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AN ALTERNATIVE APPROACH TO TRAVEL DEMAND MODELING: CONSTRAINTS-ORIENTED THEORIES AND WOMEN'S ROLES

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1. INTRODUCTION

1.1 Conceptual Issues

This paper is concerned with raising some fundamental issues which are related to the study of the behaviors of individuals and population groups, including but not limited to the travel behavior of women. It presents the case for new ways of conceptualizing, modeling, and developing experimental data analysis designs primarily for the study of the travel decisions of selected kinds of sub-populations in cities in urban-industrial societies. The paper, however, has implications which extend beyond the analyses of either travel or travel issues related to women into the general area of the development of new modeling and quantitative data analytic approaches for urban public policy. Because of the limitations on the scope of this paper, the broader implications of the approach outlined here for the study of the recurrent movement of urban population groups can only be indicated.

The first point to be made is that conceptual issues precede modeling and data collection and analysis issues, and policy prescriptions. Although this point is self-evident to many, it is worth repeating here, given the current clash between the orthodox analytical-deductive approach to modeling movement, which has been used for both aggregate and disaggregate travel demand modeling (as reflected in, for example, Stopher and Meyburg, 1976; Adler and Ben-Akiva, 1977) and those more recent empirico-inductive approaches adopted by workers such as Heggie (for rationale see June, 1976, manuscript) and Brog et al (1976). Central to this clash are unclarified a priori positions about how the causal structures of individual and group travel should be verbally defined, prior to quantitative study, for different policy purposes.

The point which may be elaborated here is that how the world of the individual and the population group is initially conceptualized by researcher and respondents, that is, the verbal language in which it is initially conceived, reflects what is taken throughout all subsequent work as axiomatic and not axiomatic, what variables are included as relevant, how they are related to each other, and, even more importantly, what variables and relationships are omitted and what differing emphases are placed on both present and absent variables and relationships. How one initially conceptualizes the world of the individual and the population group will be reflected in whatever language is used, whether this language is employed by the respondent or the researcher and whether it is ultimately incorporated in analytical-inductive modeling approaches, empirico-inductive ones, or in the simpler questions which lay persons or planners or politicians might pose to answer about the world. Raising and resolving conceptual issues thus takes precedence over modeling and data analysis issues, and different resolutions of conceptual issues will lead to different models and/or data analysis designs, different findings, and different policy implications concerning women's travel or any other kind of human behavior. Hence it is absolutely necessary to ask whether individual and group behaviors are currently appropriately conceptualized for the study of movement of subpopulations in cities. This paper contends that for some purposes they are not, indicates how, suggests and documents an alternative conceptualization for the study of individual and group travel, and notes the broad range of societal issues it might address, including some of specific interest to women.

Several papers illustrate these points about the way in which conceptualization determines analysis and policy prescriptions. For example, the Hartgen paper emphasizes how current data bases may be handled to give answers to some women's travel issues. In particular, the author points to how such information may be utilized to indicate current patterns and trends in women's travel behaviors, and in the causal variables controlling them. This kind of analysis, however, rests on a conceptualization which assumes first, that the world is planned largely to accommodate present aggregate patterns and trends in behavior, without radical alterations or modifications in them, and second, that the changing distribution of behaviors over given and known alternatives reflects what individuals and groups actually prefer to do. This view of the world, while common, is nonetheless debatable.

Another illustration may be taken from the Koppelman and Tybout paper, which reflects current disaggregate conceptualizations of individual and group decision-making. The paper conceives the world as composed of individuals and groups who distribute choices over available alternatives, and concentrates therefore on asking what are the differences in the choices, and in the causal variables governing the choices, of different subpopulations. While this approach yields much valuable information concerning the needs of different groups, given opportunity sets (e.g., sets of travel alternatives, such as modes) as they exist now, it says little about the degree of variability between groups in the nature of the opportunity sets in the first place and how this affects preferences and behavior; thus it cannot address questions related to the effects of unequal opportunities on, and the need to equalise opportunities for, mobility of different groups, surely a major focus for studies of minority behavior, and of women's behavior too. A world planned on the basis of distributing behavior over current opportunity sets, with no precise knowledge as to how these are formed, runs the risk of re-engraving on the city immense differences in opportunities between individuals, or at least never precisely addressing the issues which might be raised by considering explicitly differences in the availability of travel opportunities (activities, destinations, modes) for different kinds of people. This is especially important, since recurrent movement connects the individual to urban resources (places for employment, recreation, social activities, medical care and travel itself), many of which are now widely scattered at different locations outside the individual's home. A conceptualization of individual and group behavior in cities, relating the movement of different types of individual to variations in the contents of their opportunity sets, is clearly essential for the study of differences in the welfare of population groups in cities, including women, yet neither the Hartgen nor Koppelman and Tybout conceptualizations, stemming from older aggregate and newer disaggregate approaches to movement, permit this central question to be addressed.

At this point, it is wise to remark that this paper presents an argument for the explicit recognition of the need for, and effects of, plurality in research on individual and group behavior, that is, a diversity of initial conceptualizations and hence of modeling and/or data analytic approaches and policy prescriptions. Clearly, however, there is a need for some other perspective than existing ones, which can at least handle some key unaddressed aspects of the welfare of different groups, including women. The features of an alternative conceptualization of individual and group behavior for the development of new models of movement are thus outlined.

1.2 The Need for Still More Realistic Assumptions in Disaggregate Approaches to Movement

At the moment, the most widespread scientific basis for understanding and predicting the travel behavior of different population groups, such as women's and men's, is provided by disaggregate travel demand models. The multinomial logit model (MNL) is often used to describe the distribution of choices by different population groups over sets of activities, sets of modes, sets of possible travel times, sets of possible destinations, etc. The MNL, as is well-known, can be derived from micro-economic theory (see Stopher and Meyburg, 1976). Recently, this model and its micro-economic theory base have been criticized on a number of grounds, which may be summarized as follows (see also Burnett and Hanson, 1978):

(1) The unit of behavior, the dependent variable, is considered to be simple, not complex, as, for example, a trip is considered as a path by a single person simply between two points in space;

(2) The choice set of an individual for any decision is assumed to contain at least two and often "many" alternatives, and either to be the same as, or to vary randomly from, or to differ in some ad-hoc fashion from, other individuals' choice sets; there is no systematic variation assumed to exist between individuals in their choice sets, with such systematic variation explained in terms of causal variables;

(3) Each and every individual is assumed to behave in a strict utility-maximizing fashion; that is, each person characteristically develops an overall unique utility for each alternative in a set, normally derived by summing part-utilities of the alternatives on different criteria, and the person is then able to order the so-derived set of unique utilities for all alternatives and to make choices so that the ratio of the probabilities of selecting any one alternative in comparison with any other is the same as the ratio of the alternatives' utilities.

These assumptions can be criticized on the grounds that they are simply unrealistic, that it is a general goal of "science" to produce models with increasingly realistic axioms, and that this might be appropriate now, especially with reference to the choice set axioms (following Jones, 1976; Dix, 1977; Heggie, 1977, 1978). However as has been argued elsewhere (Burnett and Hanson, 1978), models in the social sciences have still more stringent requirements for realistic assumptions than do models in other sciences, because the possibility should remain open for their use to obtain desired radical alterations in societal or group behaviors, and this constitutes an additional reason for the creation of models and conduct of data analyses without "unrealistic" assumptions (for example, it is widely accepted that, to induce mode switch or changes in car-ownership for energy conservation, we need to know the actual attributes of modes which govern choice and actual decision rules, implying a need for models with "realistic" assumptions about decision-making). Since, in the case of womenas well as other population groups, we cannot rule out the notion a priori that some major changes in their world might still be required, and some radical alterations in their travel needs or travel habits might consequently need to be allowed for, it behooves us particularly to explore the possibility of developing models and theories of travel with the most realistic possible assumptions, the better to identify policies to create desirable changes, and to accurately predict responses to proposed policy alternatives. The remainder of the paper concentrates on documenting and developing a more realistic conceptualization of travel for these purposes: one which not only assumes that the individual's behavior is complex, but also especially that choice sets are highly variant for individuals and groups and deserving of some systematic causal explanation, and that decisionprocesses are simpler than hereto conceived.

2. THE IMPORTANCE OF THE THREE DIFFERENT TYPES OF AXIOMS AND SOME POLICY IMPLICATIONS OF RELAXING THEM

2.1 Documentation from the Literature

Although each of the three kinds of axioms listed above have been mentioned in recent criticisms of models of travel decisions, the relative importance of each one is different. In particular, the relaxation of the axioms regarding choice sets seems the most critical to investigate, particularly in the current context of developing improved circumstances for women and/or other population groups who might be considered disadvantaged.

By focusing on how the choice sets of individuals and groups are formed in cities, and by thus defining access to employment, educational, recreational and other urban resources, the mathematical modeling of recurrent movement for the design of urban transportation systems is related quantitatively to broader aspects of urban environmental (physical land use) design, to group and individual welfare, and to the "quality of life." Thus -- although some modeling, data analysis and policy issues which stem from a reconceptualization of travel through altering each kind of axiom will be explored -- most emphasis in this and later sections of the paper will be paid to conceptual, modeling, data analysis and policy issues flowing from the explicit mathematical formulation of relations between choice sets, variables influencing them, and behaviors, for different population groups such as men and women.

Movement as complex, not simple, behavior. The assumption that the individual's behavior is simple, reflected in the definition of a trip as a single base-to-base movement by a person, has, of course, been criticized for many years. However, considering movement as a complex rather than simple phenomenon has little-known implications concerning the ways in which mobility differences between different population groups might be measured and evaluated. These latter implications can be traced out by considering in some detail what is meant by complex as distinct from simple behavior, particularly with reference to the travel of different types of individuals, including women.

At present, considering the trip as a link between two stops (bases or destinations) leads naturally into considering activity, frequency, mode, time of day and destination to be "choices" which different types of individuals confront for the conduct of each trip. The trip is theoretically the unit of "derived demand" for different kinds of individuals, though there are many varieties of trips from which to choose (trips by auto or bus or walk, for example, or trips to shopping or to work). However, American geographers early remarked that movement was not simple base-to-base travel, but a complex sequencing by the individual of his/her activities over space and through time during a given decision period (usually considered to be a day). Thus, Marble in 1959 conceptualized the individual's travel in the form of home-to-home circuits, and categorized movement by persons into single-purpose (simple trip) and multiple-purpose (complex trip) travel (see also Nystuen, 1959 and 1967; Curry, 1962). Much emphasis was also placed on the statistical analysis of longitudinal data on the linkages of land use types by individuals in American cities in order to define as rigorously as possible the types of multiple-purpose journeys which persons tended to make (Nystuen, 1959 and 1967; Marble, 1967; Hanson and Marble, 1959). Patterns in the linkages of other aspects of trips (such as the linkage of mode or activities on successive trips), were not, however, investigated. The contributions of this conceptualization of behavior and related data analyses were: an early emphasis on the individual's travel as movement through time and over urban space on an extended series of stops; a demonstration that patterns or regularities in the complex behaviors of individuals can be objectively identified, comprising systematic behaviors which should therefore be susceptible to scientific explanation as dependent variables in modeling and theory development (see also Hanson, 1977); and, above all, an implication that such patterns of behavior could be associated statistically with the sociographic characteristics of individuals, such as gender.

Of course, in the middle of the seventies, work in the disaggregate modeling of destination choice outside geography broached the question of patterns in the linking of non-work trips by individuals. Recent work by Adler and Ben-Akiva (1977) is an example of an approach which independently elaborates on the earlier conceptualization of movement as complex behavior by geographers. The proliferation of concepts such as "tours","chains", "journeys", "travel patterns" reveals a recognition that movement is in fact a linking of stops by individuals in sequence over a space and time, implying not only destination linkages but also linkages of activities, modes, timing, and other aspects of travel as well. Little work in America has so far been carried out on the further implications of this reconceptualization of travel, namely, that quantitative research is required with longitudinal trip data for large samples of individuals now for American cities to establish what, if any, kinds of linkage patterns exist in reality, and how these might vary for different kinds of groups, including women and men.

The two-dimensional geometric representation of the individual's movement as a space-time path in Figure 1, attributable originally to Lenntorp (1976), and reappearing variously in Thrift (1976) and Dix (1977), represents the first attempt to depict in a quantitative form what the individual's movement might be in reality, once it is granted that he/she does not make a trip, but a sequence of trips to different places, that is, a sequence of stops over time, where a day is one arbitrary division of time. One of the less obvious features of the representation of the individual movement in Figure 1 is that, by portraying it just as a line in two dimensions (time of day, distance), information about what is normally considered as other crucial aspects of trip-making (activities, modes, destination types and locations) has been collapsed into that space. Technically, Figure 1 is a simplified representation of the individual's travel as a path in n dimensions, one being time of day, one being distance from last stop to the next, and the others representing the remaining particularly important aspects of travel which could be considered, such as mode, activity type and location of destination, at least. The individual's path, properly represented in the n-dimensional space -- where some of the dimensions are categorical or qualitative variables, and some are not -- becomes a line joining a sequence of points, representing stops, each stop possessing a set of coordinates (or values) on a separate axis giving at least time of arrival at stop, distance from last stop, location of present stop on north-south and east-west axes, mode used to get to stop and activity conducted at the stop (it is clear that any other important aspects of travel could be portrayed on further dimensions, e.g., duration of stay at a stop). The more rigorous geometrical presentation of individual's daily travel as a path in n dimensions is shown in Figure 2.

What does this reconceptualization of travel imply for future modeling work, data analysis and policy relevant to the travel behavior of different population groups, such as women? First of all, it is evident that significant differences in the behaviors of different kinds of individual, for example, between men and women, might not show up when travel for modeling or data analysis is conceived as simple interbase movement. For example, most studies show that the average distance traveled by women, measured for simple interbase trips, is shorter than that of men (the latest report of this is in Kostyniuk's paper). This could be taken to imply that women have a shorter range about the home than men, and even as an indication that they are less mobile.

However, if the total daily travel patterns of women are compared with those of men, then the number of stops on a day and the distances and directions they lie from each other will determine whether, in reality, women do travel a shorter distance, are less mobile and have a smaller range than men. It is conceivable that women, particularly women employed in the paid labor force part-time or not at all, might make many more stops over a day than do men, that their total distance traveled is greater even though the average interbase trip length is smaller, and that the maximum distance and area they need to range away from home is even greater to or equal to men's. In addition, by simply comparing the distribution of women's and men's interbase trips between different modes, no information is gained as to the complexity of the sequence of modes which men and women use to accomplish their daily activity-travel. For example, homemakers in one-car households, deprived of a car during the day, might need to use two or three non-auto modes while men might simply use a car for all trips. The total costs of the female transit-oriented group would be clearly greater in this case than the travel costs of the male auto-oriented group, to a degree that is not reflected in simple statistics showing that women use transit on trips and men use cars. Thus, it is particularly important to reconceptualize the dependent variable of travel demand models as complex behavior, that is, in the form of a path over space and time, in order to provide, among other things, for more appropriate measures of differentials in overt behavior between gender and also other groups, that is, of differentials in kinds of travel needs which exist under current circumstances.

One policy implication that flows from this reconceptualization is a clearer understanding of how demands for flexibility and reliability in modes might arise, particularly for some kinds of population (for example, the population groups noted in the Koppelman and Tybout paper). Indeed, it could be remarked that until travel is redefined in this way, crucial aspects of the routing and scheduling of different modes which might affect the demands for them are likely to be ignored on modeling, data analysis and policy. Consequently, it is exceedingly important to determine what kinds of paths exist, how they are associated with different kinds of individuals, and how they are formed under the current conditions of supply of travel opportunities. However, while such endeavors will be of considerable interest to those concerned about measurement and classification problems, of much more theoretical interest and policy relevance is the relaxation of the choice set axioms of current work.

The choice set axioms. Any attempt to relax the choice set axioms, that is, the axioms under (2) above, would first involve the development of a causal choice set formation model for the individual. Specifically, the probabilities of an individual or the members of a group selecting a particular kind of travel behavior (option), would be expressed as the joint probability or the option being in the choice set for members of the group, and the probability of its selection conditional on its inclusion in the set. i.e.,

$$P(j) = P(j \varepsilon A) \cdot P(j | j \varepsilon A), \; j=1,\ldots,n \quad \text{I}$$

where A is the set of options and n is their number. The specification of $P(j \varepsilon A)$ would lead to the development of a causal choice set formation model of an explanatory-descriptive variety (the nature of some of its variables and the use of I to redevelop microeconomic choice theory and thence reformulated analytic-deductive travel models is further discussed in Burnett, 1978, and Burnett and Hanson, 1978). Although the notion of an individual choice set formation (generating) model was first raised by Lerman and Adler (1976), a review of the spasmodic literature on the topic suggests that many more explanatory variables need to be taken into account than was originally considered. Over a decade ago, North American geographers investigated the relations between the individual's opportunity set for spatial choice (all his/her spatial alternatives in the city), his/her "cognitive" opportunity set (the known alternatives of the opportunity set), and his/her choice set (all those known alternatives ever used) (Marble and Bowlby, 1968; Hanson, 1973). The variables defining each kind of set included the average distances from home or workplace of different land use types, the timing of activities at different locations (e.g., the hours of business of shops), as well as such variables as the relative prices of goods and services offered at stores in the case of shopping place choice sets. The development of choice set models by engineers, notably Tardiff (1976) and Recker and Stevens (1977), introduced the idea that the socio-demographic characteristics of an individual might be particularly important too in defining the probabilities of different alternatives being in the choice set. For example, car ownership and availability as well as age might affect the range over which an individual can travel and hence the opportunities in the objective and cognitive opportunity sets. Independently, workers in Europe (Westelius, 1973; Lenntorp, 1976; Brog et al, 1976; Jones, 1976; Heggie, 1977; Dix, 1977; Wermuth, 1978) began inquiring into the ways in which many possible variables (constraints) limited the number of alternatives which individuals have for many decisions, in many instances reducing the number of alternatives in choice sets to one or zero. The European work emphasized the significance of institutionally-derived constraints for choice set formation. These are constraints on the content of the individual's choice set for any purpose, resulting from organizational or collective decisions beyond his/her control and operating through the institutions of an advanced urban-industrial society (through urban planners, corporate organizational decisions). Many such constraints are expressed and encountered by the urban individual in the form of the detailed spatial distributions of urban activities (the locations of residences, work places, shops etc.) and their scheduling, which limit his/her travel options (space-time constraints). In addition, recent work by both Americans and Europeans emphasizes the importance of time and money budgets and "roles" as "personal" constraints on the opportunities in any travel choice set for the individual (e.g., Dix, 1978; Jones, 1978; Heggie, 1978; Zahavi, 1974).

All these constraints obviously need detailed definition and measurement for large population groups and for all kinds of travel decision, and the relative significance of institutional (space-time) constraints versus personal constraints needs to be determined. Especially, the relative importance of space-time constraints versus constraints placed by the individual's sociodemographics needs to be discussed for different population groups, including gender groups such as women and men. In the short run, there needs to be an assessment of how much of the variance in observations of the complex daily travel patterns of individuals is explained by variables under his/her control, with such behavior therefore being manipulable by marketing strategies, and how much is outside the individual's control, arising from organizational decisions restricting choice sets by the private or corporate sector, and needing government policy or industrial reorganization to handle. For example, it is quite possible that the space-time constraints of a suburban middle class housewife with children under five and no car are such that for many hours of the day she has only one or no acceptable alternative within any choice set for travel (e.g., walk only in her mode choice set). (see Palm and Pred, forthcoming; Tivers, forthcoming): the relative contributions of gender-related roles and the supply of travel opportunities needs to be investigated here.

All this implies that in order to specify a choice set formation model for each different type of population group, considerable exploratory data analysis needs to be done to identify relevant groups, to specify the variables which define their choice sets, and to develop the mathematical statements about the ways in which these variables determine the probabilities of different alternatives being in or out of individual's sets. This is clearly a very complex question for future empirical research and special simulation gaming procedures (following Marble, 1967; Biel, 1972, and Heggie, 1978, Jones, 1978). Consequently, before proceeding further, it is desirable to produce some data to support the contention that there might be significant inter-individual variations in choice sets indicating susceptibility to grouping, and that these variations are related to inter-individual differences in complex travel behavior, in order to document that the present reconceptualization of movement is a fruitful direction for further research. This question is taken up later in the paper.

Variable decision rules. One result of recent research in choice theory is that, in instances where individuals do have choices (more than one alternative in their set), decision strategies may vary both with the type of individual and the complexity of the situation (Slovic, Fischoff and Lichtenstein, 1977, p. 8). Moreover, decision strategies are much simpler than the strict utility-maximizing assumption postulates: "In general people prefer strategies that are easy to justify and do not involve reliance on relative weights, tradeoff functions or other numerical computations." Strategies may include elimination-by-aspects, disjunctive, conjunctive, or lexicographic rules, where features of many of these are reliance on threshold values of one, or a few, critical dimensions of alternatives to partition choice sets into satisfactory and unsatisfactory alternatives; and several stages of judgement. Thus, the expansion of $P(j/j \leq A)$, the choice model of Equation I, will require the identification and modeling of the simple choice strategies which different kinds of individuals use in different situations. There has been no investigation of differences between groups in decision rules in modeling travel so far, for example, in studies of differences between men and women in the set of criteria which they use for judging travel options and in their importance and in the process by which they use the criteria to make a decision. For marketing strategies in transportation, e.g., "selling" new modes, the possibility of such gender differentials should be allowed for: for example, threshold choice strategies, in contrast with utility-maximizing ones, imply zero return to anything but "critical" major alterations in "important" dimensions of alternatives such as travel modes. Similarly, the effects of intergroup differentials in all aspects of decision-making should be considered in choice modeling, the analysis of choice data, and policy descriptions derived from them.

2.2 Documentation from a Small-Sample Experiment

The Data Set. To document further the points which have been made about the reconceptualization of individual and group behaviors in general and women's travel behavior in particular, a pilot study was undertaken with a small sample of persons. This sample initially comprised the 35-day travel records of 34 individuals selected as a stratified proportional random sample from members of each of six life-cycle groups; the latter comprised a larger proportionate random sample of 531 individuals and 296 households by life cycle groups in Uppsala, Sweden, 1971 (Table 1).* This data set was chosen for three reasons: firstly, because it contained information about social roles and gender which are missing from other data bases; secondly, because, although Sweden by 1971 had implemented a considerable amount of social legislation to equalize the opportunities of men and women in both work and parental roles, persons of different genders undertook significantly different activities (Hanson and Hanson, forthcoming) as is the case in U.S.A. (Robinson, 1978); and thirdly, detailed longitudinal data for individuals were available. Thus, this data set seemed ideal to explore whether travel could be treated as complex behavior, and whether gender-related explanations of it might be appropriate. There is a considerable amount of evidence that such gender-linked roles especially comprise societal expectations of what is appropriate for each sex at different stages of the life cycle, and that life cycle and sex influence travel (Heggie, 1976). Any lack of effects of gender-linked roles on travel in this instance could be taken to indicate either the influence of small sample size, the absence of sex and/or life cycle role effects, or an inappropriate definition of roles to define groups, or any combination of these.

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*For purposes of exploratory analysis with the 34-person sample, life cycle groups 1 and 2 and 5 and 6 were sometimes combined. The sample was limited to 34 persons because of restrictions in the INSCAL algorithm used later in the analysis.

Which of these interpretations is favored will be considered when the results of analyzing the travel records of the small sub-sample from the larger Uppsala sample are considered.

The travel record for each individual in the sub-sample was of a standard variety, as can be seen from the example of a person's travel diary in Table 2; each individual recorded, for each stop in sequence over 35 days out of home, such aspects as mode to the stop, time of arrival and departure from the stop, activity at the stop, expenditures at the stop, and so on. In addition, on the final data tape, the land use at each stop, by one of 99 separate classes, was entered, together with the north-south and ease-west grid coordinates of the location of the stop.

It must be noted here that the analysis of these data for 34 individuals is not intended to provide any definitive statements as to how different gender groups behave, but rather to examine the notion that a new, more realistic conceptualization of travel behavior for individuals and groups can yield an adequate description of information in individual trip records; it can then guide new work in modeling, data analysis and policy development for different population groups, including women. A large-scale experimental design with a set of much larger data bases is described later which will hopefully provide more substantial support for the kind of approach taken here. At this point, however, we are concerned only with producing some evidence to show that it might be worthwhile to proceed with this larger-scale analysis. The aim of the following is therefore simply to demonstrate that hypotheses consistent with assumptions about the complexity of individual travel, inter-individual variations in choice sets and simple decision rules match forms of travel data which are also currently fitted by logit models derived from different premises. Since the new hypotheses are more realistic and raise some interesting policy issues not handled by other approaches, including some related to women, further support is provided for future modeling and data analysis based on them.

Travel as Complex Human Behavior. The results of reconceptualizing travel as complex human behavior and describing it mathematically as a path in n-dimensional space are indicated in Figure 3. For each of the 34 randomly sampled individuals, the day of his/her most complex behavior, as indicated by the day with the maximum number of stops, was selected. Two-dimensional plots, as in Figure 2, were prepared for each individual, showing the sequence of stops plotted against each pair of stop descriptors-activity at stop, time of arrival at stop, distance from last stop, NS and EW location coordinates of stop, land use at stop, mode to stop. Inspection of the diagrams leads to the conclusion that, even in the most complex cases, the individual's daily travel has a less -- rather than more -- complicated structure; the illustrative selection of diagrams in Figure 3 show how the ranges of each individual through a day are apparently limited to some maximum distance and area, and there is a limited number of different modes taken on successive stops, and some upper limit on the total distance travelled. Moreover, at least for observed travel behavior, the structure of the paths in n-dimensional space seems to be differentiated both by gender and life cycle group, with younger groups with more children showing more complex daily travel patterns in terms of the numbers and locations of stops and the variety of modes taken, and men having significantly different modal combinations from women. In some of the instances which the diagrams illustrate, too, the women of each life cycle group traveled further than the men, indicating how reconceiving travel as complex behavior might produce unexpected results about differences in movement between population groups, such as differences in modal use and distances traveled by men and women. The most important result from the simple "eyeballing" of n dimensional paths of these kinds, however, is the indication that systematic differences between the paths for different persons appear which might be identified by classifying or measuring them and associating them with socio-demographic characteristics of persons. This implies in turn that reconceiving human behavior as complex in the case of travel at least, does not lead immediately to too complex a dependent variable for handling in new kinds of mathematical models and data analysis for the study of individual and group movement. The last section of this paper describes simple procedures whereby paths like the present ones in n dimensional spacemay be measured and their associations with different population groups, including gender-defined groups, more thoroughly investigated.

Inter-Individual and Inter-Group Variations in Choice Sets. The revised axiomatic base for new kinds of travel models, data analysis, and policies postulates that travel choice sets of individuals are both more constrained and systematically variant between persons and groups than has traditionally been considered to be the case. One way of examining the validity of this statement is to show that it appears to be true of individual choice sets for the Uppsala sub-sample. The following represents an attempt to investigate this hypothesis by showing how, if it is true, specific patterns should appear in the data for the complex travel behaviors of men and women.

From the reconceptualization of travel in Figure 1, it is apparent that what has been traditionally conceived as separate "choices" (activity, mode, destination-location, destination-type, time of day, etc.) may in fact by simply descriptors or aspects of stops to the individual. From this, one tenable hypothesis, consistent both with the foregoing reconceptualization of the individual's movement, and with the notion of limited and systematically varying individual choice sets, is that different individuals choose between only a limited number of distinctive activity/mode/destination-type/destination-location/distance/time of day aspect combinations defining stops. For example, if the individual is a full-time employed married woman, then "shopping for groceries" may always and only be associated with "five minutes from home on the way from work to home", "travel by auto mode", and "5:30 p.m.", while "shopping for clothing" might be associated always and only associated with "regional shopping center", "ten miles from home", "auto mode", and "6 to 9 p.m. Thursdays and Saturday mornings". Only stops which can be labeled in this way will belong in the individuals choice set. Other kinds of individuals have possible stops described by different combinations.

What this implies is that, in an individual's daily n x 7 travel matrix comprising observations for all 7 aspects of n stops (mode, activity, time of arrival, distance from last stop, EW and NS locational coordinates, land use) the column of numbers defining the set of observations of an aspect for each stop should be paired repetitively with the columns of numbers describing each other aspect of the stops. Thus, if 1 (or any other) number represents "shopping activities", it should always, or almost always, recur with, one single other number, say 7, representing mode and the appropriate single numbers for say, time of day and distance from home. This implies that some measure or pattern of association between the aspects of stops could be used to determine how restricted the individual's choice set is, and permit inter-individual and intergroup comparisons in the degree of restriction of the choice sets. In this instance, the Peasonian correlation coefficient, r, is used to measure the patterns of association between each pair of aspects for each individual; it is appropriate as a co-association index in this case, and will be invariant irrespective of the numbers assigned to different categories of qualitative variables (e.g., mode) as well as to quantitative variables . . . (It will be noted that the use of r as a pattern index is different in this instance from its use as a statistic to measure the relative influence of one variable on another, not controlling for the effects of other variables, the more common use). In the present case, the magnitude of r is an index of the degree of restriction of the individual's choice set; low $|r|$ values represent little association, that is, the pairing of one value for one stop aspect (e.g., representing one mode) with highly variable values of another aspect (e.g., representing many different kinds of land use or destination types). High values of $|r|$ indicate a consistent association of one value of one stop aspect (representing one mode) with one value of another stop aspect (a single land use). Consequently, the inter-correlations of all pairs of aspects of stops were computed for each individual and summary tables prepared, as shown in Table 3. From this table, it can be seen that, while the majority of individuals tend to have r values between .25 and -.25 for all aspect pairs, and while this is also the case for each aspect pair separately, there is significant inter-individual variation in both the magnitude and the nature of the association. This is reflected in the high coefficient of variation, and the symmetrical distribution, of r's over the entire range of its possible values for the set of 34 individuals, both in the case of each aspect pairs separately and all aspect pairs taken together. Certain kinds of individuals might hence be found with differences in their choice sets, or, more specifically, systematic differences in the choice sets of individuals of different types might exist which could be modeled. Of course, what variables most contribute to the choice sets and the nature of their content is left open for exploration in future work, but at least the existence of significant choice set variations is indicated. An analysis of variance of the differences in correlation coefficients for aspect pairs by the life-cycle, gender, and life cycle/gender combination of individuals showed no statistically significant main or interaction effects. Although this could result simply from small sample size, if gender or life cycle determinants had been highly important, one would have expected some significant effects, at least for some categories of gender or life cycle; these did not appear. The conclusion at this point should not however be that it is highly doubtful that there are gender-related role differences in choice sets; rather, more attention should be paid to the development of additional role descriptors which might interact with or complement the effects of simple gender and lifecycle differences. The experimental design described below for use with much larger samples of individuals will permit a much better exploration of possibly complex role effects on choice sets and travel.

Simple Decision Strategies. Finally, trip records for the sample of 34 can be used to investigate the hypothesis that decision strategies are simple rather than complex and vary between different individuals and population groups. If decision strategies are simple, one hypothesis which is tenable under the reconceptualization of travel used here is that the measures of aspects of chosen stops which reflect the nature of choice sets, should also reflect the operation of simple decision rules. Thus, we may ask, if individuals of different types are evaluating stops, which are defined by values on different aspects, how would they evaluate the range of aspects of stops in order to select the stops they chose? What criteria could be used to judge the different aspects of stops? Two or maybe three dimensions which could be simply used to assess the costs and benefits of all aspects of stops used in travel are the familiar subjective travel time, travel cost, and, perhaps, service. The use of just two or three dimensions is, of course, supported by the now immense volume of literature on aggregate and disaggregate approaches to travel which documents the overwhelming significance of these criteria. If this hypothesis is true, then:

(1) The $|r|$ values describing the association between pairs of aspects of

stops for the individual measure similarities between stimuli to the indi= vidual for judgment purposes;

(2) If so regarded, the 34 intercorrelation matrices for each of 34 individuals, for eachpossible pair of aspects describing stops, represent similarities matrices for input into a scaling algorithm such as INSCAL;

(3) Recovered configurations from the algorithm should show a high degree of resolution in two or three dimensions, with a dispersion of the stimuli (aspects of stops) along each dimension in individual and group spaces;

(4) There should be a high level of variation in the subject weights for each dimension, perhaps exhibiting statistically significant differences for individuals grouped by gender and/or life cycle group. (See Burnett and Hanson, 1978, for fuller details of this use of INSCAL).

Thus, the subjection of the individual intercorrelation matrices to INSCAL analysis will produce results to test the assumption of the simplicity of the decision rules of individuals, and their variation between different population groups, such as gender-related ones.

Results of the INSCAL analysis are shown in Figure 4. The basic hypothesis that there are at most two or three underlying dimensions which are used by individuals for the judgment of different stops appears to be upheld; however, MANOVA analysis of the weights on each dimension, to capture the effects of gender and/or life cycle group on configurations or decision rules, produced no significant main or interaction effects for either two or three dimensions. Again, this could simply be the result of the small sample size; however, if gender/life cycle-related effects had been very strong, one would expect either or both variables to have exhibited some statistically significant effect on configurations by weights, even for such a small sample. The results indicate either that role variables are not appropriately defined, or the other variables are more significant in defining groups with different decision rules (see especially similarities in "male," "female," and "group" spaces in Figure 3).

In sum, some evidence has been presented to indicate that, by reconceptualizing the individual's travel as complex, choice sets as constrained and systematically varying between persons, and decision rules as simple and also varying between persons, statistical hypotheses can be generated which are consistent with observations of travel behavior. Thus, hypotheses and data analyses which are derived from radically different kinds of assumptions about movement might provide just as good a fit to observations of travel behavior as current formal models like the logit, which are based on different and less realistic hypotheses. The inference from this should not be that a replacement for the logit is immediately needed for all modeling, data analytic and policy prescription purposes, but rather that there needs to be a clearer articulation of the kinds of policy each approach might provide (Burnett and Hanson, 1978). However, in the long run, both for scientific and policy purposes, clearly there appears to be a case for developing the new kinds of model and data analysis for individual and group behavior to which the present reconceptualization can lead, and for the mathematical exploration of new ways of handling differences in travel behavior and opportunities for different groups. From the preceding discussion, however, the question as to what kinds of groups would be used for aggregation purposes in new kinds of models and analysis remains unresolved. In particular, the relative importance of gender-linked variables for behaviors, choice sets, and decision strategies deserves further consideration. This essentially requires the investigation of precisely what and how much gender linked variables contribute to the explanation of observed complex travel behaviors, vis a vis other socio-demographic descriptors of persons, and space-time constraints. Consequently, the remaining section of this paper describes a design for the future investigation of the relative importance of gender-linked and other variables on travel, given the acceptability of the reconceptualization of travel and its explanation offered in this paper.

3. A LARGE-SAMPLE EXPERIMENTAL DESIGN FOR THE DEVELOPMENT OF NEW MODELS OF INDIVIDUAL AND GROUP BEHAVIOR

Table 4 displays an outline of an experimental design which uses large samples of individual daily trip records, together with large-scale data bases of the point locations and scheduling of 37 classes of urban activities, to further explore the main issues raised by the conceptualization of individual and group movement and their explanation. In particular, the following analysis investigates whether one should explicitly consider the effects of space-time constraints and the effects of socio-demographic variables on complex travel behavior for all population groups. The results should clearly demonstrate the consequences of not hitherto effectively considering space-time constraints as dominant variables in choice set formation models in the study of movement: the key conceptual shift advocated both for science and public policy inthis paper. But the results should also indicate more precisely, too, the effects of gender-linked variableson travel.

In the experimental design of Table 4, the individual's complex travel behavior is determined by a vector of measures, one set of measures for each individual in designated space-time constraints and socio-demographic categories. The socio-demographic categories reflect the recent empirically- and theoretically-based tendency to segment thepopulation by role descriptors for the study of movement; however, the complexity of the possible class-race-gender-linked "role complexes" for each person (see discussion Fried, Havens and Thall) is probably still inadequately represented by this "ad hoc aproach" to role descriptors, and indicates the paucity of definition and measurement procedures in this area. The space-time constraints categories are developed from computer analysis of "Dime-Files" giving the street address and between-address distance/time for the activities in a city. Uppsala, West Berlin and Baltimore are the only three cities to our knowledge with both the Dime-File and large samples of individualtrip records for this analysis. The design is set up for data analysis by MANOVA (multiobservation, multiway analysis of variance with unequal cell frequencies) and, although statistics are not available to estimate the relative importance of space-time constraints versus socio-demographics on travel for all population groups, various indices are availablefor this purpose.[2]

The Uppsala travel diary data set, and geo-coded land use data set enables the contributions by all categories of socio-demographics versus all categories of space-time constraints to be explored in great detail. This data set will provide the basic control for examining the relative significance of socio-demographic categories versus space-time contraints categories For the remaining two data sets, the number of categories of socio-demographics versus the categories of space-time contraints which could be set up was limited by the total number of individual travel records available. The strongest test of the hypothesis that space-time constraints are more significant than socio-demographics, or vice versa, will occur if the study population is limited to those kinds of individuals who are neither operating without constraints or under severe constraints; thatis, if sub-populations at either extreme are eliminated. Thus,the Baltimore and West Berlin populations are confined to groups of persons who are not single, neither low nor high income, and not out of full-time employment. The separate analysis of the data for the three populations will not only answer the main conceptual issues raised above, but also check on the ultimate transferability of the new approach and allow crosscultural comparisons of the movement patterns of different groups, such as women.

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[2] The Wilkes-λ F ratio for a main effect converts to a measure of the relative strength of the effect through the formula $1-\lambda^2$, for example.

4. CONCLUSION

This paper has pointed out that there are some fundamental conceptual issues in the analysis of women's travel behavior at the moment, as in the analysis of any group or individual behavior. It has been demonstrated how alternative means of defining movement as complex and then of explaining it might provide a satisfactory interpretation of ordinary trip records of individuals, but might produce different and even conflicting policy implications for women and other groups in comparison with current aggregative and disaggregative approaches applied to the analysis of movement. This implies the need for much further research into the foundations of causal explanations of the travel behaviors and mobility needs of different population groups, rather than "palliative"-oriented research immediately geared to the analyses of data or to the provision of quick answers to pragmatic policy questions. In particular, the approach of this paper shows that some sensitivity is needed to the fact that the humanworld is very complex; not only is behavior itself complex, but the environments in which individuals find themselves in cities are highlyvariable, and the decision rules and strategies and ways of acting within the environments are also likelyto vary. Unless we become less simple-minded in our interpretations of individual and group behavior, and more sensitive to the demand for complexity from the world without, rather than to the demand for simplicity for formal analysis from the world within, we run the risk of asking the wrong questions, mis-specifying models, measuring the wrong things, describing and mis-emphasizing different kinds of policies. It should also be clear from this paper that quantitative methods are not beyond our grasp for dealing with the modeling, measurement and experimental design issues raised by the complexities of real world environments and of individuals, including women, in cities, even though the outline of the models and the experimental designs for their development is not as rigorous mathematically perhaps as our former training and ways of analyses might push us to pursue. At this point, the paper suggests it might be better to strike out for informed judgments about broad societal questions related to the welfare of urban population groups such as women, including questions about the complicated connections between the realm of opportunities and the realm of preferences and behaviors of different population groups in general and women in particular. The accent on more informed judgments about complex issues represents a shift from a tendency to emphasize the development of rigorous quantitative methods at the expense of asking less important questions; certainly the kind of approach advocated here raises spectors of far more broadranging societal requirements (such as the control and redesign of the urban environment per se) for handling women's mobility needs, than the narrowminded focus and purely technological solutions to problems of movement which current conceptualizations can propagate.

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TABLES

Table 1

The Distribution of Sample Households and Individuals

in Uppsala, Sweden, 1971 by Life-Cycle Group

Group No.	Characteristics	Number of Sampled Households	Number of Sampled Individuals
1	Head of household 67 or older	47	68
2	Head of household between 50 and 66; no children living at home	51	80
3	Head of household between 18 and 49; single persons only	26	27
4	Head of household between 18 and 49; two person house-hold with no children	51	99
5	Head of household between 18 and 49; at least one adult and at least one child over seven years; no preschool children	62	141
6	Head of household between 18 and 49; at least one adult and at least one child less than five years of age	59	116
TOTALS		296	531

Stop number _______ Did you plan to make this stop when you left home?	Yes No
Means of Travel 1 foot 2 bicycle 3 bus 4 car (driver) 5 car (passenger) 6 taxi 7 moped 8 other __________	
Were you accompanied by someone from your household? Yes No	If yes, by how many? __________
Where did you make this stop? (please give address)	New? ______
When did you arrive at this place? ________ hours	When did you leave this place? ________ hours
What did you do at this place? 1) ______	Expenditure ______
2) ______	______
3) ______	______
4) ______	______

Stop number _______ Did you plan to make this stop when you left home?	Yes No
Means of Travel 1 foot 2 bicycle 3 bus 4 car (driver) 5 car (passenger) 6 taxi 7 moped 8 other __________	
Were you accompanied by someone from your household? Yes No	If yes, by how many? __________
Where did you make this stop? (please give address)	New? ______
When did you arrive at this place? ________ hours	When did you leave this place? ________ hours
What did you do at this place? 1) ______	Expenditure ______
2) ______	______
3) ______	______
4) ______	______

Is this trip continued on the next sheet? Yes No
If, No, fill in the section below.

/hen did you return to home? __________ hours	
'leans of 'avel 1 car 2 bicycle 3 bus 4 car (driver) 5 car (passenger) 6 taxi 7 moped 8 other ________	
'ere you accompanied by meone from your household? Yes No	If yes, by how many? ________

Table 2

Page from Individual's Travel Diary, Uppsala, Sweden

Table 3

Frequency Distributions of r Values

for 34 Individuals in Uppsala Subsample

A. All Aspect Pairs, All Individuals

|r| Value	Number	Relative Frequency (F)	$\bar{F}^a$	V_F^a
0 to .24	260	.36	.37	.45
.25 to .49	192	.27	.27	.47
.50 to .74	179	.25	.25	.51
.25 to .99	83	.12	.12	.83

B. Separate Aspect Pairs, All Individuals

1. Mode / Time of Arrival

r Value	Number	Relative Frequency (F)	$\bar{F}^b$	V_F^b
-1.00 to -.01	6	.18	.06	7.83
-.50 to -.01	5	.15		
.00 to .49	19	.55		
.49 to 1.00	4	.12		

2. Mode / Land Use

r Value	Number	Relative Frequency (F)	$\bar{F}^b$	V_F^b
-1.00 to -.51	0	0	.43	.86
-.50 to -.01	5	.15		
.00 to .49	12	.35		
.49 to 1.00	17	.50		

3. Mode / Activity

r Value	Number	Relative Frequency (F)	$\bar{F}^b$	V_F^b
-1.00 to -.51	7	.21	-.12	-3.52
-.50 to -.01	12	.35		
.00 to .49	14	.41		
.49 to 1.00	1	.02		

4. Mode / EW Location Coordinate

r Value	Number	Relative Frequency (F)	$\bar{F}^b$	V_F^b
-1.00 to 0.51	11	.32	-.07	-7.83
-.50 to -.01	7	.21		
.00 to .49	9	.26		
.49 to 1.00	7	.21		

(cont.)

5. Mode / NS Location Coordinate

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	8	.24	-.06	-8.88
-.50 to -.01	11	.32		
.00 to .49	9	.26		
.49 to 1.00	6	.18		

6. Mode / Distance

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	0	0	.60	.38
-.50 to -.01	0	0		
.00 to .49	10	.29		
.49 to 1.00	24	.71		

7. Time / Land Use

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	2	.05	-.03	-11.22
-.50 to -.01	16	.47		
.00 to .49	15	.44		
.49 to 1.00	1	.02		

8. Time / Activity

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	15	.44	-.38	-1.08
-.50 to -.01	15	.44		
.00 to .49	2	.06		
.49 to 1.00	2	.06		

9. Time / EW Location Coordinate

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	12	.35	-.19	-2.71
-.50 to -.01	10	.29		
.00 to .49	8	.24		
.49 to 1.00	4	.18		

10. Time / NS Location Coordinate

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	2	.06	-.04	-8.87
-.50 to -.01	13	.38		
.00 to .49	9	.26		
.49 to 1.00	10	.29		

(cont.)

11. Time / Distance

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	2	.05	-.04	-8.87
-.50 to -.01	14	.41		
.00 to .49	18	.52		
.50 to 1.00	0	.00		

12. Land Use / Activity

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	2	.05	-.01	-20.90
-.50 to -.01	14	.41		
.00 to .49	18	.53		
.50 to 1.00	0	.00		

13. Land Use / EW Location Coordinate

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	8	.24	-.15	-2.87
-.50 to -.01	12	.35		
.00 to .49	13	.38		
.50 to 1.00	1	.02		

14. Land Use / NS Location Coordinate

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	.15	.15	-.04	-10.11
-.50 to -.01	.41	.41		
.00 to .49	.32	.32		
.50 to 1.00	.11	.11		

15. Land Use / Distance

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	1	.03	.32	.94
-.50 to -.01	1	.03		
.00 to .49	24	.71		
.50 to 1.00	8	.24		

16. Activity / EW Location Coordinate

r Value	Number	Relative Frequency (F)	F^b	V_F^b
-1.00 to -.51	8	.24	.04	12.82
-.50 to -.01	7	.21		
.00 to .49	10	.29		
.50 to 1.00	9	.26		

(cont.)

17. Activity / NS Location Coordinate

r Value	Number	Relative Frequency (R)	$\bar{F}^b$	V_F^b
-1.00 to -.51	10	.29	-.04	-7.44
-.50 to -.01	7	.21		
.00 to .49	9	.26		
.50 to 1.00	8	.23		

18. Activity / Destination

r Value	Number	Relative Frequency (R)	$\bar{F}^b$	V_F^b
-1.00 to -.51	2	.05	.25	2.41
-.51 to -.01	17	.50		
.00 to .49	14	.41		
.50 to 1.00	1	.03		

19. NS Location Coordinate / Distance

r Value	Number	Relative Frequency (R)	$\bar{F}^b$	V_F^b
-1.00 to -.51	7	.21	-.13	-3.49
-.51 to -.01	16	.47		
.00 to .49	7	.21		
.50 to 1.00	4	.12		

20. EW Location Coordinate / Distance

r Value	Number	Relative Frequency (R)	$\bar{F}^b$	V_F^b
-1.00 to -.51	7	.21	-.01	-36.71
-.51 to -.01	12	.35		
.00 to .49	7	.21		
.50 to 1.00	8	.24		

a $\bar{F}$ is the mean relative frequency of $|r|$ values in each class, and V_F the coefficient of variation of the relative frequency of r values in each class, over all individuals.

b $\bar{F}$ is the mean of the r value for the aspect pair, and V_F its coefficient of variation, for the individuals.

Table 4

Large-Sample Experimental Design: Effects of

Space-Time Constraints and Role-Related Sociodemographics on Travel

Space-Time Constraints[a] Categories	Sociodemographic Role Descriptors						
	Role Categories	Class Categories Income Group	Family Categories				Gender
			Life Cycle	Employment Status	Marital Status		
#1 Categories #2 Categories . . . . #n Categories	Entries in cells: measures of individual's complex daily travel[b]						

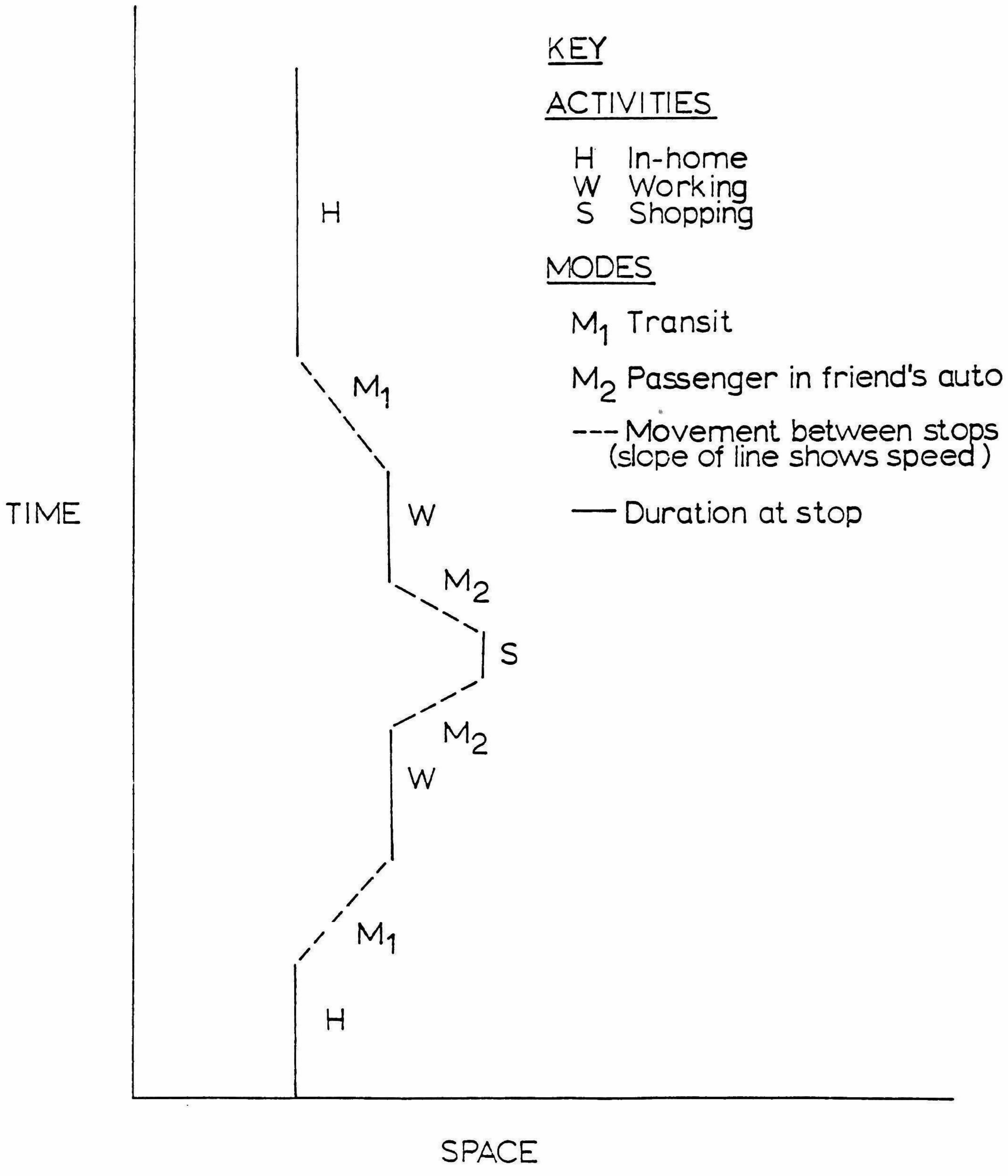
a. Space-Time Constraints include: distance/travel time from home to nearest bus stop; distance;travel time from workplace to nearest bus stop; number of different establishments, for each of 37 types, within given space and time intervals from home; same from work.

b. Measures of Complex Travel include: total travel distance/time for day; total stops for a day; # different modes used; # different land use types used; average interbase trip length.

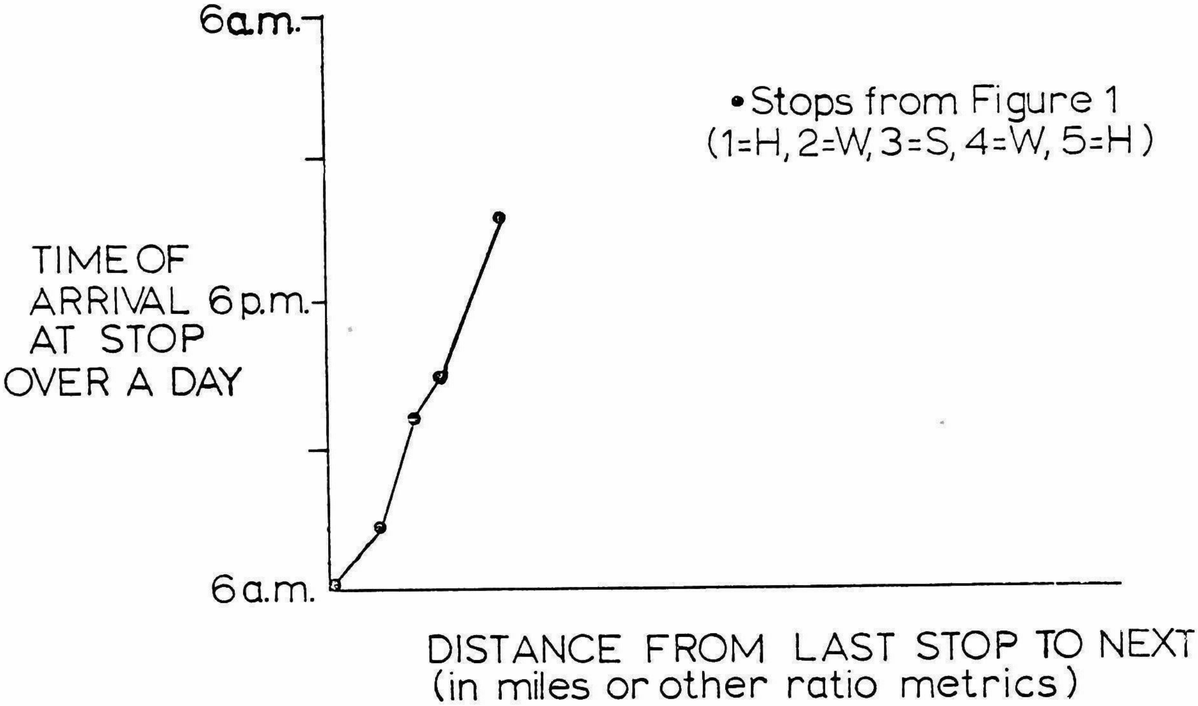
Note: The Uppsala data set contains approximately 20,000 records of individual daily travel for persons of all race, income and family categories; the Baltimore data set contains approximately 500 records for all married, middle income, full-time employed, married men and women, and the West Berlin data set contains approximately 7,100 records for the same kind of population. In the latter two cases, to increase expected cell frequencies, factor analysis of individual space-time constraints data might be performed to reduce the number of space-time dimensions and categories.

FIGURES

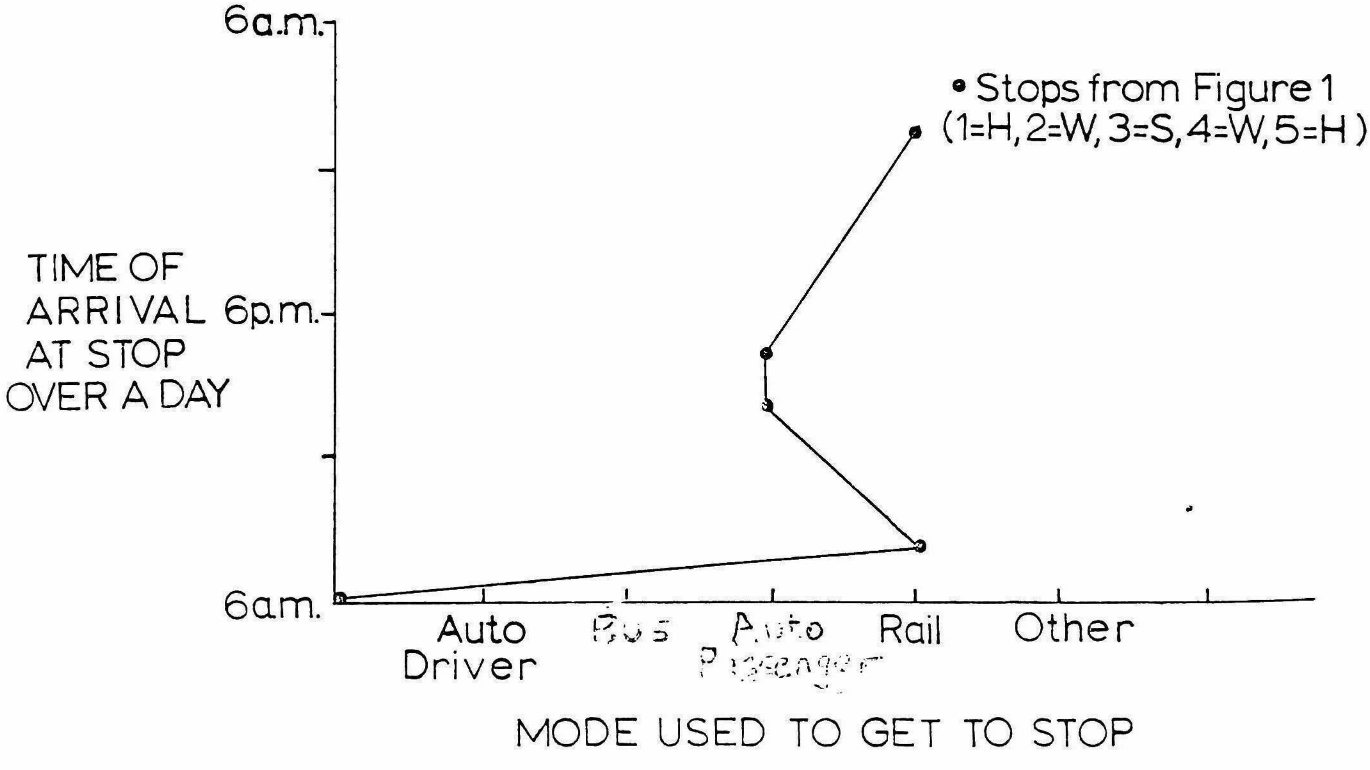
List of Figures

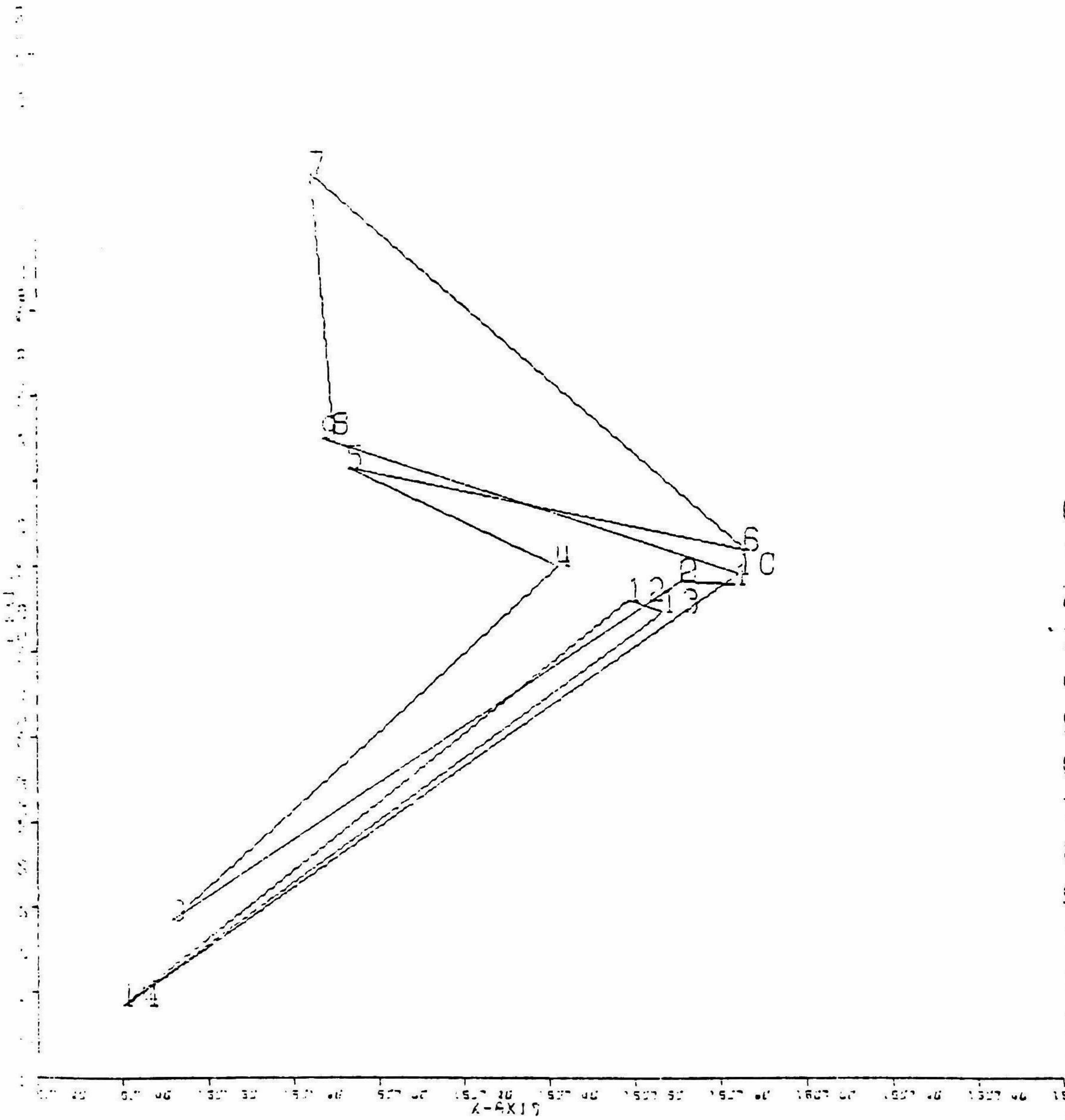

KEY
ACTIVITIES
H In-home
W Working
S Shopping
MODES
M1 Transit
M2 Passenger in friend's auto
--- Movement between stops (slope of line shows speed)
— Duration at stop
TIME
SPACE
H
M1
W
M2
S
M2
W
M1
H

A.


6a.m.
• Stops from Figure 1
(1=H, 2=W, 3=S, 4=W, 5=H)
TIME OF
ARRIVAL 6 p.m.
AT STOP
OVER A DAY
6 a.m.
DISTANCE FROM LAST STOP TO NEXT
(in miles or other ratio metrics)

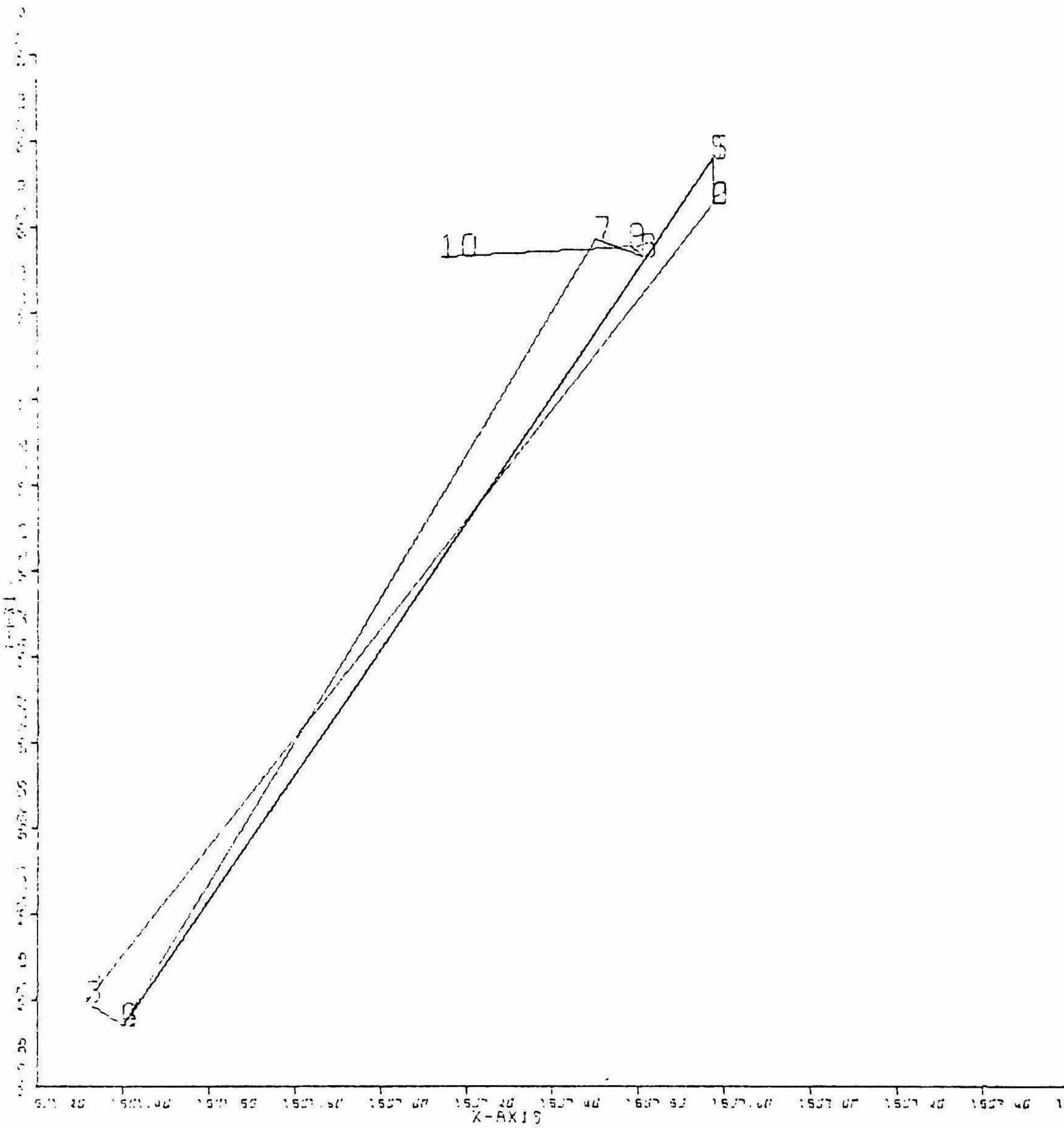
B.


6a.m.
• Stops from Figure 1
(1=H, 2=W, 3=S, 4=W, 5=H)
TIME OF
ARRIVAL 6p.m.
AT STOP
OVER A DAY
6a.m.
Auto
Driver
Bus
Auto
Rail
Other
MODE USED TO GET TO STOP



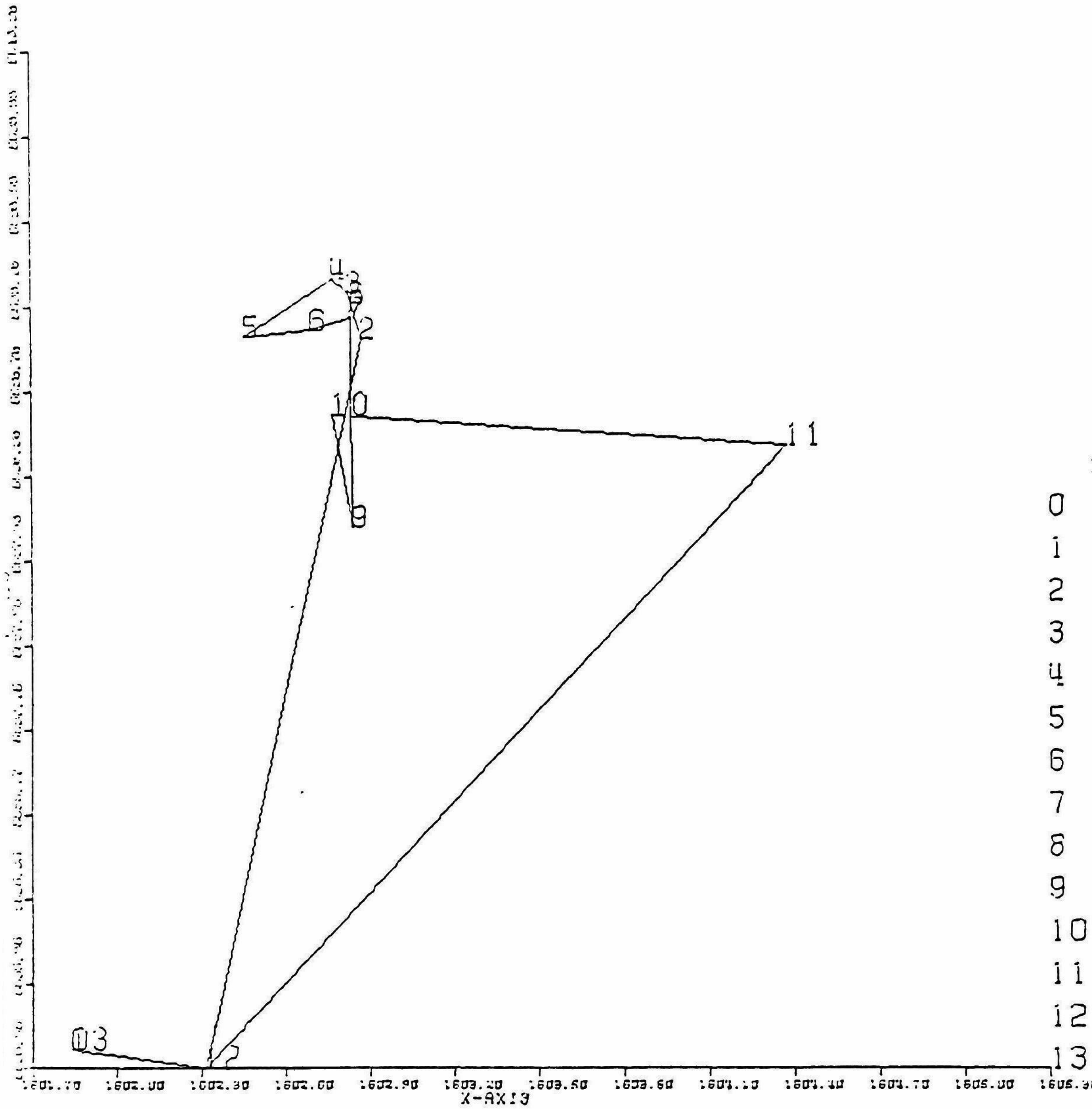
	X-COOR	Y-COOR
0	1602 71	6639
1	1602.83	6639.
2	1602.71	6639.
3	1601.51	6637.
4	1602 42	6639
5	1601.93	6639
6	1602.65	6639.
7	1601.64	6641.
6	1601 89	6639.
9	1601.87	6639.
10	1602.84	6639.
11	1601.40	6637.
12	1602.58	6639.
13	1602.66	6638.
14	1601.40	6637.

4②052 31 F



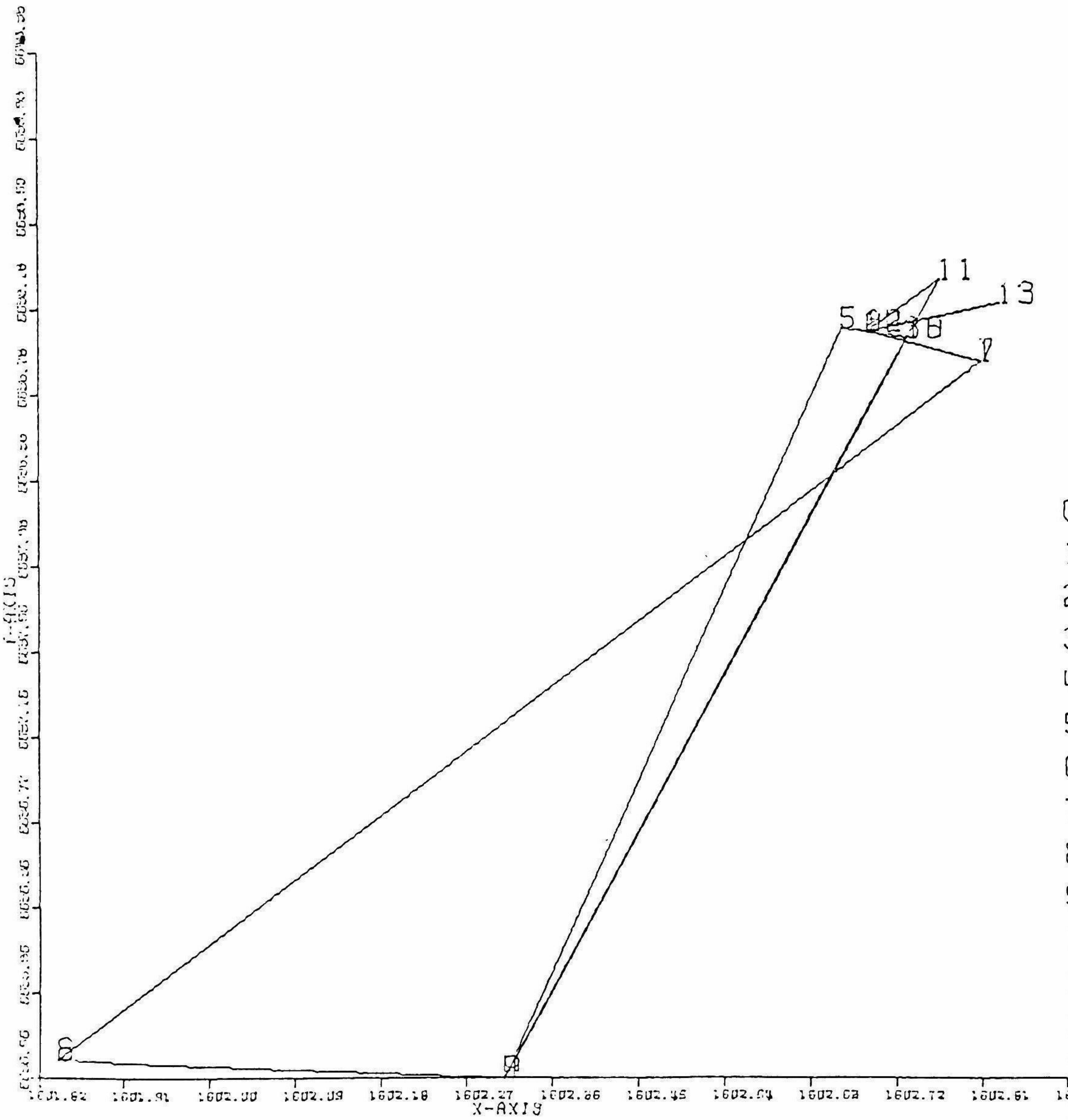
	X-COOR	Y-COOR
0	1602.76	6639.
1	1602.78	6639.
2	1602.78	6639.
3	1601 31	6637.
4	1601.40	6637.
5	1602.78	6639.
6	1601.40	6637.
7	1602.50	6638.
8	1602 61	6638.
9	1602.58	6638.
10	1602.14	6638.

42051 18 M



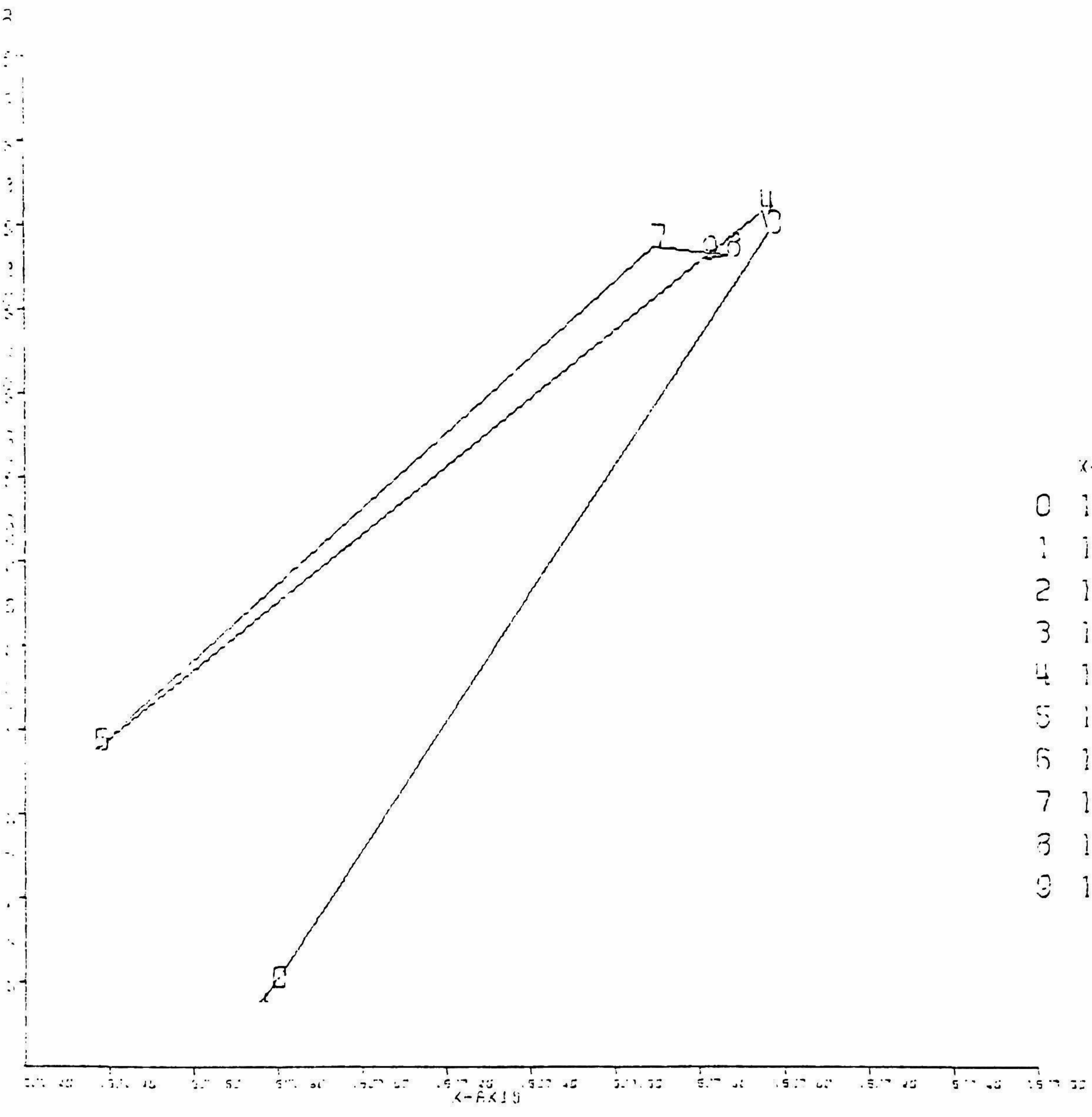
	X-COOR	Y-COOR
0	1601.84	6635.6
1	1602.31	6635.5
2	1602.87	6639.0
3	1602.82	6639.2
4	1602.77	6639.3
5	1602.46	6639.0
6	1602.69	6639.0
7	1602.82	6639.1
8	1602.83	6639.2
9	1602.84	6638.1
10	1602.77	6638.6
11	1604.37	6638.5
12	1602.31	6635.5
13	1601.84	6635.6

15142 24 F



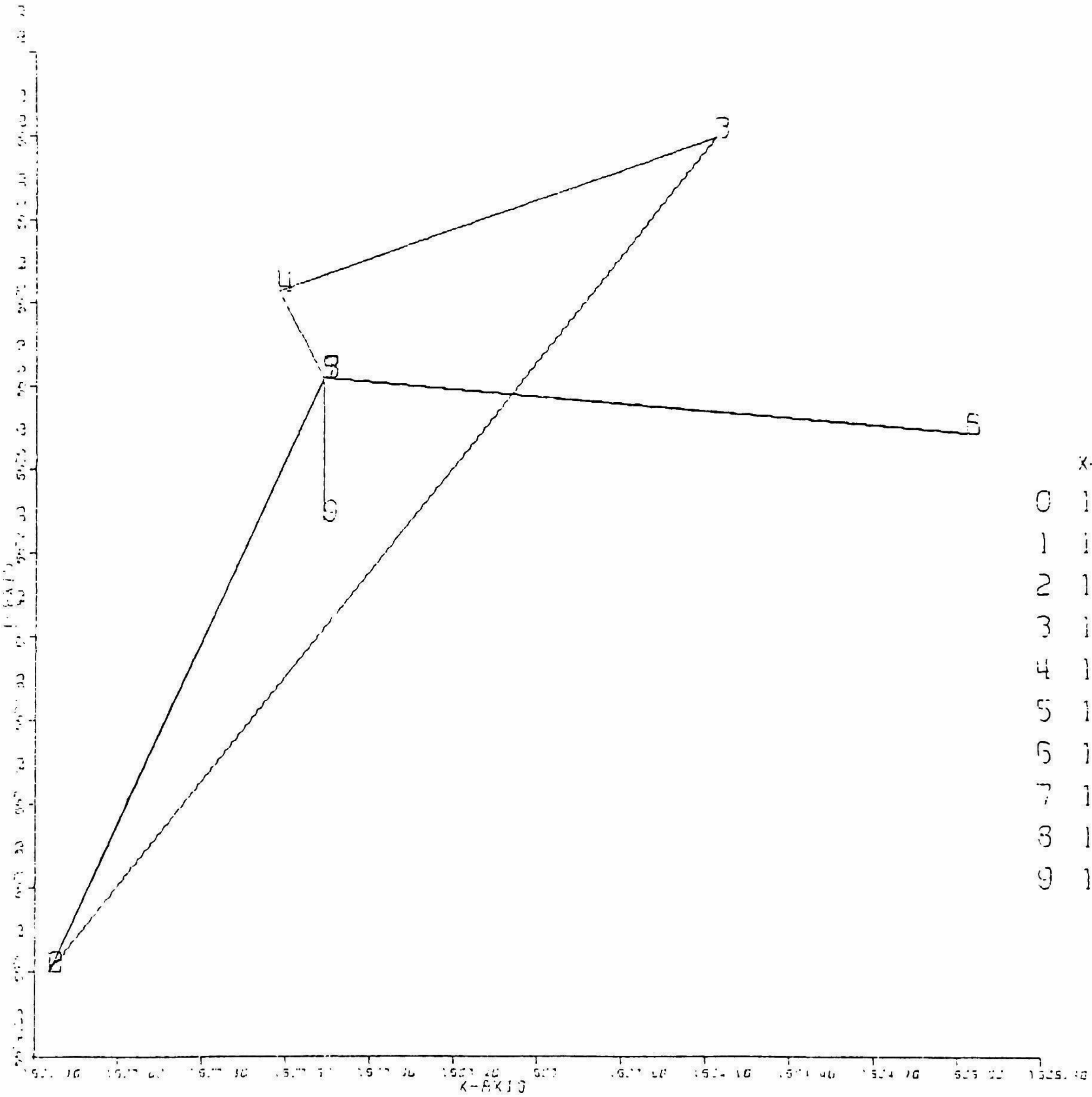
	X-COOR	Y-COOR
0	1602.69	6639.
1	1602.81	6638.
2	1602.69	6639
3	1602.73	6639
4	1602.31	6635.
5	1602.66	6639.
6	1602.69	6639.
7	1602.81	6638.
8	1601.84	6635.
9	1602.31	6635.
10	1602.73	6639.
11	1602.77	6639.
12	1602.69	6639.
13	1602.83	6639.
14	1602.69	6639.
15	1602.73	6639.

15141 9 M



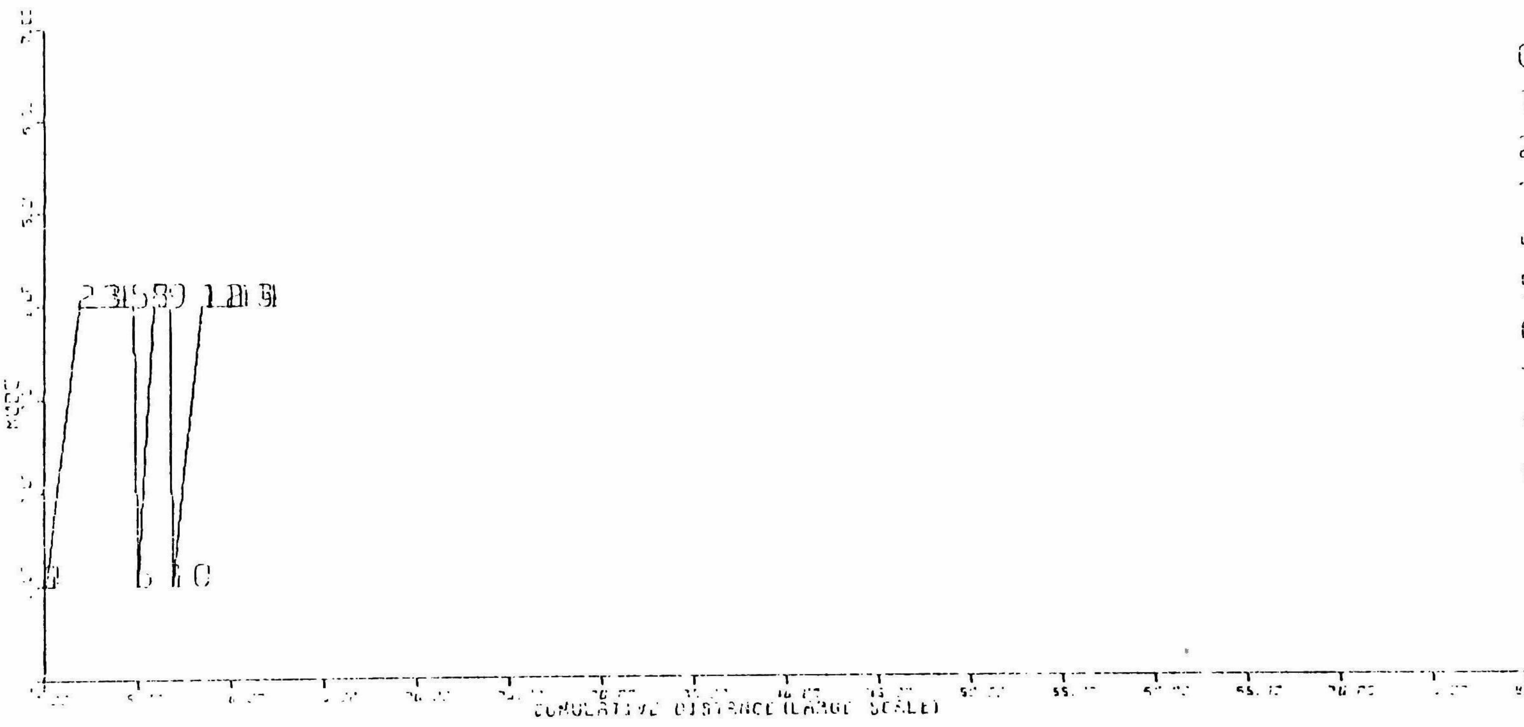
	X-COOR	Y-COOR
0	1601.79	6635.3
1	1601 75	6635.4
2	1601 79	6635 5
3	1602 06	6639 1
4	1602.95	6639 2
5	1601.37	6635.5
6	1601.37	6635 6
7	1602 69	6639 0
8	1602 87	6639.0
9	1602 81	6639.0

46072 11 F



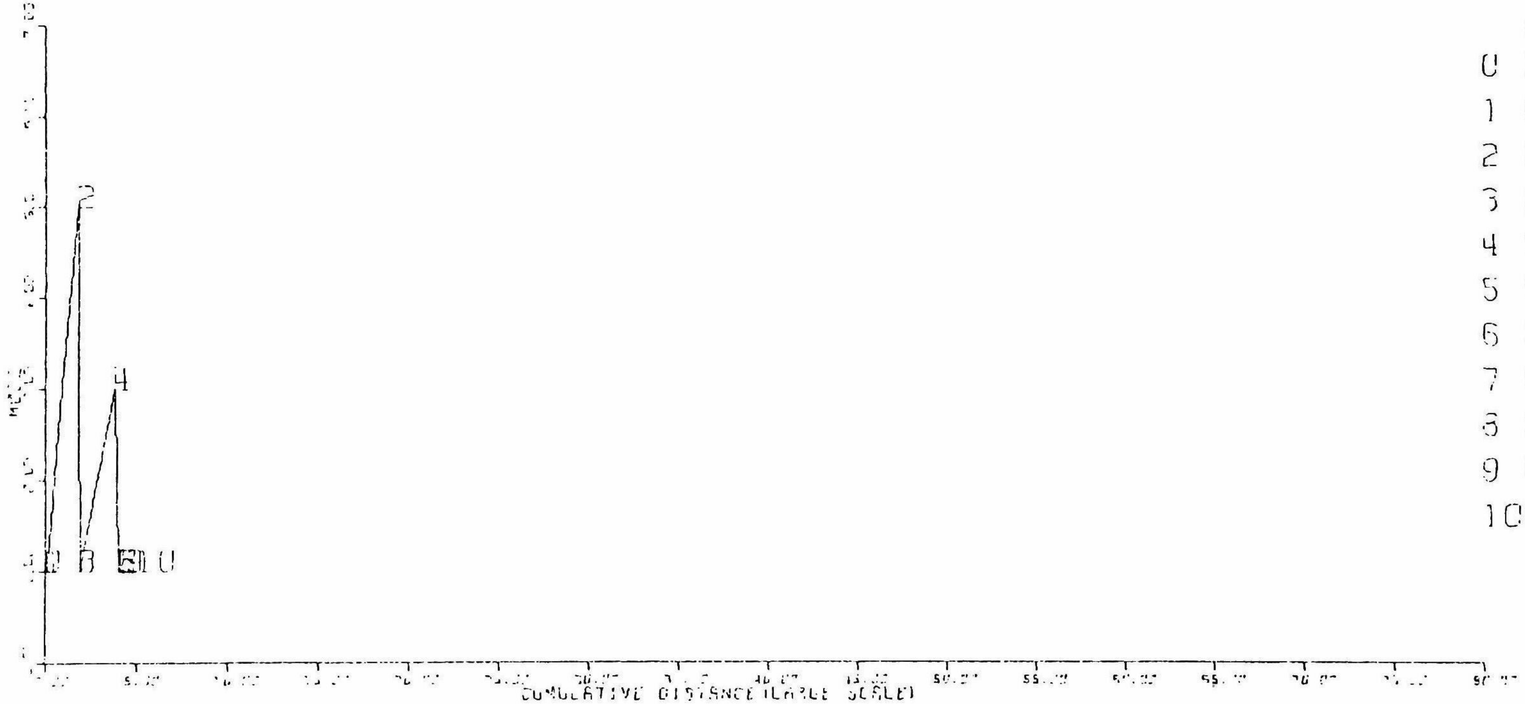
	X-COOR	Y-COOR
0	1601 75	6635
1	1602.73	6639
2	1601.75	6635.
3	1604.15	6640.
4	1602 57	6639.
5	1602.73	6639.
6	1605.04	6636.
7	1602.73	6639.
8	1602.73	6639.
9	1602 73	6636.

46071 37 M



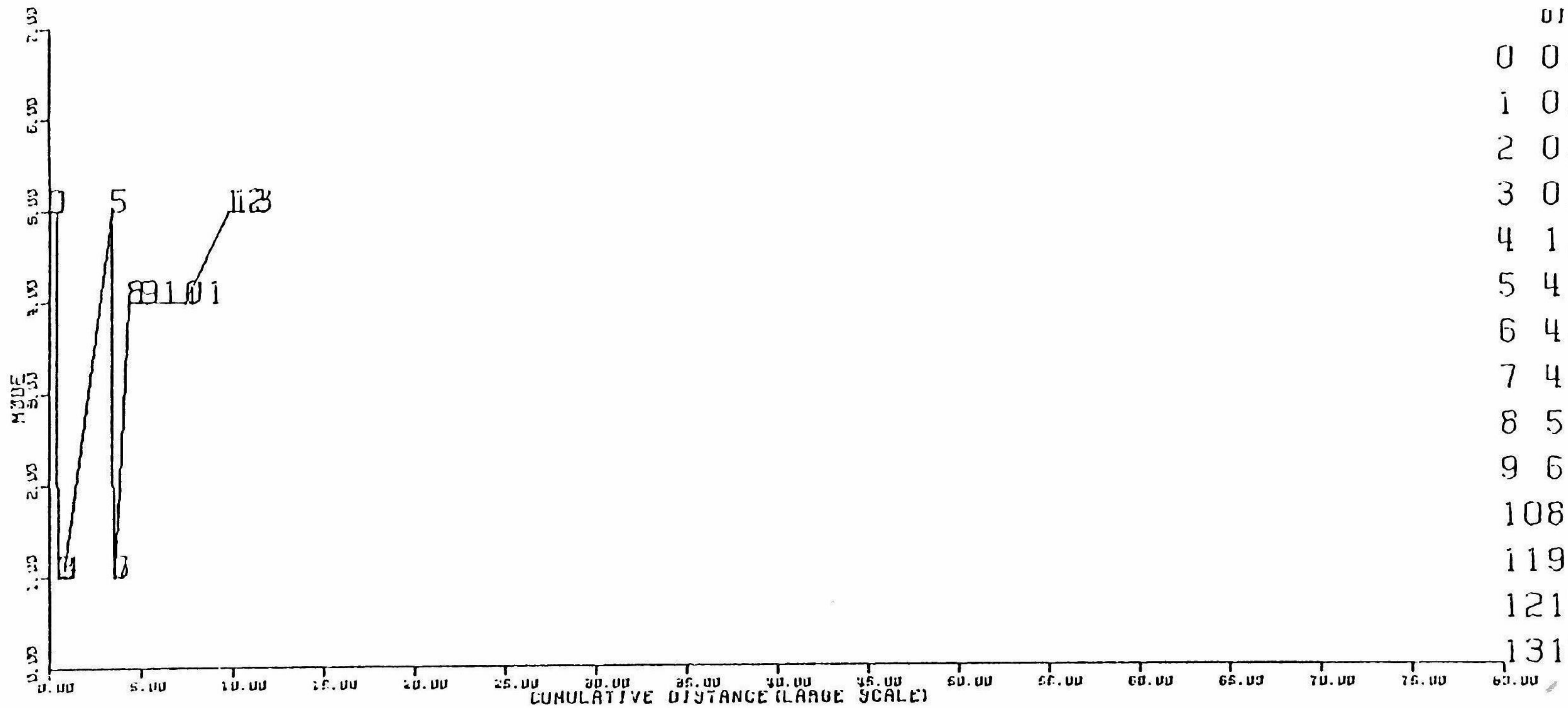
	DISTANCE	[illegible]
0	0.00	1.00
1	0.13	1.00
2	2.50	4.00
3	4.33	4.00
4	5.07	4.00
5	6.45	4.00
6	6.61	1.00
7	7.[illegible]	4.00
8	7.67	4.00
9	9.03	4.00
10	9.15	1.00
11	11.38	4.00
12	11.45	4.00
13	13.71	4.00
14	14.12	4.00

40 2 31 F



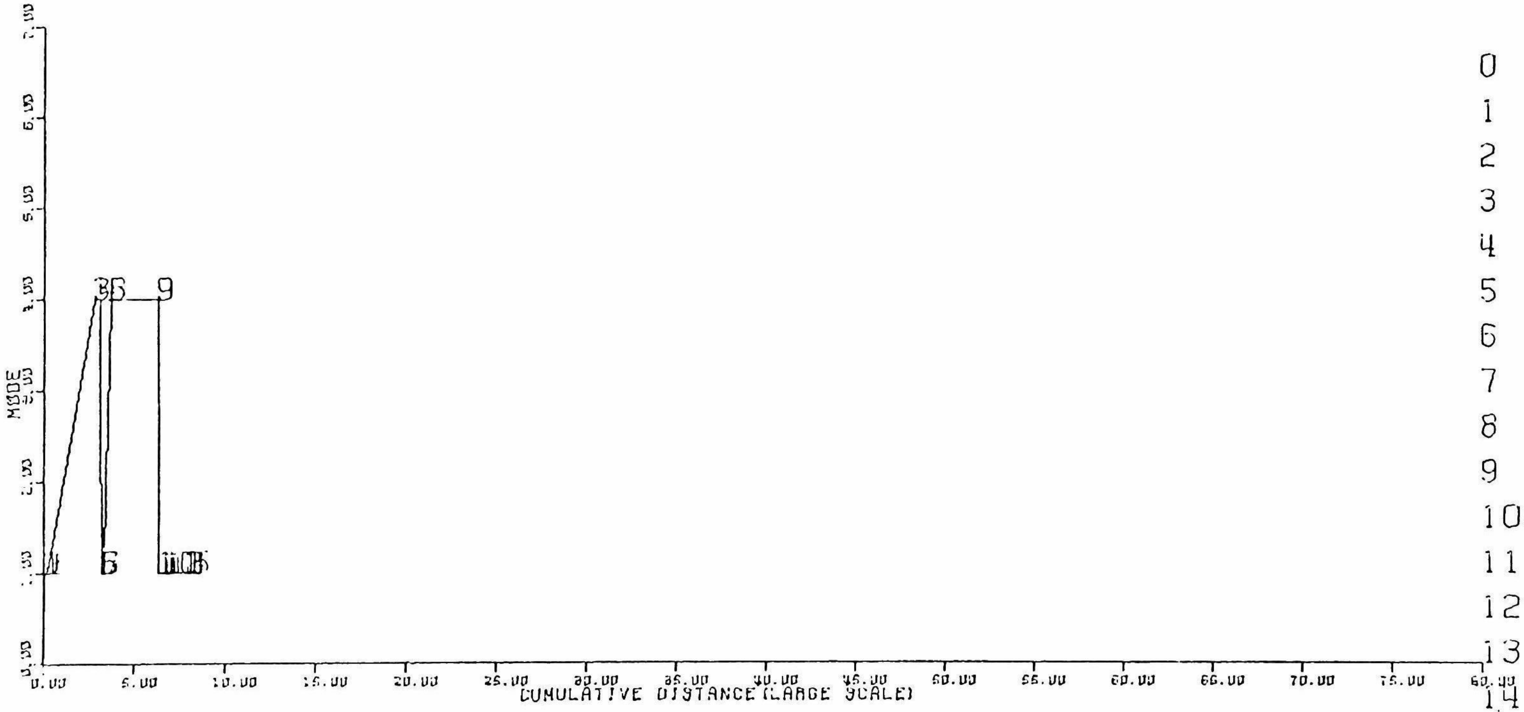
	DISTANCE	MODE
0	0.00	1 00
1	0.11	1 00
2	2.46	5.00
3	2.57	1.00
4	5.01	3.00
5	5.34	1.00
6	5.44	1.00
7	5.55	1.00
8	5.59	1 00
9	6.03	1 00
10	6.71	1 00

4(2)051 18 M



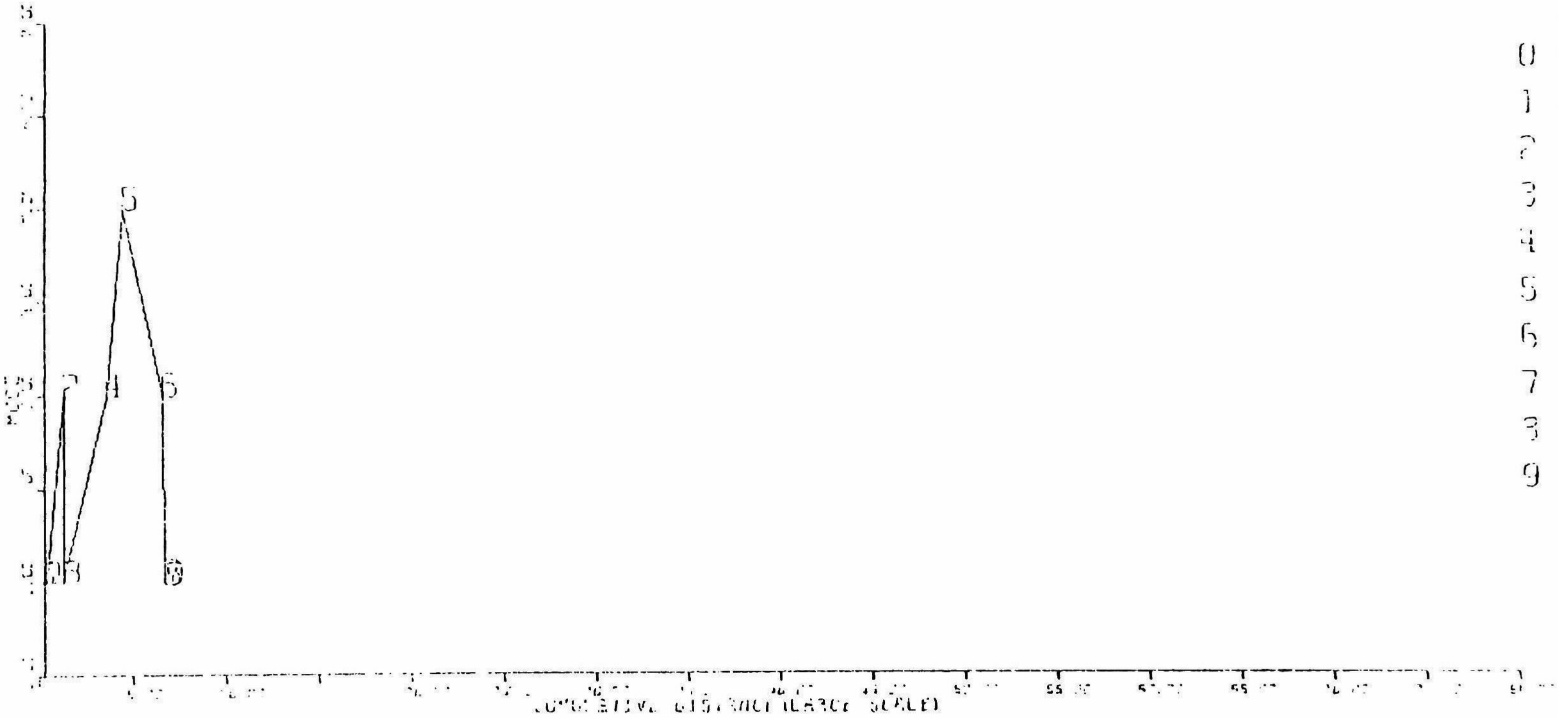
	DISTANCE	MODE
0	0.00	5.00
1	0.48	5.00
2	0.70	1.00
3	0.78	1.00
4	1.04	1.00
5	4.49	5.00
6	4.63	1.00
7	4.70	1.00
8	5.76	4.00
9	6.73	4.00
10	8.34	4.00
11	9.93	4.00
12	13.05	5.00
13	13.52	5.00

1(5)142 24 F



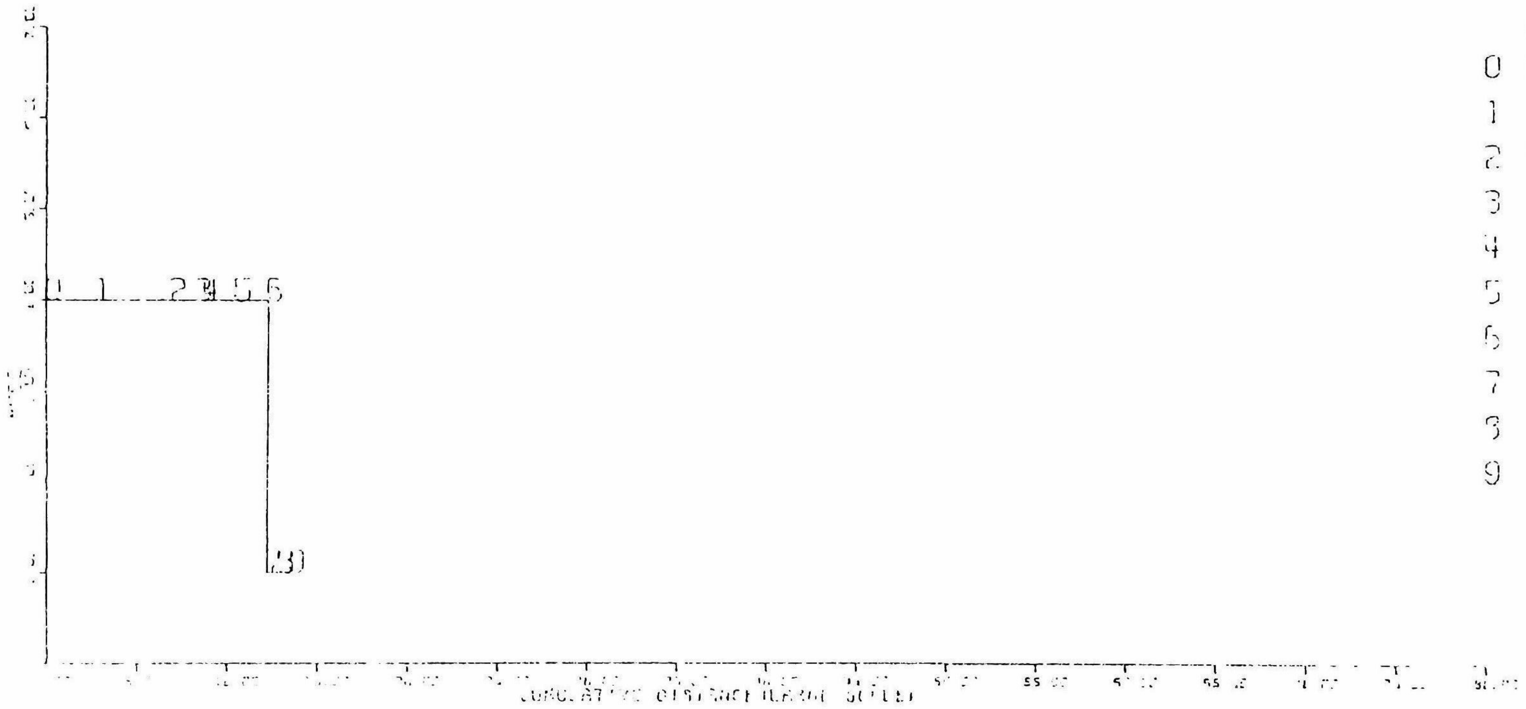
	DISTANCE	NODE
0	0.00	1.00
1	0.18	1.00
2	0.23	1.00
3	3.71	4.00
4	4.19	4.00
5	4.22	1.00
6	4.40	1.00
7	4.40	1.00
8	4.88	4.00
9	8.35	4.00
10	8.41	1.00
11	8.65	1.00
12	8.84	1.00
13	9.03	1.00
14	9.08	1.00
15	9.36	1.00

1(5)141 9 M



	DISTANCE	MASS
0	0.00	1.00
1	0.08	1.00
2	1.29	3.00
3	1.39	1.00
4	4.36	3.00
5	5.65	5.00
6	8.37	3.00
7	8.55	1.00
8	8.61	1.00
9	8.80	1.00

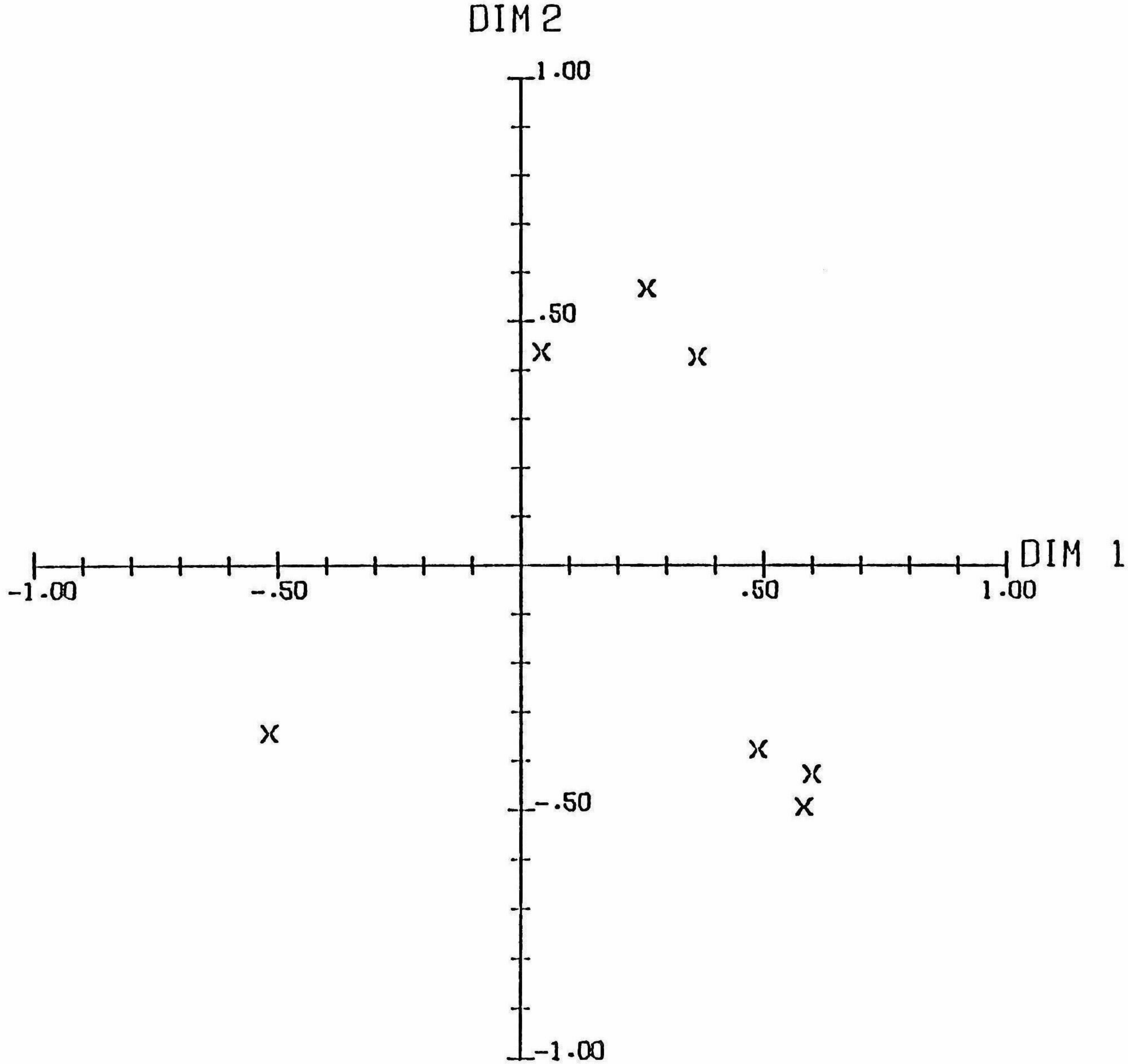
46072 11 F



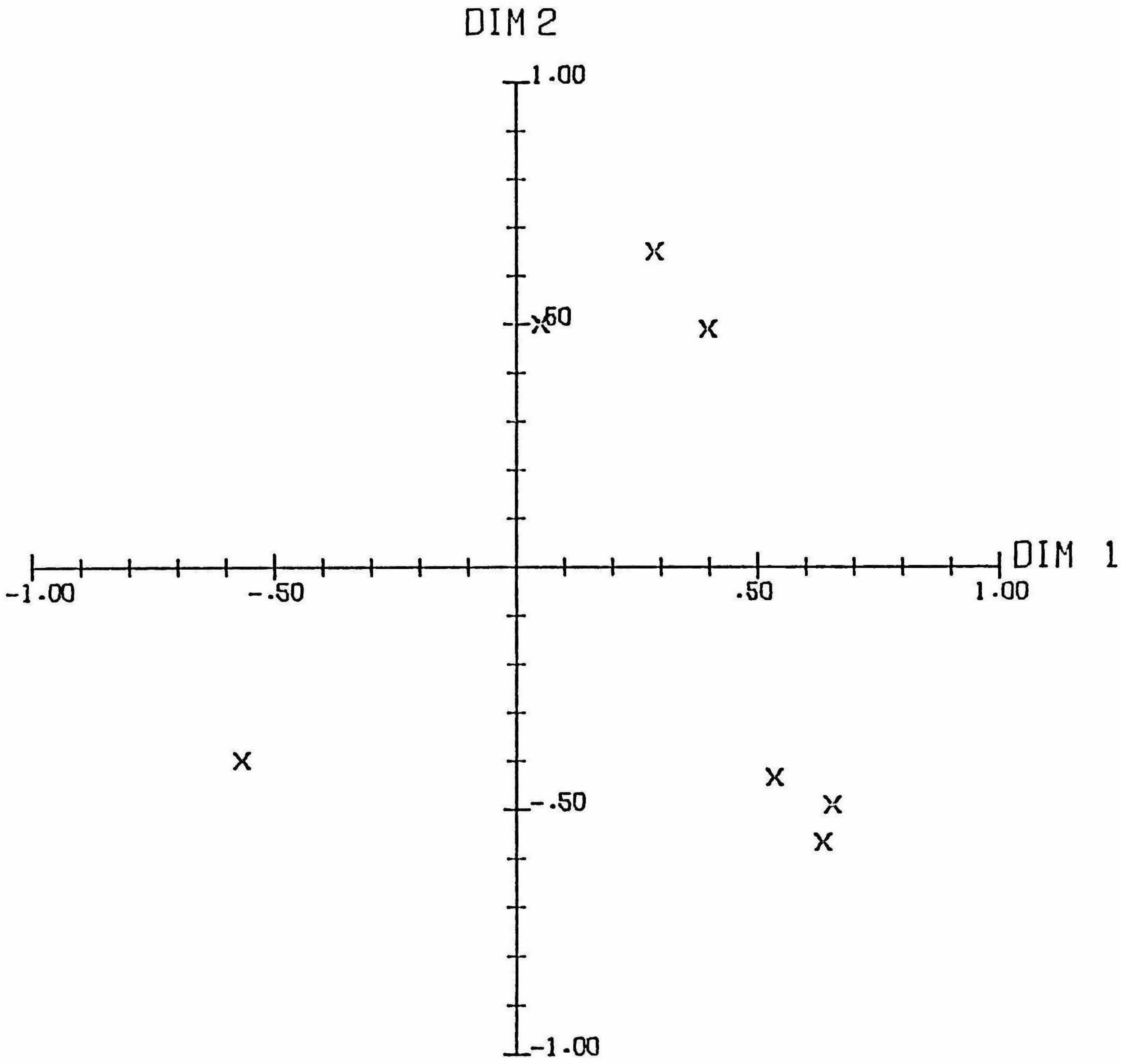
	DISTANCE	MODE
0	0.00	4.00
1	3.66	4 00
2	9.22	4 00
3	11 04	4 00
4	11 59	4 00
5	13.92	4 00
6	15.26	4 00
7	15.26	1 00
8	17.12	1 00
9	17.98	1 00

96071 37 M

2-D AVERAGE SPACE MALES



2-D AVERAGE SPACE FEMALES



2-D COMMON SPASE TOTAL SAMPLE