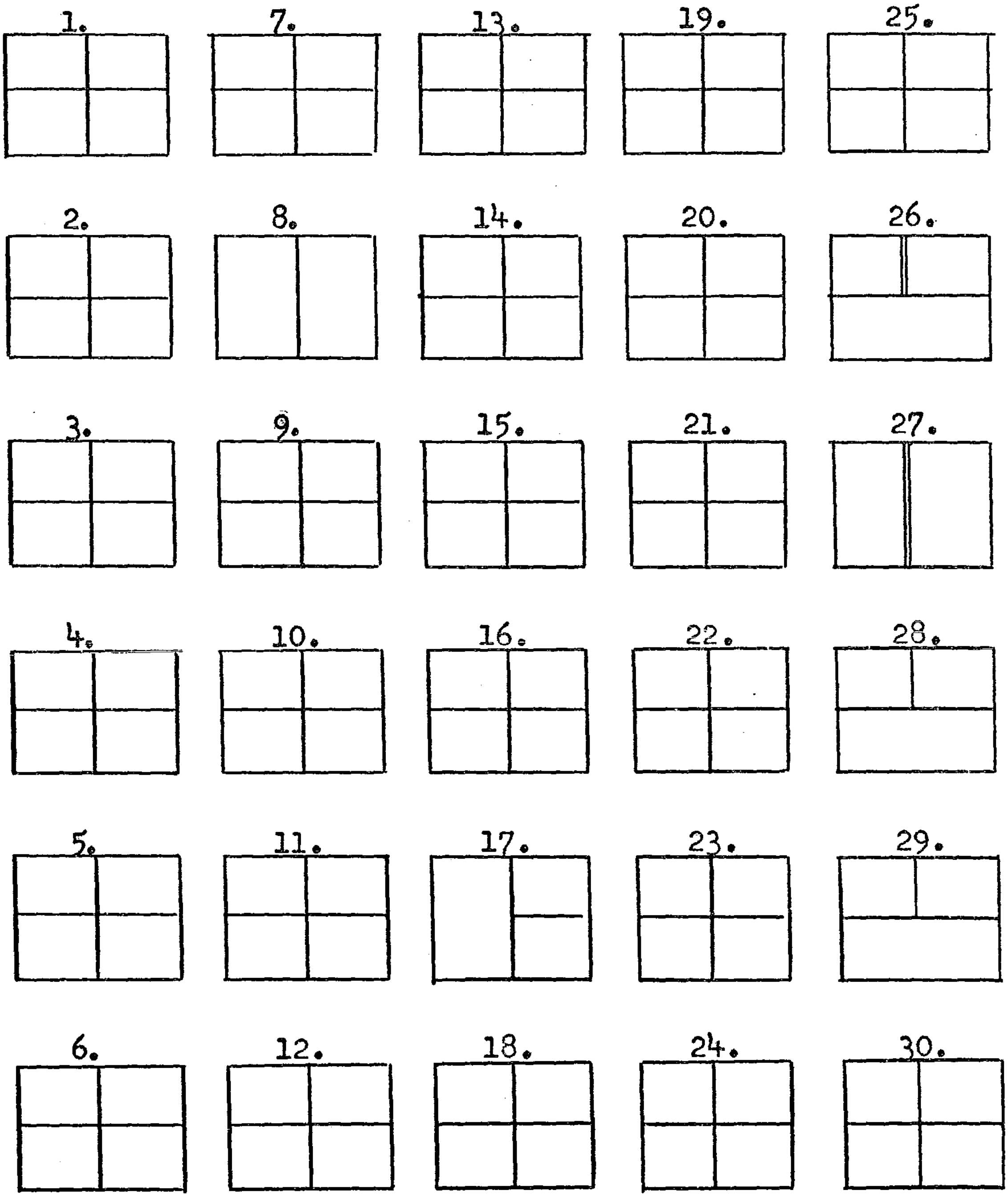


Figure 7. Componential Diagrams, Thirty Athapaskan Sibling Terminologies.

the thirty cases in Table 3. Thus you will note that thirty individual cases reduce to six types, by taking note of common structural features. This is a not inconsiderable reduction of apparent diversity.

Now, recall the fact mentioned in the introduction of this chapter, namely, that all Athapasken societies are assumed to derive from a common ancestral stock and hence that they are all demonstrably "related". We can ask the question: What is the "best" way to characterize the pattern of similarity between the six types?

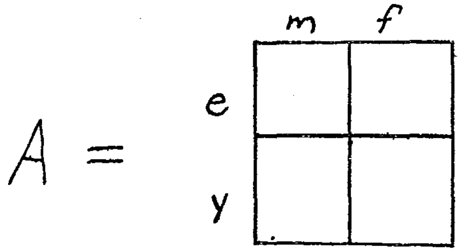
Lexicostatistical percentages will be used as a measure of similarity between the languages of the Athapaskan linguistic grouping. Before these cognate values are compared with the corresponding sibling similarity measures, the information measure, which was developed in the second chapter, is "applied" to the sibling "space".

To recapitulate, H(x) is the uncertainty of x, and p is a probability measure where a sibling terminology, x, has probabilities $p_1, \ldots, p_n$.

Recall the three previously discussed dimensions of contrast (relative age, sex of referent, and parity), and the resulting eight possible distinctions. These components of sibling terminology are represented as partitions on the set siblings, and the partitions provide boundaries on probability spaces.

A Similarity Measure

In order to determine the quantity or bits of information in a sibling terminology, consider the following paradigm (A), defined by the components of sex (m and f) and relative age (e and Y).



The two components define a set of four terms (denoted by em, ef, ym, and yf). The probability of occurrence of any one term is $\frac{1}{4}$. Therefore the information associated with terminology A is:

$$H(A) = -\left(\tfrac{1}{4}\log_2 \cdot \tfrac{1}{4} + \tfrac{1}{4}\log_2 \tfrac{1}{4} + \tfrac{1}{4}\log_2 \tfrac{1}{4} + \tfrac{1}{4}\log_2 \tfrac{1}{4}\right)$$

$$= \log_2 4 = 2 \text{ "bits".}$$

Notice that the information measure has the property of always being positive, and is at a maximum when the probability distribution is uniform.

Now, given two measures of information, H(x) and H(y), H(x,y) is the sum of their individual information values--the information of a joint event. But H(x) and H(y) often overlap, e.g. they share information. Therefore, let I(x,y) be the information transmitted (Attneave 1959: 48).

This relationship can be depicted quite simply with the aid of Venn diagrams, where $I(x,y)=H(x)+H(y)-H(x,y)$.

Notice, with reference to the (b) part of figure 8, that the total information associated with any two sibling terminologies is not necessarily equal to the sum of their individual information values. A sibling terminology x (denoted by em, ym, ef, and yf) and a terminology Y (denoted by //m, //f, xm, and xf) share the component of sex, and therefore, the sum of their information values is three, and not four.

It might also bear mentioning that $I(x,y)$ has more than one property of the measure of the correlation between x and y. As a matter of fact, 1,3863nI (where n is the number of occurrences of the event that one uses to estimate probabilities involved) yields a value which is essentially the same as the value of chi square that one would compute to test the null hypothesis that x and y are independent (Miller 1953: 3-11; Attneave 1959: 27-30, 63-66).

The formula for $I(x,y)$ would be a reasonable measure of similarity in itself, but it requires normalization. A pattern of similarity for the individual Athapaskan sibling terminologies is then based on the normalized similarity measure (Boyd <u>et al.</u> 1973: 12):

$$S(x,y) = \frac{I(x,y)}{H(x,y)} \qquad (0 \leqslant S \leqslant 1)$$

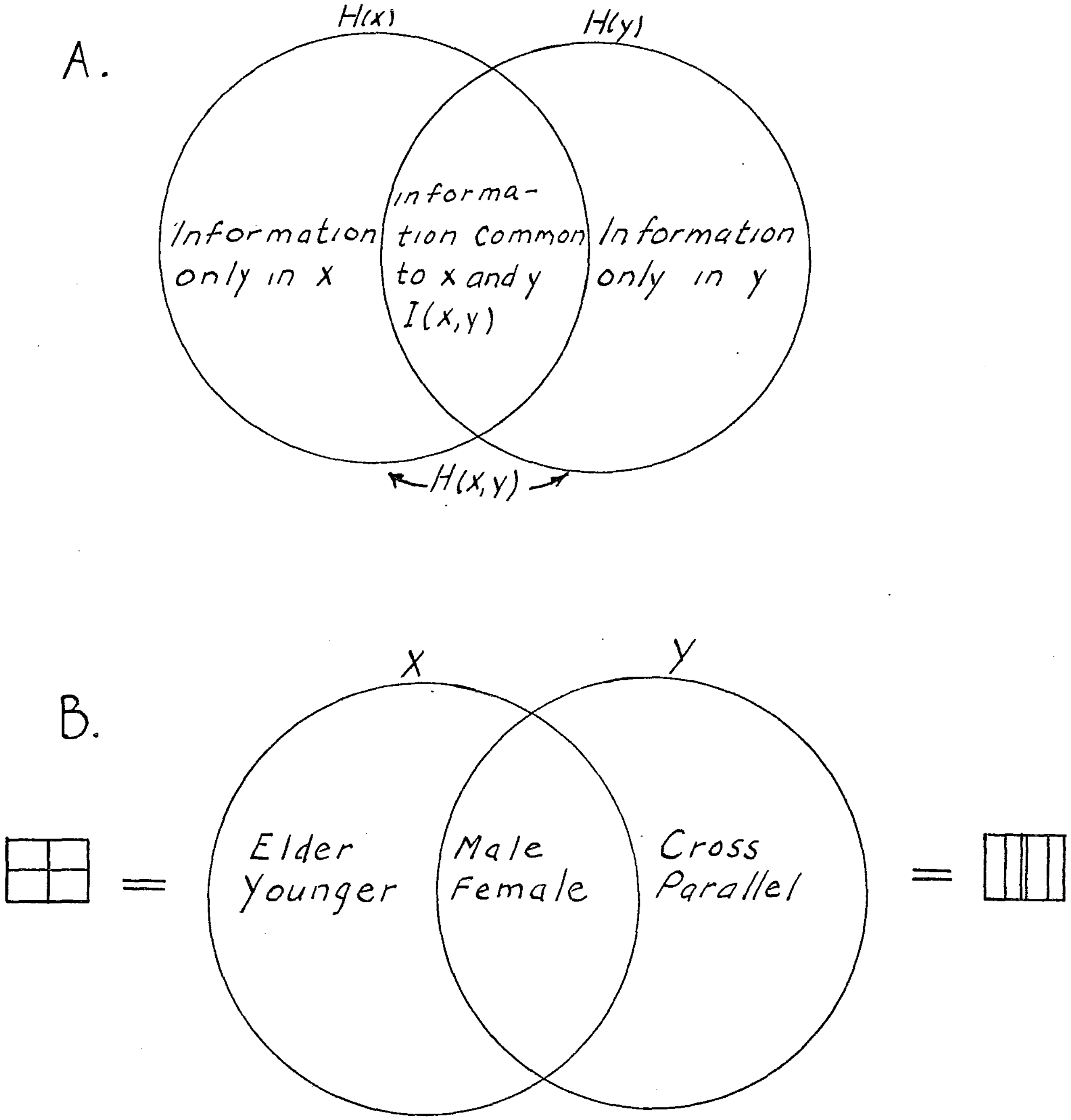


Figure 8. Schematic Representation of the Several Quantities of Information that are involved when Messages are Received from Two Related Sources, after Miller 1953.

Table 4 is a matrix of the similarity values for the thirty Athapaskan sibling terminologies.

Swadesh (1955) has developed the "glottochronological" method, by which (on the basis of a posited constant retention rate for lexicon) the "timedepth", or length of time since the divergence of two languages or dialects, may be computed. For, given limited assumptions about rates of change in languages, those entities which have most recently begun to diverge from each other should at present be most similar.

A test of Murdock's hypothesis, e.g. "...patterns [of sibling terminology] tend strongly toward correlation with linguistic groupings...", is made possible by Athapaskan lexicostatistical data, from Hoijer (1956b).

In order to test the strength of Murdock's posited association, a matrix of shared cognate values between fourteen Athapaskan languages was compiled from Hoijer's (1956b: 219-232) data. Table 5 shows this matrix.

If patterns of sibling terminology, and by implication other kinship categories, tend strongly toward correlation with linguistic groupings, there should be a significant correspondence between Table 4 and Table 5.

The correlation in fact, between the fourteen Athapaskan sibling terminologies and the cognate values of the corresponding languages is $r = 0.25$. This correlation is significant only at the twenty per cent level. Thus, from

Table 4. Similarity Values for a Subset of Athapaskan Sibling Terminologies, N = 14.

	Car	Chip	Kut	Sar	Hare	Hupa	Wail	Kato	Nav	Chir	SC	Jic	Lip
Beav	.75	.75	.75	.75	.75	.75	.75	.75	.75	.25	.50	.50	.50
Car		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	.50	.75	.75	.75
Chip			1.00	1.00	1.00	1.00	1.00	1.00	1.00	.50	.75	.75	.75
Kut				1.00	1.00	1.00	1.00	1.00	1.00	.50	.75	.75	.75
Sar					1.00	1.00	1.00	1.00	1.00	.50	.75	.75	.75
Hare						1.00	1.00	1.00	1.00	.50	.75	.75	.75
Hupa							1.00	1.00	1.00	.50	.75	.75	.75
Wail								1.00	1.00	.50	.75	.75	.75
Kato									1.00	.50	.75	.75	.75
Nav										.50	.75	.75	.75
Chir											.25	.25	.25
SC												1.00	1.00
Jic													1.00
Lipan													

Table 5. Per Cent Cognate Values for a Subset of Athapaskan Languages, N = 14.

	Car	Chip	Kut	Sar	Hare	Hupa	Wail	Kato	Nav	Chir	SC	Jic	Lip
Beav	.73	.62	.73	.78	.77	.68	.63	.74	.76	.76	.71	.72	.71
Car		.77	.70	.71	.70	.65	.62	.65	.72	.71	.68	.69	.70
Chip			.77	.76	.76	.67	.62	.71	.77	.76	.72	.74	.74
Kut				.65	.81	.60	.58	.65	.70	.71	.66	.67	.66
Sar					.68	.62	.61	.64	.68	.68	.65	.68	.66
Hare						.61	.62	.65	.69	.72	.68	.68	.68
Hupa							.67	.67	.64	.64	.61	.63	.60
Wail								.70	.65	.65	.63	.65	.62
Kato									.68	.67	.66	.65	.64
Nav										.94	.89	.89	.87
Chir											.91	.92	.91
SC												.87	.84
Jic													.91
Lipan													

the data available, I can find a weak association between the variables.

The failure of the lexicostatistical and sibling data to support Murdock's hypothesis poses an interesting anomaly. After all, as Hoijer (1956a: 309) has put it;

> ... kinship systems are in part sets of words, and the analysis and comparison of kinship systems, with a view to determining their historical relationships, may well profit from comparative linguistic studies.

Two reasons may be proposed for this incongruity. One reason revolves about the general problems associated with the glottochronological method. It may be argued that the 100 word lists, which are utilized in lexicostatistical studies, are not representative of the language vocabulary from which they are taken. Another non-trivial quibble is that due to the varying pressures of diffusion and borrowing on different societies and languages, one may question the assumption that all languages change at a uniform rate, e.g., over a 1000 year period, 81 forms out of 100 will be retained.

The assumption that the words in the lists express universal and essentially non-cultural meanings, which can be found in all societies, is also questionable. Most lexicostatistical studies must be supplemented with words from an additional 100 word list. Note that Hoijer (1956b: 219) could us only 78 items of the "preferred list". The usual reason given for these deletions is that adequate lexical data for the languages under consideration were unavailable. It is possible that the reason for this "unavailability" of data is that the items on the preferred list do not strictly represent universal categories.

A second set of reasons for this lack of concordance is that the Athapaskan cognate values were presumably based on both form and "meaning", as an index of linguistic similarity. The similarity numbers for the sibling terminologies used in this study ignore the form of the sibling term per se, as they are indexed only by semantic components. It can be suggested that these data illustrate the independence between sign and symbol in languages (Boyd et at. 1973: 16).

The kinship terminology of the Arizona Tewa provide an interesting example of the incongruity between phonological (sign) and semantic (symbol) change(Dozier 1955: 242-257). The ancestors of the Tewa of Arizona split from their relatives in New Mexico about the end of the seventeenth century and settled with the First Mesa Hopi. These immigrant Tewa borrowed heavily from their Hope neighbours, especially in the area of kinship systems. The result has been a different retention of cultural patterns by the Tewa of New Mexico and their Arizona counterparts.

Today, the Arizona Tewa kinship structure resembles that of the Hopi more than it does the New Mexico Tewa.

The kinship structure of the New Mexico Tewa is characterized by bilateral descent, with a generational or descriptive terminology. The social and economic unit is the extended (bilateral) family with patrilocal residence.

The kinship systems of the Hopi and Arizona Tewa are extremely similar, but quite devergent from that of the New Mexico Tewa. Both have matrilineal lineages with matrilocal residence. Intermarriage and kinship relations between the two groups go on with only minor adjustment. Although the structure of the kinship systems is similar, the Arizona Tewa and Hopi use different kin terms. The Arizona Tewa still use terms cognate with the New Mexico Tewa.

The similarities between the lexical forms of the New Mexico and Arizona Tewa are not indicative of shared lexical meaning. The kinship system of the Arizona Tewa represents an important situation where organization and behaviour have changed, but where the original kinship terminology has been retained.

The Arizona Tewa and Hopi are similar in the actual usage of their kin terms, and the behaviour evoked in response to these terms, but there is an extremely wide divergence in the kinship terminology. The two groups have similar kinship organization and behaviour, although they do not correlate all in lexical form. Arizona Tewa kin terms were formerly organized about a bilateral, generational kinship system. After their migration, the kinship system of these Tewa was made to fit into a lineal system, and the behaviour adjusted accordingly. Alterations in the Arizona Tewa kinship structure shows, at least in this case, that lexical form is more resistent to change than is the corresponding semantic denotata. In the Tewa case, new usages and their behavioural counterparts have been acquired without a corresponding change in phonetic form.

One might speculate that a reasonable hypothesis is: "kinship concepts evolve as systems relatively independent of gross linguistic changes". In other words, specific lexical sets, such as kinship terms, within a language are probably susceptable to particular "pressures", while the language as a whole remains relatively unaffected. Thus, gross language changes, and the resulting linguistic groupings, are less affected by specific pressures. But these pressures may have a dramatic effect on small lexical units, which in turn are not a function of broad "genetic" processes. At least the strength of the relationship between the distribution of types of sibling terminology, and the boundaries of linguistic groupings, seems less convincing than Murdock appears to believe.

There is, however, another way of viewing the relationship between linguistic groupings and patterns of sibling terminology. Figure 7, the componential diagrams of the Athapaskan sibling terminologies, shows that the terminologies can be divided into two main groups. One group utilizes variations of the primary components of relative age and sex of referent, while another group utilizes the primary component of parity.

This division corresponds to the linguistic division of northern and southern Athapaskan speakers. The division is actually more dramatic when we note that all of the Apachean languages (Navaho. San Carles, Chiricahua-Mescalero, Jicarilla, Lipan, and Kiowa) have an alternate system where siblings fall into two classes: siblings of the same sex as speaker vs. siblings of the opposite sex of speaker (cf. Hoijer 1956a: 315). Although this gross division between northern and southern Athapaskans is consistent with Murdock's hypothesis, it is not exactly a profound revelation.

However, the fact that Apachean languages use, or have used, an alternate system has important implications for the historical reconstruction of the proto-Athapaskan kinship system.

Kroeber (1937: 603) suggested that proto-Athapaskan had two systems for sibling terms, one specifying sex and seniority, and the other, the Apachean scheme. On the other hand, Hoijer (1956a: 315) states quite unequivocally for the proto-Athapaskan sibling terminology;

> ... siblings are put in four groups, OB/YB/OSs/YSs, which is unquestionably also the PA system (emphasis mine).

There is a considerable amount of finality inherent in this statement. It is worth noting that the complete lattice of partitions of the eight sibling kin-types, which comprises all the possible ways to partition these, forms the space for the natural experiment of evolving a sibling terminology. This space was first systematically enumerated by Nerlove and Romney (1967).

The size of the problem--that is, the size of the space involved in a taxonomy of thirty objects--may not be immediately obvious. Roughly, the space might be conceived as the set of all possible partitions for a set of "n" ob-nects. Recursively, this number is (Birkhoff 1968: 97);

$$P_{(n+1)} = \sum_{i=1}^{n} \binom{n}{i} . P_i \text{, where } P_0 = 1 \text{ and } \binom{0}{1} = 1.$$

In this case, the number of logically possible types of sibling categories, e.g. the number of partitions for "n" objects is $P_1=1$, $P_2=2$, $P_3=5$, $P_4=15$, ..., $P_8=4,140$. Put differently, 4,140 is the number of non-empty subsets that can be extracted from a universe consisting of only eight points (Niven 1965: 112-113).

Thus, the number of distinct sibling terminologies that can be "made" assuming the three dimensions, as above, with four kin terms (and eight kin types) is calculated from the formula;

$$g(m.k) = \frac{1}{K!}\left[K^m - C(K,1)\,(K-1)^m + C(K,2)(K-2)^m - \ldots + (-1)^{K-1}\,C(K,K-1)^m\right]$$

where "m" is the number of kin types and "K" the number of kin terms.

Thus, for the number of terminologies with four terms we have;

$$g^{mK}(8,4)=\frac{1}{4!}\left[4^{8}-\binom{4}{1}(3)^{8}+\binom{4}{2}(2)^{8}-\binom{4}{3}(1)^{8}\right]$$
$$=1,701.$$

Granting Hoijer the reconstruction of a four term system, we note that there are 1,701 possible terminologies for four terms. The probability of Hoijer's assertion, ceretis paribus, is 1/1701.

All of these combinations, of course, are not plausible in an ethnographic sense. The number of possible types of sibling terminology can be reduced, for example, if one eliminates "disjunctive" categories, which allow alternate criteria for membership (Lounsbury 1969: 194).

But the question here is, how, or by what rule or algorithm, did Hoijer eliminate all of the other 1700 possible four term systems, as possible proto systems?

Kirk and Epling (1972: 81-93) have discussed phylogenetic reconstruction within genetic units, in terms of the formal properties of the problem.

The heart of the problem, briefly, is this: given a matrix of (e.g.) similarity numbers, derived from an observation of events at some ending time--the present--which of all possible sub-trees of the phylogenetic space is most likely to have generated the sub-tree implied by this matrix? <u>Specifying</u> the point in the best-fit sub-tree where the evolution began (e.g., specifying the beginner or prototype) is a special sub-problem of the more general concern.

CONCLUSION

This thesis has been concerned with two different but related problem areas. One of these areas, which has been the principle focus of the first half of the thesis, is the nature and logical foundation of the technical concept of information. It was found that certain prerequisites, namely a precise formulation of probability space, must be met in applications of information theory. Semantic components of kinship terminology provide, theoretically, these necessary parameters on probability.

The second part of the thesis was concerned with the relationship between quantities of information and ethnographic data. It was shown that the information measure is of some general utility in the formulation and testing of hypotheses which necessitate comparison (cross-cultural) of kinship terminology.

I am not at all certain that the ideas ventured in this thesis, concerning possible applications of information theory to the study of kinship, lead in the "right" direction. But an attempt has been made to provide a substantive foundation for such applications.

The application of information theory to anthropological concerns, admittedly, tends to raise more problems than it solves. However it does provide a basis for the solution of some rather pristine queries.

The search for universal categories of culture, for example, has been a recurrent theme in anthropology. Twenty years ago, Kluckhohn (1953: 507) asked if there were "fairly definite limits within which cultural variation is constrained by panhuman regularities in biology, psychology, and the processes of social interaction". These limits of variation, Kluckhohn thought, could be useful as a basis for cultural description and comparison.

An interest in cross-cultural comparison is, of course, still prevalent in anthropology, yet the problem of limits of variation has not received satisfactory consideration.

Since the efflorescence of componential analyses, more comprehensive and precise data on cultural variation is now available. And information theory provides a satisfactory measure for the quantification and comparison of cultural variation.

Psychologists, such as George Miller, have been attempting to deal with the problem of human variation for some time. Anthropologists are now in a position to contribute their particular expertise to the solution of Kluchkhohn's query.

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