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The Ohio State University, Ph.D., 1970 Business Administration

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AN EMPIRICAL INVESTIGATION OF MULTIDIMENSIONAL

SCALING AND MULTIDIMENSIONAL UNFOLDING

TO PREDICT BRAND PURCHASING BEHAVIOR

DISSERTATION

Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

By

Reza Moinpour, B.S., M.B.A.

* * * * * *

The Ohio State University 1970

Approved by Adviser Department of

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VITA

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CHAPTER I

INTRODUCTION

Since its emergence almost three decades ago, multidimensional scaling (MDS) techniques have received increased attention by researchers from various fields. A psychometrics procedure, the early contributors were psychologists. Among the most notable are: Torgerson (1952, 1958), Coombs (1950, 1964), Shepard (1962), and Kruskal (1964).

The MDS methodology has been employed in marketing research recently. Its application has been something of a novelty; the state of art is still in its infancy. A proliferation of attempts principally in the area of application have been made. However, only a few published studies in MDS can be found in the marketing literature. The most prominent contributor in MDS, and the man responsible for its introduction to the field of business, has been Green (1968, 1969).

What is MDS

The essence of MDS is the representation of n objects (stimuli) geometrically by n points, such that the interpoint distances (of n points) correspond to the experimental relationships (similarity, dissimilarity or other measures of proximity) between n objects (n(n-1)/2 possible pair comparisons).

¹ Warren S. Torgerson, "Multidimensional Scaling of Similarity," Psychometrika, 30 (December, 1965), pp. 379-82.

The final outcome is a configuration in r-dimensional space that satisfies the above condition. The next objective is to represent the configuration, with minimum loss of information, by as few dimensions as possible, or by a number of dimensions prescribed "a priori."

The interpretation of this configuration in its reduced dimensional space is the analyst's description of the n objects (stimuli) in terms of their characteristics. The configuration, in other words, reveals the underlying structure of the n objects, pointed out by the dimensionality and the dimensions.

Another concept which has become a necessary corollary of MDS is multidimensional unfolding (MDU). While MDS deals with judgments of similarity-perception, MDU has to do with judgments of preferenceattitude. As stated by Coombs:

The basic assumptions of the theory of preferential choice on which the unfolding technique in one dimension is based are as follows: Each individual and each stimulus may be represented by a point on a common dimension called a J scale, and each individual's preference ordering of the stimuli from most to least preferred corresponds to the ranked order of the absolute distances of the stimulus points from the ideal point, the nearest being the most preferred. The individual's preference ordering is called an I scale and may be thought of as the J scale folded at the ideal point with only the rank order of the stimuli given in order of increasing distance from the ideal point. The data consists of a set of I scales from a number of individuals, and the analytical problem is how to unfold these I scales to recover the J scale.²

²Clyde H. Coombs, <u>A Theory of Data</u> (New York: Wiley and Sons, 1964), p. 80.

This basic concept has been generalized by Bennett and Hays for multidimensional unfolding. Given a number of I scales, the objective is locating both individuals and stimuli in a joint space of more than one dimension. Again as stated by Coombs:

The unfolding model in a joint space assumes (1) that the individuals and the stimuli are mapped into points in a common space, (2) that an individual's preference ordering between any two stimuli reflects which stimulus point is nearer his ideal point. . .⁴

Purpose of the Research

There is a tendency to presuppose knowledge of the dimensions of the area being investigated in terms of presumed unidimensional attributes. This approach has been somewhat expedient in the study of customer brand purchasing behavior. It is limited in scope, however, and it can lead to inaccurate results.

This research is designed to study brand purchasing behavior in the decision-making process of self-medication (drug product-line headache and pain remedies). The aim of this investigation is to identify the factors involved and to expose their underlying structure. Multidimensional scaling will be concerned with determining the dimensionality and dimensions of the complex multidimensional behavior in question. This exploration hopes to find answers to the following:

³ Joseph F. Bennett and William L. Hays, "Multidimensional Unfolding: Determining the Dimensionality of Ranked Preference Data," <u>Psychometrika</u>, 25 (March, 1960), pp. 27-43; William L. Hays and Joseph F. Bennett, "Multidimensional Unfolding: Determining Configuration from Complete Rank Order Preference Data," <u>Psychowatrika</u>, 26 (June, 1961), pp. 221-38.

⁴Coombs, "Theory of Data," p. 141.

- 1. How do self-medicators perceive similarities or differences among competing brands?
- 2. How do self-medicators evaluate competing brands?
- 3. Can consumer purchasing behavior be predicted from similarity and preference data, through the use of MDS and MDU.

Findings of the study may also indicate individual differences (the demographic and socio-economic profiles) of the consumers purchasing the various brands included in the research. The notion of individual differences is the subject of a future research project, and it will be fully investigated in a follow-up study.

Goals of the Study

It is generally assumed that when confronted with a choice of an object from a set of objects, an individual's explicit behavior is a manifestation of his implicit comparison of the object set with some "ideal" reference point. It is also apparent that the individual's "ideal" position is a consequence of his perception of the object set, which is in turn influenced by his attitudes toward that set.

The above statements constitute the fundamental aspects of this study which attempts to exhibit a causal attitude-perception-behavior process. Rather than viewing perception and attitude in a broader psychological context, a narrower view is adopted in which both perception and attitude are viewed as being object or product specific.

Thus, it is believed that a consumer's choice of purchase is based on how closely the intended product resembles his "ideal" one. It is also believed that this behavior can be predicted by, "a priori,"

examination of consumer's perception and preference ranking of the avail-

In summary, the objective of this study is twofold. First, it is aimed at examining MDS as a viable technique when dealing with the underlying perceptual and cognitive structures of attitudes and investigating the configuration invariance over different kinds of data. Second, in a broader sense the research investigates the attitude-behavior link suggested in the social psychology literature (Newcomb, Turner and Converse, 1965; ⁵ Lambert and Lambert, 1964; ⁶ and Bem, 1968⁷). In the present study preference as an object-specific measure of attitude is used to predict brand purchasing--an object-specific indicant of behavior.

In addition, it is hoped that upon completion, this project will present a potent methodology to predict market behavior. This methodology will consist of an integrated system of component programs of which the primary ingredients are MDS and MDU algorithms. The MDS algorithms will obtain the perceptual structure, while MDU algorithms will show how this structure can be used to reach the preference.

⁵ Theodore M. Newcomb, Ralph H. Turner and Philip E. Converse, <u>Social Psychology</u> (New York: Holt, Rinehart and Winston, 1965), pp. 67-72.

William W. Lambert and Wallace E. Lambert, <u>Social Psychology</u> (Englewood, New Jersey: Prentice-Hall, 1964), p. 54.

7 Daryl J. Bem, "Attitudes as Self-Description: Another Look at Attitude Behavior Link," in <u>Psychological Foundations of Attitudes</u>, ed. by Anthony G. Greenwald, Timothy C. Brock and Thomas M. Ostrom (New York: Academic Press, 1968), pp. 197-215.

Justification: Application to Consummer Behavior

One of the most interesting developments in marketing in recent years has been the emergence of some scholarly expositions on the subject of consumer behavior. Models of buyer behavior have been constructed in an effort to explain the complex patterns of such behavior (Nicosia, 1966⁸ and Engel, et. al., 1968⁹). Changes in concepts of consumer behavior have occurred with a consideration of a wide range of sociological and psychological constructs (such as motivation, attitude, and perception) as well as the concern for their measurement. In the last decade, abandoning the earlier descriptive approach, the marketing literature has increasingly addressed itself to attempts at a systematic theory of consumer behavior.

Much of the behavior that is of interest to researchers is a consequence of a complex infusion of many variables, and as such it is multidimensional in nature. This reality, however, is often avoided; unidimensional attributes are examined and presumed to reveal the structure of complex phenomena. The unidimensional approach is too limited in its scope, since it fails to obtain a full and accurate description of complex phenomena.

The behavior phenomena under consideration may well be multidimensional in character. MDS provides an understanding of the underlying

Francesco M. Nicosia, <u>Consumer Decision Processes</u> (Englewood, New Jersey: Prentice-Hall, 1966).

James F. Engel, David T. Kollat and Roger D. Blackwell, <u>Consumer</u> <u>Behavior</u> (New York: Holt, Rinehart and Winston, 1968).

cognitive and perceptual structure of the set of stimuli (brand purchasing pattern). It can accomplish this by indicating both the dimensionality and the dimensions of the stimuli set.

Myers and Nicosia (1968) "On the Study of Consumer Typologies," suggest two approaches to classification:

. . . The first consists of postulating one or more qualities or dimensions, chosen on the basis of a theory. . . The second strategy is the opposite of the first, a variety of empirical observations on many subjects are first collected and through computational procedures, some dimensions are identified. . . The dialogue between the researcher's view of the world and its empirical representation is a two-way process.10

Engel, Knapp and Knapp (1967), "The Decision-Making Process in Self-medication and Its Relation to Community Health," propose:

Since there are no intensive studies on the decisionmaking process in self-medication, . . To explore this process and thus lay the foundations for an integrated theory of behavior in this area, it is believed that constructing such a theoretical model previous to the research would be premature and probably inaccurate. Thus it is felt that a more empirical and lower-level theoretical approach is more appropriate at this time (cf., Katona, 1960).¹¹

The points of view expressed by Nicosia and Engel reinforce this writer's implementation of MDS. This strategy, at the outset, explains rather than predicts. It proposes to investigate the underlying structure of the phenomena, and to provide insight into the dimensionality and understanding of the dimensions involved. It can be predictive, however,

10 John G. Myers and Franscisco M. Nicosia, "On the Study of Consumer Typologies," Journal of Marketing Research, 5 (May, 1968), pp. 182-3.

11 James F. Engel, David A. Knapp and Deanne E. Knapp, "The Decision-Making Process in Self-Medication and its Relation to Community Health," The Ohio State University, 1967 (mimeographed), p. 9.

when it comes to testing the reliability of the model and the validity of its results in terms of predicting customer purchases.

Moreover, it is believed that the proposed methodology can provide meaningful insight in such areas as market segmentation (MDS-individual differences in perception), product life cycle (MDS overtime), brand image and share (MDU-"ideal" point), advertising evaluation (MDU-"ideal" point). In addition, this methodology can be used as a management decision tool and a guide to research in both finding new markets and providing new products.

CHAPTER II

REVIEW OF THE LITERATURE

Most of the literature on Multidimensional Scaling can be found in the field of psychology since the early contributions came from Psychometrics. Only recently has this methodology been employed in marketing research.

The existing literature may be classified in many ways. One approach would be to categorize available writings as being methodological in construct, applicational in character, or computer programs.

However, for the purpose of this paper, the field will be divided into three parts: Multidimensional Scaling (MDS), Multidimensional Unfolding (MDU) and models of individual differences, and contributions in business. The existing literature will be surveyed within the above taxonomy. Moreover, in each category both theory and application will be reviewed.

Multidimensional Scaling

Emergence of MDS

Multidimensional Psychophysics received its beginning when Richardson (1938) suggested that psychological judgments are based on a complex of variables. He then proceeded to examine such phenomena in a

more realistic approach of multidimensional nature.¹ His experiment consisted of obtaining scaled judgments of similarity (i.e., psychological "distance") between stimuli using Thurstone's (1927) paired comparison method.² These results were then analyzed by a model developed by Young and Householder (1938) for a solution in n-dimensional space of a set of points (configuration) in terms of their distances.³

A classical application of Young and Householder's model was presented by Klingberg (1941) who employed the technique to examine the structure of friendship among nations. He reported measuring attitudes toward stimuli as psychological distances, using psychometric methods, between any two stimuli in terms of a set of attributes in order to represent the stimuli as points in a multidimensional space.⁴ He suggested that the number of dimensions necessary to construct an accurate configuration, preserving inter-stimulus distances, is also an indicant of the number of factors (attributes) necessary to explain the configuration (attitude space).⁵

The fundamental assumption of Richardson and others, that psychological space is Euclidean in nature, was criticized by Attneave (1950).

1 M. W. Richardson, "Multidimensional Psychophysics," <u>Psychological</u> <u>Eulletin</u>, 35 (October, 1938), pp. 659-60. (Abstract)

²L. L. Thurstone, "A Law of Comparative Judgment," <u>Psychological</u> <u>Review</u>, 34 (July, 1927), pp. 232-7.

³Gale Young and A. S. Householder, "Discussion of a Set of Points in Terms of Their Mutual Distances," <u>Psychometrika</u>, 3 (1938), pp. 19-22.

⁴Frank L. Klingberg, "Studies in Measurement of the Relations Among Sovereign States," <u>Psychometrika</u>, 6 (December, 1941), p. 355.

⁵Ibid., p. 339.

As an alternative, he offered the "city-block" model which suggests that the difference between two stimuli is the arithmetic sum of their projections on each dimension.⁶

Period of Development

Torgerson (1952) improved upon Young and Householder's model by providing a procedure for obtaining the coordinates of stimuli as the projections on axes from the inter-stimulus distances.

Other studies representing both extensions and applications of the Euclidean model were carried out. Notable among such investigations are: A multidimensional examination of attitudes by Abelson (1954);⁸ a procedure for the solution of the additive constant--a problem first considered by Torgerson⁹--by Messick and Abelson (1956);¹⁰ a study by Messick (1956) to examine the dimensionality of a set of perceived attitude relationships;¹¹ and an effort by Jackson, Messick and Solley (1957) to

⁶Fred Attneave, "Dimensions of Similarity," <u>American Journal of</u> <u>Psychology</u>, 63 (October, 1950), p. 521.

Warren S. Torgerson, "Multidimensional Scaling: I. Theory and Method," Psychometrika, 17 (December, 1952), pp. 410-12.

⁸Robert P. Abelson, "A Technique and a Model for Multidimensional Attitude Scaling," <u>Public Opinion Quarterly</u>, 18 (Winter, 1954-1955), pp. 405-18.

⁹Torgerson, "Multidimensional Scaling," p. 403.

¹⁰Samuel J. Messick and Robert P. Abelson, "The Additive Constant Problem in Multidimensional Scaling," <u>Psychometrika</u>, 21 (March, 1956), pp. 1-17.

11 Samuel J. Messick, "The Perception of Social Attitudes," Journal of Abnormal and Social Psychology, 52 (January, 1956), pp. 57-66. investigate the relevance of MDS for the study of perception of personality; they found the method to be appropriate.

Also of importance are three studies by Shepard (1957, 1958) on the relation between generalization and dissimilarity. He regarded dissimilarity as psychological "distance" and suggested that measures of generalization can be interpreted in terms of conditional probabilities of 13 stimuli leading to responses.

In a discussion of MDS models, Torgerson (1958) stated that, regardless of models used, the fundamental concern is essentially the same and is formulated in the following procedure:

Given a set of stimuli which vary with respect to an unknown number of dimensions, determine a) the minimum dimensionality of the set, and b) projections of the stimuli (scale values) on each of the dimensions involved.¹⁴

Torgerson further stipulated that the problem can be viewed theoretically in terms of two distinct models: "A <u>distance model</u> for obtaining distances between all pairs of stimuli, and a <u>spacial model</u>

12 Douglas N. Jackson, Samuel Messick, and C. M. Solley, "A Multidimensional Approach to the Perception of Personality," <u>Journal of</u> <u>Psychology</u>, 44 (October, 1957), pp. 311-18.

¹³Roger N. Shepard, "Stimulus and Response Generalization: A Stochastic Model Relating Generalization to Distance in Psychological Distance," <u>Psychometrika</u>, 34 (December, 1957), pp. 325-45; Roger N. Shepard, "Stimulus and Response Generalization: Tests of a Model Relating Generalization to Distance in Psychological Space," <u>Journal of</u> <u>Experimental Psychology</u>, 55 (June, 1958), pp. 509-35; Roger N. Shepard, "Stimulus and Response Generalization: Deduction of the Generalization Gradient from a Trace Model," <u>Psychological Review</u>, 65 (July, 1958), pp. 242-56.

¹⁴Warren S. Torgerson, <u>Theory and Methods of Scaling</u> (New York: Wiley and Sons, 1958), pp. 247-48.

for obtaining the dimensionality of the space and the projections of the stimulus points on axes of the space."¹⁵ Torgerson also considered the statistical notion of "goodness of fit" which he discussed in terms of goodness of fit of derived distances between stimuli to observed data.¹⁶

Worthy of mention are articles by Indow and Uchizono (1960) and Indow and Kanazawa (1960) dealing with mapping of Munsell Colors. Their inquiry was aimed at evaluating the possibility of representing perceived differences among colors as Euclidean distances.¹⁷ In addition, Abelson and Sermat (1962) employed MDS to identify the emotions displayed in facial expressions.¹⁸

Period of Reconception

With the advent of computers a major contribution has been made by Shepard (1962) who proposed two important notions. First, he introduced as the necessary aspect of the approach the monotonicity requirement. Second, he indicated that the rank order of the dissimilarities are sufficient to determine the final solution; thus eliminating the

¹⁵<u>Ibid</u>., p. 250. ¹⁶<u>Ibid</u>., p. 279.

¹⁷Tarow Indow and Tsukiko Uchizono, "Multidimensional Mapping of Munsell Colors Varying in Hue and Chroma," Journal of Experimental Psychology, 59 (May, 1960), pp. 321-29; Tarow Indow and Kei Kanazawa, "Multidimensional Mapping of Munsell Colors Varying in Hue, Chroma and Value," Journal of Experimental Psychology, 59 (May, 1960), pp. 330-36.

18 Robert P. Abelson and Vello Sermat, "Multidimensional Scaling of Facial Expressions," Journal of Experimental Psychology, 63 (June, 1962), pp. 545-54. previously existed need of a "distance function" to convert implicit 19 proximity measures to explicit distances.

The objectives of Shepard's iterative procedure which are carried out by a computer program are:

- a) minimum number of dimensions of the Euclidean space required such that the distances in this space are monotonically related to the initially given proximity measures,
- b) an actual set of orthogonal coordinates for the points in this minimum space, and
- c) a plot showing the true shape of the initially unknown function relating proximity to distance.²⁰

Shepard also pointed out that monotonicity can provide an indicator for determining the appropriate minimum dimensionality of the final solution.²¹ In a subsequent paper, Shepard (1962) presented results of some tests employing his computer program for MDS which is capable of handling non-metric data.²²

However, it was Kruskal (1964) who gave monotonicity primary importance as a criterion in his MDS technique which was an attempt to improve upon Shepard's procedure. Kruskal viewed MDS as a statistical regression analysis of fitting dissimilarities and distances in the configuration. The technique is essentially one of performing a monotone regression of distance upon dissimilarity for a given configuration.

²²Roger N. Shepard, "The Analysis of Proximities: Multidimensional Scaling with an Unknown Distance Function, 2," <u>Psychometrika</u>, 27 (September, 1962), pp. 219-46.

¹⁹Roger N. Shepard, "The Analysis of Proximities: Multidimensional Scaling with an Unknown Distance Function, 1," <u>Psychometrika</u>, 27 (June, 1962), pp. 128-34.

²⁰<u>Ibid.</u>, p. 128. ²¹<u>Ibid.</u>, pp. 137-8.

The residual variance, called "stress," indicates the goodness of fit 23 between configuration and data.

In Kruskal's own terminology:

Stress = S =
$$\begin{bmatrix} \sum_{i < j} (d_{ij} - \hat{d}_{ij})^2 \\ \vdots \\ \sum_{i < j} d_i \\ i < j \quad ij \end{bmatrix}^{\frac{1}{2}}$$

Where the d_{ij} denote the distance from x_i to x_j If x_i is expressed in Orthogonal Coordinates by $x_i = (x_{i1}, \dots, x_{i5}, \dots, x_{it}),$

then we have:

$$d_{ij} = \begin{bmatrix} t \\ \sum_{s=1}^{\infty} (x_{is} - x_{js})^2 \end{bmatrix}^{\frac{2}{2}}$$

And the \hat{d}_{ij} are a monotone sequence of numbers which minimize $S.^{24}$

This procedure can be generalized to non-Euclidean space such as Minkowski r-matrics.²⁵ In a companion paper, Kruskal (1964) described a numerical method and a computer program to handle his procedure.²⁶ The combined works of Shepard and Kruskal are often referred to as Shepard-Kruskal algorithm.

²⁶Joseph B. Kruskal, "Nonmetric Multidimensional Scaling: A Numerical Mathod," Psychometrika, 29 (June, 1964), pp. 115-29.

²³ Joseph B. Kruskal, "Multidimensional Scaling by Optimizing Goodness of Fit to a Nonmetric Hypothesis," <u>Psychometrika</u>, 29 (March, 1964), pp. 2-10.

²⁴Ibid., p. 9. ²⁵Ibid., p. 23.

Other articles of methodological importance include those by Carroll and Chang (1964) and Miller, Shepard and Chang (1964) dealing with finding interpretable directions in psychological "space."²⁷ Also of interest are two problems considered by Cliff (1966). He presented procedures for rotating two factor solutions orthogonally until they reach a similar position, and rotating a factor matrix orthogonally to a specified target matrix.²⁸ In addition, McGee (1966) introduced the notion of elasticity in the monotonic transformation of dissimilarities into distance measures.²⁹

Period of Integration

Although Shepard and Kruskal provided the first computerized iterative programs, others soon followed with new procedures. A notable contribution is that of Guttman and Lingoes (1965).³⁰ Among the first improved formulations is that of Kruskal's (1967) MDS program.³¹ In

²⁷ J. Douglas Carroll and Jih-Jie Chang, "A General Index of Nonlinear Correlation and its Application to the Interpretation of Multidimensional Scaling Solutions," <u>American Psychologist</u>, 29 (July, 1964), p. 540; Joan E. Miller, Roger N. Shepard, and Jih-Jie Chang, "An Analytical Approach to the Interpretation of Multidimensional Scaling Solutions," <u>American Psychologist</u>, 19 (July, 1964), pp. 579-80.

²⁸Norman Cliff, "Orthogonal Rotation to Congruence," <u>Psychometrika</u>, 31 (March, 1966), pp. 33-6.

²⁹Victor E. McGee, "The Multidimensional Analysis of 'Elastic' Distances," <u>The British Journal of Mathematical and Statistical</u> <u>Psychology</u>, 19 (November, 1966), pp. 181-83.

³⁰J. C. Lingoes, "An IBM 7090 Program for Guttman-Lingoes Smallest Space Analysis-I," <u>Behavioral Science</u>, 10 (May, 1965), pp. 183-84.

³¹Joseph B. Kruskal, "Now to Use MDSCAL, A Multidimensional Scaling Program," Bell Telephone Laboratories, Murray Hill, New Jersey, May, 1967. (Mimeographed) addition, there is Torsca - a program for Shepard-Kruskal MDS analysis by Young and Torgerson (1967).³² Also, a program for orthogonal fitting, based on Cliff's orthogonal rotation, has been written by Pennell and Young (1967).³³ Of particular importance are fully integrated programs of Young (1963) - TORSCA-9,³⁴ and Kruskal (1968) - MDSCAL-4M.³⁵ All of these procedures deal with the problem of finding the monotonic transformation that provides a configuration of low dimensionality with a best fit. TORSCA-9 will be discussed more fully later, since it is an integral part of the methodology of this study.

More recent applications and extensions of MDS include a multidimensional scaling of a set of artistic drawings by Skager, Schultz and Klein (1966). They hypothesized relationships between characteristics of drawings and the psychological characteristics of individuals who perceive and prefer them. ³⁶ In addition, there are two studies by Brown

32 Forrest W. Young and Warren S. Torgerson, "TORSCA, A FORTRAN 4 Program for Shepard-Kruskal Multidimensional Scaling Analysis," <u>Behav-</u> ioral Science, 12 (November, 1967), p. 498.

33 Roger J. Pennell and Forrest W. Young, "An IBM System/360 Program for Orthogonal Least Squares Matrix Fitting," <u>Behavioral Science</u>, 12 (November, 1967), p. 165.

34 Forrest W. Young, "TORSCA-9: A FORTRAN 4 Program for Nonmetric Multidimensional Scaling," <u>Behavioral Science</u>, 13 (July, 1968), pp. 343-44.

³⁵Joseph B. Kruskal, "How to Use MDSCAL, a Program to do Multidimensional Scaling and Multidimensional Unfolding (Versions 4 and 4M, all in Fortran 4)," Bell Telephone Laboratories, Murray Hill, New Jersey, March, 1965. (Mimeographed)

³⁶ Rodney W. Skager, Charles G. Schultz, and Stephen P. Klein, "The Multidimensional Scaling of a Set of Artistic Drawings: Perceived Structure and Scale Correlates," <u>Multivariate Behavioral Research</u>, 1 (October, 1966), p. 426.

(1967) and Smith and Siegel (1967) dealing with dimensions and analysis of job settings.

Another study conducted by Boyd and Jackson (1967) examined the perceived structure of social attitudes and personality. They investigated the adequacy of MDS to depict relationships between attitudes and personality.³⁸ Also of interest is an application of MDS technique to judgments of complexity, interestingness and pleasingness by Berlyne, Cgilvie and Parham (1968).³⁹ Another application of MDS to determine the structure of personality impressions is reported by Rosenberg, Melson and Vivekananda (1968).

Brown and Brumaghim (1968) designed a MDS usage for investigation of perceptual equivalence and pattern perception between visual and tactual stimulus.⁴¹ Also, Behrman and Brown (1968) used both metric and nonmetric MDS methods to analyze the psychophysics of visual form

37 K. Q. Brown, "Job Analysis by Multidimensional Scaling," Journal of Applied Psychology, 51 (June, 1967), pp. 469-75; R. J. Smith and A. I. Siegel, "A Multidimensional Scaling Analysis of the Job of Civil Defense Director," Journal of Applied Psychology, 51 (June, 1967), pp. 476-80.

³⁸J. Edwin Boyd and Douglas N. Jackson, "The Perceived Structure of Social Attitudes and Personality: A Multidimensional Scaling Approach," Multivariate Behavioral Research, 2 (July, 1967), pp. 281-2.

39 D. E. Berlyne, J. C. Ogilvie, and L. C. Parham, "The Dimensionality of Visual Complexity, Interestingness and Pleasingness," Canadian Journal of Psychology, 22 (May, 1968), pp. 376-79.

⁴⁰Seymour Rosenberg, Carnot Nelson, and P. S. Vivekananda, "A Multidimensional Approach to the Structure of Personality Impressions," Journal of Personality and Social Psychology, 9 (April, 1968), pp. 283-84.

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41 D. R. Brown and Stanley H. Brumaghim, "Perceptual Equivalence, Pattern, Perception and Multidimensional Methods," Perception and Psychophysics, 4 (April, 1968), pp. 253-54.

perception.⁴² An interesting exposition presented by Cliff and Young (1968) tested the hypothesis that individual's internalized conceptions can be displayed via MDS analysis of his judgments of interstimulus similarity of a set of stimuli. Finally, a most recent report by Ramsay (1969) considers some of the shortcomings of current methods of estimating the perceived differences, and offers suggestions for 44 improvement.

Multidimensional Unfolding and Models of Individual Differences

Individual differences exist in judgment of similarity (perceptual structures) and consequently in judgments of preference (attitude structures) which entail the use of the perceptual structures. Individual differences in preference have often been investigated through unfolding models.

Period of Conceptualization

The unfolding approach was first investigated in a unidimensional form by Coombs (1950, 1954). He postulated that both individuals and stimuli can be positioned along the same joint continuum - <u>J scale</u>. He

⁴²Bruce W. Behrman and D. R. Brown, "Multidimensional Scaling of Form: A Psychophysical Analysis," <u>Perception and Psychophysics</u>, 4 (January, 1968), pp. 19-20.

43 Norman Cliff and Forrest W. Young, "On the Relation Between Unidimensional Judgments and Multidimensional Scaling," <u>Organization</u> Behavior and Human Performance, 3 (March, 1968), pp. 269~85.

⁴⁴J. O. Ramsay, "Some Statistical Considerations in Multidimensional Scaling," <u>Psychometrika</u>, 34 (June, 1969), pp. 167-70.

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also suggested that preferences of subjects for stimuli, in terms of an underlying attribute, is a function of relative positions of stimuli to subjects' "ideal points."⁴⁵ Thus it becomes apparent that given individuals' rank order preferences of a set of stimuli-<u>I scales</u>, one can recover the <u>J scale</u> that generated them in order to study the attribute underlying preferences.

The Coombsian unfolding model was generalized to the multidimensional case by Bennett and Hays (1960). They replaced Coombs' single continuum by an attribute space of r-dimensions. They discussed the dimensionality of ranked order preference data and problems associated with determining a configuration of stimulus-objects.⁴⁷ Their solutions involved representing both the stimuli and subjects as points in the same multidimensional space. However, its limitation is the assumption of a single perceptual structure for all individuals.

Period of Development

Although the work of Bennett and Hays does lead to a theoretical solution, difficulties are encountered when both stimuli and dimensionality of the proposed configuration increase in number. Coombs (1964) recognized this problem and suggested a metric version of his unfolding

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45 Clyde H. Coombs, "Psychological Scaling Without a Unit of Measurement," <u>Psychological Review</u>, 57 (May, 1950), p. 146.

46 Clyde H. Coombs, "A Method for the Study of Interstimulus Similarity," <u>Psychometrika</u>, 191 (September, 1954), pp. 183-84.

47 Bennett and Hays, "Multidimensional Unfolding," pp. 27-43; Hays and Bennett, "Multidimensional Unfolding," pp. 221-38.

technique as an approximation for the nonmetric case.⁴⁸ He defined a "median individual" as a central or an average individual to represent the configuration of individuals containing the attributes which generate their preferences.

Along the same lines Coombs and Kao (1960) suggested factor analysis of the correlation matrix of individuals' ranked preferences which is then compared to the solution obtained from the unfolding technique. They found that multiple factor analysis provides a space of dimensionality which is one greater than that obtained from the unfolding method.⁵⁰ Ross and Cliff (1964) examined the above study and suggested that factor analysis can be used to recover the configuration (of objects and individuals) if squared distances rather than distances between individuals and stimuli are correlated.⁵¹

A somewhat similar approach is the vector model proposed by Tucker (1960). He suggested that different subjects can be represented by different vectors in a multidimensional space which also contain the stimulus-objects. Subject's preference order of stimuli is then obtained by the projection of stimuli on the vector.

⁴⁸Coombs, "Theory of Data," pp. 181-92. ⁴⁹ <u>Ibid.</u>, p. 181. 50

50 Clyde H. Coombs and Richard C. Kao, "On a Connection Between Factor Analysis and Multidimensional Unfolding," <u>Psychometrika</u>, (September, 1960), pp. 219-21.

51 John Ross and Norman Cliff, "A Generalization of the Interpoint Distance Model," <u>Psychometrika</u>, 29 (June, 1964), pp. 167-76.

⁵² Ledgard R. Tucker, "Intra-individual and Inter-individual Multidimensionality," in <u>Psychological Scaling: Theory and Application</u>, ed. by Harold Gullikson and Samuel Messick (New York: Wiley and Sons, 1960), pp. 155-67.

Although it is possible to discover the perceptual space which underlies preference judgments via the above models, total dependence on preference data alone--internal analysis ---fails to uncover the appropriate perceptual structure. To combat this difficulty, the analysis can begin with an "a priori" set of dimensions (obtained from MDS of similarities) as the underlying structure to which preference judgments of individuals are related -- external analysis. The external analysis also called "preference mapping of stimulus space," along with generalization of Coombsian unfolding models has been discussed by Carroll and Chang (1967). They have programmed an algorithm for external analysis of data for a hierarchy of models. The analysis evolves around linear or quadratic regression equations which can be solved, based on either metric or nonmetric assumption of preference values. Their procedure also alleviates the shortcomings of the simple unfolding model by relaxing the rigid assumption of a common perceptual space for all individuals; each individual is allowed to choose a reference frame within 55 that space and to weight or stretch the dimensions differentially. More will be said about this procedure later; for this model is part of the methodology of this study.

⁵³ J. Douglas Carroll, "Individual Differences and Multidimensional Scaling," Bell Telephone Laboratories, Murray Hill, New Jersey, 1969, p. 13. (Mimeographed)

⁵⁵J. Douglas Carroll and Jih-Jie Chang, "Relating Preference Data to Multidimensional Scaling Solutions via a Generalization of Coombs' Unfolding Model," Bell Telephone Laboratories, 1967, pp. 1-18. (Mimeographed)

⁵⁴ Ibid.

As stated previously, it is possible to uncover the stimulus space by an internal analysis of preference values alone. Two promising techniques for recovering the perceptual structure from preference data exist. The first is parametric mapping suggested by Shepard and Carroll (1966). The second procedure, a polynomial factor analysis by Carroll (1969),⁵⁷ contains less general assumptions than parametric mapping.

Models of Individual Differences in Perception

It has been known for some time that different individuals, due to different cognitive structures, may possess different perceptions of a set of stimuli.

The first model of individual difference was proposed by Tucker and Messick (1963). Their procedure utilizes the Eckart and Young (1936) theorems of approximating a matrix by another one of a lower rank. ⁵⁸ Their "point of view analysis" is an attempt to represent separate multidimensional perceptual structures for individuals with different viewpoints about stimulus-objects. ⁵⁹ The method consists of computing an intercorrelation matrix of subjects' similarity judgments which is factor analyzed to yield a space containing clusters of subjects. The procedure is basically a clustering of subjects who

⁵⁶Roger N. Shepard and J. Douglas Carroll, "Parametric Representation of Nonlinear Data Structures," in <u>Multivariate Analysis</u>, ed. by Parachuri R. Kirshnaiah (New York: Academic Press, 1966), pp. 561-92.

⁵⁷Carroll, "Individual Differences," p. 62.

⁵⁸Carl Eckart and Gale Young, "The Approximation of One Matrix by Another of Lower Rank," <u>Psychometrika</u>, 1 (September, 1936), pp. 211-18.

⁵⁹ Ledyard R. Tucker and Samuel Messick, "An Individual Difference Model for Multidimensional Scaling," <u>Psychometrika</u>, 28 (December, 1963), pp. 333-44. share similar viewpoints in homogeneous groups which can then be represented by an "ideal" or average subject. Ross (1966) and Cliff (1968) 60 have both criticized and offered interpretations of this procedure.

Other models include one by Johnson (1967) which is a technique and a computer program for clustering subjects into homogeneous groups based on some measures of similarity (for example interpoint distances of stimuli perceived by subjects) among the subjects. Also, McGee (1968) has suggested a way to deal with individual differences which permits each subject to have his own monotone function relating distances 62to similarity judgments.

The most recent developments in this area, however, are reflected in the work of Carroll and Chang (1969) and Horan (1969). Carroll and Chang have outlined a MDS routine allowing individuals to share a common perceptual space whose dimensions can be weighted differentially according to their saliences. The limitation of this model is that it does not allow differential rotation of axes and that stretching can only take place along fixed dimensions. Horan's method deals with solving

⁶⁰John Ross, "A Remark on Tucker and Messick's 'Point of View' Analysis," <u>Psychometrika</u>, 31 (March, 1966), pp. 27-32; Norman Cliff, "The 'Idealized Individual' Interpretation of Individual Differences in Multidimensional Scaling," <u>Psychometrika</u>, 33 (June, 1968), pp. 225-32.

61 Stephen C. Johnson, "Hierarchical Clustering Schemes," <u>Psycho</u> metrika, 32 (September, 1967), pp. 241-54.

⁶² Victor E. McGee, "Multidimensional Scaling of N Sets of Similarity Measures: A Nonmetric Individual Differences Approach," <u>Multi-</u> variate Behavioral Research, 3 (April, 1968), pp. 233-48.

63 J. Douglas Carroll and Jih-Jie Chang, "Analysis of Individual Difference in Multidimensional Scaling via N-Way Generalization of 'Eckart-Young' Decomposition," Bell Telephone Laboratories, Murray Hill, New Jersey, 1969, pp. 1-5. (Mimeographed)

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for the group stimulus space as the means of individual distances estimates. Combining the squares of these distances leads to a perceptual structure corresponding to a common attribute space with some degree of distortion along those axes of the configuration on which stimuli differ.⁶⁴

Computer programs based on models of individual differences in perception have been instrumental in advancing the practical aspect of the technique. Notable among these programs are MDSCAL-4M and TORSCA-9 65 which have incorporated ways of dealing with individual difference. Also, Young and Pennell (1967) have developed VIEWS, a procedure to carry out Tucker-Messick "point of view" analysis.⁶⁶

Some papers on individual differences notion have cast light on the application of this concept. Helm and Tucker (1967) employed the Eckart-Young technique to analyze differences between groups of individuals, where individuals within each group were assumed to have the same perceptual structure.⁶⁷ Various uses of MDS and ways to account for different points of view are demonstrated by Jackson and Messick (1963)

⁶⁴C. B. Horan, "Multidimensional Scaling: Combining Observations when Individuals Have Different Perceptual Structures," <u>Psychometrika</u>, 34 (June, 1969), p. 163.

⁶⁵Kruskal, "How to Use MDSCAL, Version 4M;" Young, "TORSCA-9."
⁶⁶Forrest W. Young and Roger Pennell, "VIEWS: An IBM System/
360 Program for Points of View Analysis," <u>Behavioral Science</u>, 12
(March, 1967), p. 166.

67 Carl E. Helm and Ledyard A. Tucker, "Individual Differences in the Structure of Color Perception," <u>American Journal of Psychology</u>, 75 (September, 1962), p. 439.

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in a study of the role of the perceiver in the complexity of social perception.⁶⁸ Tucker (1964) provides new applications for several methods to explore preference judgments of individuals.⁶⁹ An investigation into the manner in which people make inferences about personality traits of others, and implementation of "point of view" analysis to get at group consensus has been carried out by Walters and Jackson (1966).⁷⁰ Finally, Messick and Kogan (1966) have reported a study utilizing individual difference models of MDS to exemplify the corolates of consistent individual viewpoints about role similarity.⁷¹

Eusiness Contributions

The available literature in business can perhaps best be characterized by its recency and concentration, as a result of heavy contribution by few authors. Nost of the exploration has been attempted by Green and his associates over the past three years. The result of their studies has been expressed in a series of working papers and

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⁷⁰ Herman A. Walters and Douglas N. Jackson, "Groups and Individual Regularities in Trait Inference: A Multidimensional Scaling Analysis," <u>Multivariate Behavioral Research</u>, 1 (April, 1966), p. 145.

⁷¹Samuel Messick and Nathan Kogan, "Personality Consistencies in Judgments: Dimensions of Role Constructs," <u>Multivariate Behavioral</u> <u>Research</u>, 1 (April, 1966), p. 166.

 ⁶⁸ Douglas N. Jackson and Samuel Messick, "Individual Differences
in Social Perception," <u>British Journal of Social and Clinical Psychology</u>,
2 (February, 1963), pp. 1-10.

Ledyard R. Tucker, "Systematic Differences Between Individuals in Perceptual Judgments" in <u>Human Judgments and Optimality</u>, ed. by Maynard W. Shelly and Glenn L. Bryan (New York: Wiley and Sons, 1964), pp. 85-98.

Marketing Science Institute monographs some of which have appeared in professional journals. These studies encompass a wide range of material dealing with both the methodology (MDS, MDU and clustering methods) and applications in marketing research. The purpose of this section is to present a survey of these articles.

Contributions of Green and Associates

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The first related article which appeared in the literature was an application of clustering technique by Green, Frank and Robinson (1967). They suggest a test market selection procedure based on similarity characteristics among the markets. More specifically, a set of measurements on relevant characteristics of markets is analyzed to obtain homogeneous clusters of markets with similar properties.⁷² This is indeed an improvement over past approaches of arbitrary selection of test markets; it obviates overlap and insures choosing desired sites.

Two early attempts presented by Green and Robinson (1968) and Frank and Green (1968) served as position papers. The first deals with the historical aspect of MDS and offers derived perceptual and preference configurations using some of the listed computer algorithms; it also cites a few marketing applications.⁷³ The second reviews methods of

72 Paul E. Green, Ronald E. Frank and Patrick J. Robinson, "Cluster Analysis in Test Market Selection," <u>Management Science</u>, 13-B (April, 1967), pp. 389-91.

⁷³Paul E. Green, Frank J. Carmone, and Patrick J. Robinson, "Nonmetric Scaling in Marketing Analysis: An Exposition and Overview," <u>Wharton Quarterly</u> (Winter-Spring, 1968), pp. 29-31.
grouping based on similarity measures and notes application.⁷⁴ A recent application of clustering is reported by Green, Carmone and Fox (1969). They suggest a method of subjective clustering of stimuli by subjects prior to submitting the resulting similarity data to MDS algorithms.⁷⁵ This leads to groupings of subjects in homogeneous clusters.

There has been several articles concerned with the issue of configuration invariance over different types of data. The first one by Green, Carmone and Robinson (1968) reports the comparability of perceptual maps of several magazines derived from both direct measures of similarity and confusion data.⁷⁶ In addition, Green and Rao (1969) investigate the stability of solutions with changes in the stimuli composition and different respondents. They find acceptable configuration invariance over various data as well as different stimuli set.⁷⁷ However, the resulting invariant configurations may not necessarily share similar interpretations of axes. Also in this group is a report

74 Ronald E. Frank and Paul E. Green, "Numerical Taxonomy in Marketing Analysis: A Review Article," Journal of Marketing Research, 4 (February, 1968), pp. 83-94.

75 Paul E. Green, Frank J. Carmone and Lee B. Fox, "Television Program Similarities: An Application of Subjective Clustering," Journal of Market Research Society, 2 (1969), pp. 20-22.

⁷⁶ Paul E. Green, Frank J. Carmone, and Patrick J. Robinson, "A Comparison of Perceptual Mapping via Confusions Data and Direct Similarity Judgments," in <u>Marketing and the New Science of Planning</u>, ed. by Robert L. King (Proceeding of the A.M.A., Fall, 1968), pp. 324-33.

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⁷⁷Paul E. Green and Vithala R. Rao, "Configuration Invariance in Multidimensional Scaling: An Empirical Study," (Paper presented at the Fall Conference of the A.M.A., Cincinnati, Ohio, August, 1969), pp. 1-15. by Green and Maheshwari (1969) regarding the effects of tied data and 78 conditional proximity measures on the resulting configurations.

A number of investigations have delved into methodological issues. The first report by Green and Carmone (1969) compares the ability of various unfolding programs to recover a correct perceptual configuration when the input consist of judgments of preference.⁷⁹ Their result obviously agrees with previous findings of Carroll and Chang and other psychometricians. Another study by Green and Morris (1969) compares various models of individual differences of perception. High degree of agreement is reported between results of Tucker-Messick and Carroll models.⁸⁰ It is believed, however, that Carroll's model is more efficient. Also, Green and Rao (1969) present an article on various types of proximity measures for clustering procedures.⁸¹

The last collection of articles has to do with application of MDS techniques and consequently with the critical issue of dimension interpretation. The first study by Green and Carmone (1969) examines

⁷⁸Paul E. Green and Arun Maheshwari, "A Note on the Multidimensional Scaling of Conditional Proximity Data," M.S.I. Working Paper, July, 1969, pp. 6-18.

⁷⁹Paul E. Green and Frank J. Carmone, "Multidimensional Scaling: An Introduction and Empirical Comparison of Unfolding Technique," Journal of Marketing Research, 6 (August, 1969), pp. 337-41.

80 Paul E. Green and Thomas W. Morris, "Individual Difference Models in Multidimensional Scaling: An Empirical Comparison," (Paper presented at the Consumer Behavior Research Workshop of the A.M.A., Columbus, Ohio, August, 1969), pp. 9-12.

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Paul E. Green and Frank J. Carmone, "Advertisement Perception and Evaluation: An Application of Multidimensional Scaling," M.S.I. working paper, August, 1969, pp. 11-23.

experts versus nonexperts perceptions and evaluations of ads. The results of similar data collection on two different respondent groups are analyzed by MDS technique and show some differences. The second paper by Green, Maheshwari and Rao (1969) deals with self concept and its impact on brand preference. The reported result of MDS analysis does not seem conclusive; it indicates both positive and negative relationships between self concept and brand preference. Finally, Green and Maheshwari (1969) examine Common Stock perception and preference as related to portfolio selections. The study shows risk and growth as dominant attributes of the perceptual space. 84 It is important to note that "joint space" of stimuli and "ideal" points obtained for analysis of perception and preference data has been mentioned in relation to utility function.

Two working papers by Green and his graduate students have been of direct consequence to this research. The first study by Green, Maheshwari and Rao (1968) is concerned with the problems of dimension interpretation and configuration invariance over changes in stimuli set. They propose constructing an attribute space of predesignated

82 Paul E. Green and Frank J. Carmone, "Advertisement Perception and Evaluation: An Application of Multidimensional Scaling," M.S.I. working paper, August, 1969, pp. 11-23.

83 Paul E. Green, Arun Maheshwari and Vithala R. Rao, "Self-Concept and Brand Preference: An Empirical Application of Multidimensional Scaling," M.S.I. working paper, July, 1969, pp. 20-23.

⁸⁴Paul E. Green and A. Maheshwari, "Common Stock Perceptions and Preference: An Application of Multidimensional Scaling," <u>Journal of</u> <u>Business</u>, 42 (October, 1969), pp. 444-47.

⁸⁵Ibid., pp. 451-55.

stimuli characteristics as a guide to designation of axes of original stimuli domain.⁸⁶ Although this is an improvement over the analyst's subjective impression of final dimensions, it poses similar criticism regarding "a priori" selection of hypothesized stimuli characteristics. The second study by Green (1969) describes the methodology and offers some practical illustrations of the marketing research application. This paper also deals with the practical problem of configuration recovery using artificial data.⁸⁷ In addition, it offers meaningful insights into potential aspects of MDS and preference mapping in areas of market segmentation and product life cycle analysis.⁸⁸

Other Works on MDS

In addition to Green and associates, other authors have recently entered this domain. Doehlert (1968) reports a market research application of nonmetric MDS and preference mapping on the same MDS space for perceived similarity of automobile colors. He notes the usefulness of the method for determining market segments and a guide to research of 89 product development.

⁸⁶Paul E. Green, Arun Maheshwari and Vithala Rao, "Dimensional Interpretation and Configuration Invariance in Multidimensional Scaling: Au Empirical Study," Working paper, August, 1968, pp. 17-24.

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87 Paul E. Green, "Cardinal Method in Multidimensional Scaling," Working paper, January, 1969, p. 7.

⁸⁸Ibid., p. 29.

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⁸⁹David H. Doehlert, "Similarity and Preference Mapping: A Color Example" in <u>Marketing and New Science of Planning</u>, ed. by Robert L. King (Proceedings of the A.M.A., Fall, 1968), p. 250. Taylor (1968)'s article is basically a reproduction of Coombs' 90 classification of scaling models and appropriate data for the same. A second report by Taylor (1969) describes various ways of collecting similarity data to input MDS algorithms.

A most interesting presentation by Cook and Hernifer (1968) describes a simulation model for new product demand in terms of individual's past purchase history and his present preferences.⁹² The central feature of the model is the application of nonmetric MDS solutions to test hypothesized relationships between "expressed and revealed individual preference" via perceived attribute space.⁹³ Thus, they imply a correspondence between the rank order of preference of a set of products to the rank order of their actual purchase.

Another interesting exposition is put forth by Stefflre (1968) in his study of market structures. He defines a market as a set of items with strong substitution and competition effects and suggests placement of brands in markets in terms of their perceived similarity rather than

⁹⁰James R. Taylor, "The Meaning and Structure of Data as Related to Scaling Models," in <u>Marketing and New Science of Planning</u>, ed. by Robert L. King (Proceedings of the A.M.A., Fall, 1968), pp. 310-13.

91 James R. Taylor, "Alternative Methods for Collecting Similarities Data," (Paper presented at the Fall Conference of the A.M.A., Cincinnati, Ohio, August, 1969), pp. 4-8.

92 Victor J. Cook and Jerome D. Hernifer, "Preference Measurement in a New Product Demand Simulation," in <u>Marketing and the New Science</u> of Planning, ed. by Robert L. King (Proceedings of the A.M.A., Fall, 1968), pp. 316-18.

93 Ibid., pp. 320-22.

historical grouping of product classes. Moreover, closer examination of expressed features of the products influencing judged similarities of such products becomes a useful guideline in promotional strategy. Furthermore, a clearly defined expression of people's preferences leads to the possibility of finding products with desired descriptions. Silk (1969) and Barnett (1969) have recently explored Stefflre's proposition and suggested explicit use of consumer perception and preference judgments for market segmentation and new product development.

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Also worthy of mention are two articles by Neidell (1969) and Neidell and Teach (1969). The first report is a description of the theoretical and practical aspects of MDS. His example of the U.S. map provides for an excellent exploration of MDS algorithms.⁹⁷ The second article is of particular interest since Neidell and Teach's suggestion of "joint space" analysis to predict market share is a central feature of this research. The explicit use of "real brand-Ideal brand"

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⁹⁶Alvin J. Silk, "Preference and Perception Measures in New Product Development: An Exposition and Review," <u>Industrial Management</u> <u>Review</u>, 11 (Fall, 1969), pp. 21-37; N. L. Barnett, "Beyond Market Segmentation," <u>Harvard Business Review</u>, January-February, 1969, pp. 152-66.

97 Lester A. Neidell, "The Use of Nonmetric Multidimensional Scaling in Market Analysis," Journal of Marketing, 33 (October, 1969), p. 39.

⁹⁴ Volney Stefflre, "Market Structure Studies: New Products for Old Markets and New Markets (Foreign) for Old Products," in <u>Application</u> of the Sciences in <u>Marketing Management</u>, ed. by F. M. Bass, C. W. King and E. A. Pessmier (New York: Wiley and Sons, 1968), pp. 252-55.

⁹⁵<u>Ibid.</u>, p. 262.

distances to predict rank order of actual brand shares remains as their main contribution.⁹⁸

Summary

The purpose of this chapter has been to elaborate three major bodies of MDS literature which are MDS, MDU and business contributions. The main aspects of concern within each area has been threefold:

- 1) An examination of the theoretical position over time
- 2) A review of significant empirical research both application and computer algorithms
- 3) An emphasis on the relationships reinforcing to the conceptualization of this research.

98 Lester A. Neidell and Richard D. Teach, "Preference and Perceptual Mapping of a Convenience Good," (Paper presented at the Fall conference of the A.M.A., Cincinnati, Ohio, August, 1969), pp. 5-7.

CHAPTER III

METHODOLOGY

The concern of this chapter is to present the formulation of . hypotheses, an over-view of the necessary models, and a description of the data set which will be studied. The stated hypotheses will consequently be evaluated on the basis of the data collected. The data will be analyzed by a design which consists of integrated component computer algorithms.

The procedure just described will lead to the following results:

- An understanding of self-medicators' perceptions of different brands via a stimuli configuration.
- (2) A study of the configuration invariance over different kinds of data collection methods (direct vs indirect similarity data).
- (3) An interpretation of the configuration dimensions using subjects' perceptions of given characteristics.
- (4) A prediction of brand purchasing behavior using "joint space" configurations analysis ("ideal" point).

Hypotheses

To be more specific, the following hypotheses are formulated:

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- Hypothesis 1: The configuration of the stimuli set will be obtained in a space of low dimensionality (i.e., two dimensions).
- Hypothesis 2: The configuration of the stimuli set will remain invariant over different kinds of data (direct vs. indirect similarity data).
- Hypothesis 3: A "monotone ascending or descending" relationship exists between stimulus-Ideal point distance measures and actual brand shares. In other words, the ranking of the brands according to their proximity to the "ideal" point corresponds to the ranking of their actual market shares (Neidell and Teach, 1969). The distance measures can be stated as:

$$d_{1j} = \begin{bmatrix} n \\ \sum_{k=1}^{n} (X_{k1} - X_{kj})^2 \end{bmatrix}^{\frac{1}{2}}$$

where d_{ij} = Euclidean distance between brand j and "ideal" point I in a space of n dimensions; X_{ki} is the kth coordinate of individual's "ideal" point; and X_{kj} is the kth coordinate of the jth stimulus point. The actual market shares (in %) for various brands can be calculated:

$$S_{j} = \frac{d_{1j}}{\sum_{j=1}^{n} d_{1j}}^{2}$$

Hypothesis 4:

if monotone ascending relation exists between distance and preference



if monotone descending relation exists between distance and preference

Furthermore, a direct or an inverse relationship exists between the square value of stimulus-Ideal point distance measures and the actual size of the brands' market shares:

 $S_j = M f(d_{1j}^2)$ if monotone ascending relation exists between distance and preference

$$S_{j} = \frac{M}{f(d_{1j}^{2})}$$
 if more
relative distance of the second second

notone descending ion exists between tance and preference

where S_i = share of market for brand j; d₁₁ = stimulus-Ideal point distance (Euclidean); and M = the constant of proportionality.

This hypothesized function will be further investigated by a comparison between predicted and actual market shares. The constant M will be estimated by the least squares method.

Computer Algorithms

TORSCA-91

This is a program written by Young for Shepard-Kruskal MDS analysis. Given n(n-1)/2 similarity/dissimilarity measures S_{ii} for a set of n

¹Forrest W. Young, "TORSCA-9, An IBM 360/75 FORTRAN 4 Program for Nonmetric Multidimensional Scaling," <u>Journal of Marketing Research</u>, 5 (August, 1968), pp. 319-20.

points, this program finds a set of orthogonal coordinates xia

(i = 1,2,...,n; a = 1,2,...,m) in m-dimensional Minkowski r-space, which maximizes the function:

Alpha =
$$\propto = \frac{1}{2} + \frac{1}{2} = \frac{d_{ij} b_{ij}}{\left[(\sum d_{ij})^2 (\sum b_{ij})^2 \right]^{\frac{1}{2}}}$$

where the b are the n(n-1)/2 derived distances in m-dimensional ij Minkowski r-space:

$$b_{ij} = \begin{bmatrix} m \\ \sum_{a=1}^{m} (|x_{ia} - x_{ja}|)^{r} \end{bmatrix}^{1/r}$$

and the d_{ij} are the n(n-1)/2 monotone elements (disparities) such that $d_{ij} \leq d_{kl}$ whenever $S_{ij} \leq S_{kl}$.

Note that when r = 2, the above formula pertains to a configuration obtained in Euclidean space.

The program also provides Kruskal's stress:²

Stress = s =
$$\begin{bmatrix} \sum_{i < j} (d_{ij} - \hat{d}_{ij})^2 \\ \vdots \\ \sum_{i < j} d_{ij}^2 \\ i \\ i \\ i \end{bmatrix}^{\frac{1}{2}}$$

Where the d denote distance from x to x in Euclidean space. If x is expressed in Orthogonal Coordinates by x_{i1}, \dots, x_{it} , then we have:

²Kruskal, "Multidimensional Scaling," pp. 4-10.

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$$d_{ij} = \begin{bmatrix} t \\ \sum_{s=1}^{t} (x_i - x_j)^2 \end{bmatrix}^{\frac{1}{2}}$$

and the d_{ij} are a monotone sequence of numbers which minimize S.

Notation used for \ll and S are those employed in the original articles. However, it should be pointed out that Kruskal's d_{ij} and $\overset{\Lambda}{d_{ij}}$ correspond to Young's b_{ij} and d_{ij} respectively.

Both stress and Alpha are measures of goodness of fit. An index of .999 or more for alpha is required for satisfactory solution.³ Two sets of values exist for stress; the difference stems from the way S is calculated. Formula 1 is shown above; formula 2 has a different denominator $(\sum (\hat{d} - \tilde{d})^2)$; where $\tilde{d} = \sum \hat{d}/M$, M = n(n - 1)/2). The following guidelines have been offered for their evaluation:⁴

<u>Stress 1</u>	Stress 2	Goodness of fit
20%	40%	Poor
10	20	Fair
5	10	Good
2-2	5	Excellent
0	0	"Perfect"

In the present study, a modified version of TORSCA-9 is employed in the analysis. 5

⁴Kruskal, "How to Use MOSCAL Version 4M," pp. 8-10.

⁵F. W. Young, B. J. Carmone, Jr., and R. F. McCracken, "TORSCA: Torgerson MDS Program Version 8 Master," Marketing Science Institute, Philadelphia, Pennsylvania, 1968.

³Forrest W. Young, "Fortran 4 Program for Nonparametric Multidimensional Scaling," The L. L. Thurston Psychometric Laboratory, University of North Carolina, Chapel Hill, North Carolina, March 1968, pp. 9-11.

Unfolding Model Algorithm

This program is based on generalization of Coombs' unfolding model; it relates preference data to perceptual configuration obtained from MDS solutions. While Coombs' unfolding model assumes the preference scores to be monotonically related to distances in perceptual space, this general version assumes preference values to be linearly related to squared distances in Euclidean space. "Preference mapping of stimulus space,"by certain linear or quadratic regression equations, is discussed in terms of a hierarchy of four models (Phase I - IV). "Phase I" of this program allows for differential rotation of axes by different individuals and the subsequent differential weighting of the rotated axes. "Phase II" assumes the same set of dimensions for all subjects but allows each one to weight the dimensions individually. In both models I and II, the weights can be negative. This simply implies that with respect to a negative dimension, the "ideal" point suggests the least preferred position. "Phase III" is the simple Coombsian unfolding model with two exceptions; First, preference is related to square of distances from "ideal" point; second, while different dimensions are weighted equally, weights can be negative. "Phase IV" presents what Tucker has referred to as the "Vector model" which relates preference to projections of stimulus points on different vectors.⁶

⁶Carroll and Chang, "Relating Preference Data to MDS," p. 2.

Model I: The General Model⁷

Given 1) a matrix of coordinates of n stimuli in m dimensions (obtained from a MDS solution):

$$X = \begin{bmatrix} x \\ kj \end{bmatrix}; \quad \begin{array}{l} k = 1, 2, \dots m \text{ dimensions} \\ j = 1, 2, \dots n \text{ stimuli} \end{array}$$

where X represents the kth dimensions of the jth point

And 2) a matrix of preference scores of individuals on a set of stimuli:

$$S = \begin{bmatrix} S_{ij} \end{bmatrix}; \begin{array}{c} I = 1, 2, \dots N \text{ individuals} \\ j = 1, 2, \dots n \text{ stimuli} \end{array}$$

where S_{ij} represents the preference of the i^{th} individual for the j^{th} stimulus.

The model proposes that preference is linearly related (monotone descending) to square of Euclidean distances between stimulus j and "ideal" point I:

$$S_{Ij} = ad_{Ij}^{2} + b + e_{Ij}; a \ge 0$$

where a and b are arbitrary constants, and e_{Ij} is an error term; and:

$$d_{Ij} = \begin{bmatrix} m \\ \sum_{k=1}^{m} W_{kI} (x_{kI} - x_{kj})^2 \end{bmatrix}^{\frac{1}{2}}$$

"where X_{kI} is the kth coordinate of individual I's "ideal" point; x_{kj} is the kth coordinate of the jth stimulus point; d_{Ij} is the distance between "ideal" point I and stimulus

7<u>Ibid.</u>, pp. 1-9.

point j in a space of m dimensions; and W_{kI} is the importance of the kth dimension for subject I, the model allows for negative weights."

The difference between models I, II and III is the rotation of axes and weighting of dimensions which reflects in the way d_{Ij}^2 is defined; other assumptions are the same for the three models. While the first three models use regression equations containing quadratic terms, the regression equation for model IV contains only the linear terms. In these models, preference score is related to square of distance between stimulus j and "ideal" point I in a monotonically descending fashion (the smaller the score the more preferred the stimulus).

Data Collection

The sample space consisted of 60 housewives selected randomly from four geographical areas of greater Columbus, Ohio (Cluster sampling). The choice of housewives as sample elements was influenced by a previous self-medication project⁸ indicating that housewives purchase most of the remedies for the household. A panel of same subjects was set up for four months⁹ for the expressed purpose of obtaining records of actual purchasing behavior. The sample could well be representative of not

⁸Engel, Knapp and Knapp, "Decision-Making Process in Self-Medication."

9 Donald Y. Granbois and James F. Engel, "The Longitudinal Approach to Studying Marketing Behavior," in <u>Marketing and Economic Development</u>, ed. by Peter P. Bennett (Proceeding of the A.M.A., 1965), pp. 205-21.

only metropolitan Columbus, but also of the nation; Columbus has a nationally representative population and it is often selected as a test market.

The data, which were collected from 60 housewives by a market research agency, 10 contained (for more detail, see Appendix A):

- a) Brand data information judgments of similarity and preference (checked for counter balance)
- b) Consumer Characteristics data
- c) Remedy inventory
- d) Record of remedies obtained

The stimuli set of this study was composed of headache and pain remedies brands. Data were made up of judgments of similarity and preference of stimuli from housewives, socio-economic characteristics for each participant,¹¹ and purchases retrieved from a diary for each respondent. The survey instrument which gathered the brand data information consisted of five sections:

Section 1 - Each housewife was asked to make subjective judgments about the similarities of 10 different headache

and pain remedies brands by rating each of the 36 distinct pairs of the 9 brands, using a 10-point scale

¹⁰Part of the data was administered by Dwight Spencer and Associates, Inc.; Marketing Research Consultants; Columbus, Ohio.

¹¹Standard socio-economic characteristics were gathered following the suggestions of Weilbacher: William M. Weilbacher, "Standard Classification of Consumer Characteristics," <u>Journal of Marketing</u>, 31 (January, 1967), pp. 27-31. ranging from 1-very similar to 10-very dissimilar. These brand names appear in Table 1.

- Section 2 Each respondent was asked to rate the same 10 brands in terms of preference, using a 10-point scale ranging from 1-most prefer to 10-least prefer.
- Section 3 The respondent was also asked to rank the same 10 brands in order of preference from 1 to 10.
- Section 4 The respondent was asked to rate each brand on 9 characteristics, using a 6-point scale ranging from 1-satisfactory to 6-unsatisfactory. The list of these characteristics appears in Table 1.
- Section 5 The participant was also asked to evaluate these characteristics in terms of importance on a 6-point scale, ranging from 1-important to 6-unimportant.

TABLE 1

LIST OF STIMULI AND CHARACTERISTICS

Stimulus	Characteristic	
Rexall aspirin	Pleasant taste	
Alka Seltzer	Low price	
Empirin	Speed of relief	
Bufferin	Few side effects	
Anacin	Easy to take	
Bayer	Dissolves fast	
Bromoseltzer	Extra strength	
Excedrin	Many ingredients	
Vanquish	Relieves headache and pain	

The questionnaire was constructed to provide two kinds of measurements. Sections 1 through 3 yield direct similarity and preference judgment about the brands. A "higher ordered metric" scale¹² was used in sections 1 and 2. Section 3 yields a series of J scales, a joint distribution of stimuli and individuals.¹³

Sections 4 and 5 yield indirect similarity and preference judgments about the brands. Measures of attitudes about the brands were obtained using a modified version of Fishbein's model of weighted beliefs.¹⁴ An absolute distance formula was then used to obtain interbrand proximity measures:

$$d_{ij} = \sum_{k=1}^{n} W_k | X_{ik} - X_{jk} |$$

where d_{ij} = distance between stimulus (brand) i and j X_{ik} and X_{jk} = coordinates of stimulus i and j on dimension k (perceptions of attributecharacteristic-k for brand i and j) W_k = the weight of dimension k (importance of attribute k); W_k = 1 if attirubtes are weighted equally

¹²Roger N. Shepard, "Metric Structures in Ordinal Data," <u>Journal</u> of Mathematical Psychology, 3 (1966), pp. 287-91.

¹³Coombs, "Psychological Scaling," pp. 145-48.

¹⁴Martin Fishbein, "A Behavior Theory Approach to the Relations Between Beliefs about an Object and the Attitude Toward the Object," in <u>Attitude Theory and Measurement</u>, ed. by Martin Fishbein (New York: Wiley and Sons, 1967), pp. 391-97; Frank M. Bass and W. Wayne Talarzyk, "A Study of Attitude Theory and Brand Preference" (Paper presented at the Fall Conference of the A.M.A., Cincinnati, Ohio, August, 1969), pp. 4-6. n = number of dimensions (attributes) k. (Similar techniques, for the weighted case, have been used by Green, Maheshwari and Rao (1968) and Neidell and Teach (1969) for deriving inter-stimulus distances.)¹⁵

Experimental Procedure

Part 1 -- Data collected in section 1, consisting of similarity judgments of brands on a 10-point scale, were averaged over all respondents. The resultant (9x9) matrix of the average similarity ratings of subjects was submitted to TORSCA-9 program. The result was a configuration of the stimuli set in a reduced space of low dimensionality.

Part 2 -- Inter-stimulus proximity measures were computed from data collected in section 4, consisting of ratings of brands on different characteristics using a 6-point scale. The derived distances thus obtained were averaged over all respondents and subsequently submitted to TORSCA-9 program. The result was a configuration of the stimuli set in a reduced space of low dimensionality. Configurations obtained from parts 1 and 2 were then compared for congruence.

Part 3 -- Inter-scale proximity measures were computed from data collected in section 4, consisting of ratings of brands on different characteristics. The derived distances thus obtained were averaged over all respondents and subsequently submitted to TORSCA-9 program. The result was a configuration of the characteristics. The configuration

¹⁵Green, Maheshwari and Rao, "Dimensional Interpretation," p. 8; Neidell and Teach, "Preference and Perceptual Mapping," p. 5.

obtained from part 3 was used as a guide to the interpretation of the dimensions of the stimuli set configurations of parts 1 and 2.

Part 4 -- Data collected in section 2, consisting of preference ratings of brands on a 10-point scale, were averaged over all respondents. Both the individual and average ratings together with the configurations obtained from part 1 were submitted to the Carroll-Chang generalization of the Coombsian unfolding model. The result was the representation of the individual and average <u>ideal point</u> in the same space as the stimuli configuration. The stimulus-Ideal point distances were then used to predict brands' market shares.

Part 5 -- Inter-stimulus proximity measures were computed from data collected in sections 4 and 5, consisting of brands by characteristics ratings and importance ratings for each characteristic. The derived distances thus obtained were averaged over all respondents and subsequently submitted to TORSCA-9 program. The result was a configuration of the stimuli set and the <u>ideal point</u>. Configurations obtained from parts 4 and 5 were then compared.

In addition, the subjects are examined for individual differences. If homogeneous groups with similar perceptions are found, they will be analyzed in terms of demography. The notion of individual differences is the subject of a follow-up study. Plans have already been made to further investigate this area within the context of both perception and preference. This later study will be conducted by preferential mapping of perceptual space for each individual (as described in hypotheses 3 and 4). The predictive results will then be compared with similar

predictions obtained solely from the use of the preference scale values for each individual. Should significant individual differences arise, homogeneous subsets will be formed and analyzed in terms of demography.

In summary, the experimental procedure was aimed at two kinds of investigations: (1) the notion of the configuration invariance over different data collection methods and the examination of the dimensions of the final solution and (2) the employment of preference mapping of the perceptual space as a predictive model of buyer behavior (brand share). While the former area has been dealt with in previous MDS literature, this is a first attempt at investigating the latter concept.

CHAPTER IV

DATA ANALYSIS AND FINDINGS

After careful examination of the sixty completed sets of questionnaires, three were judged unacceptable. The remaining fifty seven were placed in two groups: The first comprised of forty subjects who indicated awareness of all the stimulus-objects (i.e., headache and pain remedies) of this study; and the second consisted of seventeen subjects who recognized all but one brand - Empirin. The analysis of this chapter is based primarily on the information collected from the main group of forty respondents who showed full awareness of the stimuli set.

Hypothesis 1:

The configuration of the stimuli set will be obtained in a space of low dimensionality.

To evaluate this hypothesis, direct similarity judgments of brands were averaged over all respondents (the aware forty). The obtained 36 pairwise comparisons (numerical ratings) were placed in a lower half matrix of dissimilarities which were subsequently rank ordered.¹ The TORSCA-9 nonmetric scaling program was operated on this matrix to find the desired solution. Figure 1 shows the nine brands

¹The lower half matrix of rank order dissimilarities is shown in Table 13, Appendix B.

as points in a Euclidean-space of two dimensions. The rank order of interpoint distances of this configuration relates closely to that of the input data. It is pointed out by Table 2, in fact, that the Spearman rank order correlation is 0.97 indicating a good fit in twodimensional space. The stress is 0.03, also a good index.

TABLE 2

CORRELATIONS....DERIVED DISTANCES TO ORIGINAL DATA DIRECT AVERAGE DISSIMILARITIES

\$	ŊĸĸĸŦĸĊĸ₩ŶĬ₩ŎĹĬĹĬĿĿĸŦŔŦ₩ĬŀĊĸĨĸĿĹĊĸĬĊĬĸĿŎĊĸŢĊĸŎŎŎŎĿŎĸĸĸĿŢĸĸĸĸĿĊĊĸĸŎĿĿĸŎĿĬĊĬĬĸŢĬĸĸŦĬĊĬĬĬĬŎŎĿĊŦŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎŎ ſĦŦĸĸĸŶŶĬ₩ŎĿ ſĦŦĸĸŶŶĬŴŎĿ
Product Moment	Spearman-S Rank Difference
r = 0.96	$r_d = 0.97$
$r^2 = 0.92$	$r_d^2 = 0.94$
Stress = 0.037	t = 23.09* with 34 d.f.
*Significant at 0.001 level	Critical Value = 3.60

The obtained scaling solution is an expression of the perception of the nine brands by the respondents. It is assumed, for the time being, that all respondents perceive the stimuli-objects in terms of a common set of dimensions. Thus, in this average profile, the relative positions of brands depict their psychological distances in the average respondent's perceptual map. In other words, points clustered together are considered to be more similar than points far apart.

In Figure 1 four clusters are clearly evident: Alka Seltzer and Bromoseltzer; Vanquish, Excedrin and Empirin; Anacin and Bufferin; and Bayer and Rexall aspirin. Moreover, while alkalizers do form a distant cluster, their presence in the same perceptual space and their proximity





to the remaining headache remedies points out to their unique usage pattern. A comparative study of headache remedies, cold remedies and alkalizers in a same space would in fact indicate an area of overlap. This is analagous to an intersection of three "ven" diagrams. This can indeed be a valuable information for management decisions regarding product planning. The recent launching of Alka Seltzer Plus to fill such an area of intersection is offered as evidence.

While more will be said about interpretation of the dimensions of this configuration later, tentative labels, for the moment, are assigned to the dimensions. A provisional label "Buffer" is given to the first axis while the second axis is designated "Strength."

It is interesting to note that the distance between Alkaseltzer and Bromoseltzer with the rest of the brands implies that the dimension of buffer for both alkalizers is of an overriding nature. So great in fact is this difference that it may have caused the polarization of the rest of the brands.

To control for the possible effects of this nonhomogeneity of the product space, a reduced configuration of seven brands (without Alka Seltzer and Bromoseltzer) for the average subject was obtained from TORSCA-9.² Figure 2 shows these seven brands as points in a two-dimensional space. It can be seen from Table 3 that the Spearman rank order correlation is 0.93 indicating a good fit in spacial dimensionality of two. The stress on the other hand is 0.007 which is judged to be excellent.

² The Lower half matrix of rank order dissimilarities is shown in Table 14, Appendix B.



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FIGURE 2

REDUCED AVERAGE DISSIMILARITY CONFIGURATION

TABLE 3

CORRELATIONS.	DERIVE	D DISTAN	NCE TO	ORIGINAL	DATA
REDUCED	DIRECT	AVERAGE	DISSIN	HILARITIES	3

מירוי אין איז	₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩
Product Moment	Spearman.S Rank Difference
r = 0.89	r = 0.93
	rd ⁻ = 0.87
Stress = 0.007	t = 11.22 with 19 d.f.
*Significant at 0.001	level Critical Value = 3.88

Closer examination of this configuration reveals average subject's perceived similarity of three groups of brands: Excedrin.Vanquish, Bufferin-Anacin, and Bayer-Rexall Aspirin. This observation is congruent with that of Figure 1. Again for management purposes, profiles of this kind are of tremendous value. The perceptual map clearly indicates the relative positions of the various brands. It can be further surmised that pattern of competition and brand switching should be studied both among and within groups.

The above described analyses clearly indicate that the configuration of the stimuli set in a space of low dimensionality has been obtained. This indeed supports Hypothesis 1.

Information Process

At this point it was decided to investigate the effect, if any, of varying amounts of information on a stimuli set. It is hypothesized that: H_{1a}: Differences in perceptions of the same objects become more pronounced as the information presented to subjects varies in amount and content.

To test this hypothesis, similarity judgments of brands were averaged over the seventeen respondents who did not recognize Empirin. The resulting configuration from TORSCA-9 is shown in Figure 3.³ While the Spearman rank order correlation of 0.92 from Table 4 indicates a good fit between derived distances of the obtained two-dimensional space and the experimental observations, the stress value of 0.11 is viewed to be only fair. However, for purposes of comparison a space of two dimensions is decided upon.

TABLE 4

CORRELATIONS--DERIVED DISTANCES TO ORIGINAL DATA DIRECT AVERAGE DISSIMILARITIES OF 17 SUBJECTS

Product Moment	Spearman-S Rank Difference
r = 0.93 $r^2 = 0.86$	$r_{d} = 0.92$ $r_{d}^{2} = 0.35$
Stress = 0.111	t = 13.99* with 34 d.f.
*Significant at .001 le	vel Critical Value = 3.60

Figure 3 exhibits a close relationship to Figure 1. A more detailed examination reveals that while both perceptual profiles indicate similar polarization of alkalizers versus other products, the position of Empirin has been affected drastically. In the absence of

 $^{^{3}}$ The lower half matrix of rank order dissimilarities is shown in Table 15, Appendix B.



information (brand awareness), the average respondent has placed Empirin somewhere between the two major clusters. But what is more interesting is that he is appropriating less of the salient attributes to Empirin than most other brands. This should serve as a reinforcement to the hypothesis that the amount of information affects perception; the support of H_{1a} is evident.

Hypothesis 2:

The configuration of the stimuli set will remain invariant over different kinds of data (direct vs. indirect data).

To evaluate the above, data consisting of ratings of brands on different characteristics were obtained. Inter-stimulus proximity measures were computed using an absolute distance formula:

$$d_{ij} = \sum_{k=1}^{n} | x_{jk} - x_{jk} |$$

The derived indirect dissimilarities thus obtained were averaged over forty respondents. They were subsequently rank ordered and submitted

⁴A computer program was written for this purpose (for more detail, see Appendix C): Reza Moinpour and Richard J. Freedman, "INPUT, A Fortran 4 Program for Computing Inter-stimulus Proximity Measures from Attribute Scores," The Ohio State University, January, 1970.

to TORSCA-9. Figure 4 shows the final solution in two dimensions. The Spearman rank order correlation from Table 5 is 0.92 which indicates a close fit between the distances of the configuration and the original data. The stress of 0.09 is regarded as acceptable.

TABLE 5

CORRELATIONS--DERIVED DISTANCES TO ORIGINAL DATA INDIRECT AVERAGE DISSIMILARITIES (Unweighted attributes)

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Product Moment	Spearman-S Rank Difference
r = 0.93	$r_{d} = 0.92$
$r^2 = 0.86$	$r_{d}^{2} = 0.85$
Stress = 0.096	t = 14.04* with 34 d.f.
*Significant at 0.001 1	evel Critical Value = 3.60

A comparison of Figures 1 and 4 shows that while some of the points have altered their positions, the overall composition of the two configurations has remained the same. In particular, it is noted that both profiles exhibit similar polarization with regard to alkalizers. Furthermore, the cluster containing Vanquish, Excedrin and Empirin is found along similar axes (possessing similar attributes) in both profiles. Finally, it is suggested that the scattering of points in Figure 4 is caused by the preservation of more judged discriminations (by subjects) by the absolute distance formula. Although the same discriminations are inherent in the direct judgments of similarity,

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⁵ The lower half matrix of rank order dissimilarities is shown in Table 16, Appendix B.



(Unweighted Attributes)

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the overall impressions of similarity leads to more clustering of stimulus-objects. It is concluded, therefore, that the stimuli configuration has remained invariant over different methods of data collection (direct vs. indirect). Consequently, Hypothesis 2 is supported.

<u>Configuration Invariance - Weighted</u> vs. Unweighted Attributes

The weighted attributes models of attribute have of late found their way in the marketing research literature (e.g., models of Osgood and Tannenbaum,⁶ 1955; Rokeach and Rothman,⁷ 1965; and Fishbein,⁸ 1967). Accordingly, it is generally assumed that consumers' judgments of similarity and preference of given products are expressed in terms of the perceived characteristics possessed by the same products.⁹ It is also assumed that different products possess different characteristics and that the intrinsic qualities of these characteristics, as well as their quantities, are perceived differentially by different consumers. The question that arises is whether, in delivering attitudinal and perceptual judgments for different products, the consumer takes into account the saliences of different products' attributes (characteristics). Or,

⁸Fishbein, "A Behavior Theory Approach."

⁹Kelvin J. Lancaster, "A New Approach to Consumer Theory," Journal of Political Economy, 24 (April, 1966), pp. 132-4.

⁶ Charles E. Osgood and Percy H. Tannenbaum, "The Principle of Congruity in the Prediction of Attitude Change," <u>Psychological Review</u>, 62 (1955), pp. 42-55.

⁷ M. Rokeach, and G. Rothman, "The Principle of Belief Congruence and the Congruity Principle on Models of Cognitive Interpretation," Psychological Review, 72 (1965), pp. 128-42.

should the various attributes be judged first as to their saliences and the obtained results consequently be regarded as coefficients to weight each attribute score in order to arrive at an appropriate expression of various products for the consumer. In other words, are the saliences of various product attributes inherent in the attribute scale values, or should these scores be treated to reflect the saliences. This question is presently being examined in the context of predicting individual brand purchase for frequently purchased household products (personal communication: Jagdish Sheth and W. Wayne Talarzyk).

To investigate the above area, the perceptual map of stimulusobjects (remedy brands) will be obtained in terms of weighted attributes and compared with the previously obtained unweighted case for congruence. It is hypothesized that:

H_{2a}: The stimuli configuration will remain invariant in terms of both weighted and unweighted attributes.

To test this hypothesis, data consisting of ratings of brands on different characteristics, weighted by importance of these characteristics, were obtained for forty respondents. Inter-stimulus proximity measures were computed using a weighted absolute value distance formula:

$$d_{ij} = \sum_{k=1}^{n} W_k \left| X_{ik} - X_{jk} \right|$$

Where d_{ij} = distance between stimulus (brand) i and j X_{ik} and X_{jk} = coordinates of stimulus i and j on dimension k (perceptions of attributecharacteristic-k for brand i and j)

10 Moinpour and Freedman, "INPUT."

n = number of dimensions (attributes) k.

The derived dissimilarities thus obtained were weighed over the forty respondents. They were then rank ordered and submitted to 11 TORSCA-9. Figure 5 depicts the two-dimensional configuration. The Spearman rank order correlation from Table 6 is 0.95 pointing to a good correspondence between the derived distances and dissimilarities. The stress of 0.06 is regarded as acceptable.

TABLE 6

CORRELATIONS--DERIVED DISTANCES TO ORIGINAL DATA INDIRECT AVERAGE DISSIMILARITIES (Weighted Attributes)

መን የመቀን የታቀ። ሲኖሩ የተማውረም የምንም የተገለቀው የሚቀን ረግድ የሳይረን ላይ የሰብ ማስተል የተለያዩ የሚያስት ላይ የተለያዩ የሚያስት ላይ የተለያዩ የሚያስት የሆኑ የ መንግ የመቀን የተሰሩ የሚያስት የመቀንም የሚያስት የመቀን የሚያስት የሆኑ የሚያስት መንግ የሚያስት መንግ የሆኑ የሚያስት የመንግ የሆኑ የሆኑ የሆኑ የሆኑ የመንግ የመንግ የመንግ	ֈՠ֎֎ֈ֎ՠՠ֎ֈՠ՟ՠ֎֎ֈ֎֎ֈ֎ֈ֎֎ֈ֎֎ֈ֎֎ֈ֎֎ֈ֎֎ֈ֎֎ֈ֎֎ֈ֎֎ֈ֎֎ֈ֎֎ֈ֎
Product Moment	Spearman-S Rank Difference
የምጥናትም ፈ ርጉ መናገለቱ የዚህ የድርጉ ርዕመር <mark>ም</mark> ጊያ ርፖንም የአካላዊ ላም ታሳ ህጃቶ ከ ይቀላዊ ለማካቸው ችምላይ እና መሆኑ የሆኑ የሆኑ የሆኑ የሆኑ የሆኑ የሆኑ የሆኑ የ	መግ ብዙ ግም አስት መስለ የሚያስት በመስለ የሚያስት የሚያስ የመስለም የሚያስት የሚያ
r = 0.95	$r_{\rm d} = 0.95$
$r^2 = 0.90$	$r_{d}^{2} = 0.90$
Stress = 0.069	t = 17.26* with 34 d.f.
*Significant at 0.001	level Dritical Value = 3.60

An examination of Figures 4 and 5 reveals that the configuration has remained invariant over both weighted and unweighted characteristics. It is therefore concluded that consumers do in fact take into account the saliences of different product characteristics when judging various

¹¹The lower half matrix of rank order dissimilarities is shown in Table 17, Appendix B.


products in terms of these characteristics. In other words, the scale values of the attributes reflect the saliences of these attributes as well. It should be noted, however, that the configuration invariance is partially the result of averaging over subjects. This constitutes valuable information for the researchers who are active in MDS techniques in that it obviates the need for collecting additional data in terms of weighted attributes on various products. The support of H_{2a} is evident from the above discussion.

Interpretation of Dimensions

To achieve a better understanding of the dimensions of the stimuli space, it was decided to construct a configuration of the attributes across products and subjects. This is analogous to the factor analysis technique suggested by Osgood, Suci and Tannenbaum.¹² This configuration is used, in turn, as a guide to the interpretation of the dimensions along which the products are perceived.

Toward this end, distance measures between different characteristics were computed using the distance formula.¹³ These values were then averaged over the forty subjects; the resulting rank ordered matrix was submitted to TORSCA-9.¹⁴ The final solution in a space of two dimensions is exhibited in Figure 6. The Spearman rank order correlation

¹²Charles E. Osgood, George J. Suci and Percy H. Tannenbaum, "The Measurement of Meaning" (Urbana, Illinois: University of Illinois Press, 1957), Ch. 2.

13 Moinpour and Freedman, "INPUT."

14 The lower half matrix of rank order dissimilarities is shown in Table 18, Appendix B.



of 0.94 is found from Table 7. The stress of 0.08 is viewed as being acceptable.

TABLE 7

CORRELATIONS-DERIVED DISTANCES TO ORIGINAL DATA AVERAGE DISSIMILARITIES (Attributes)

анны алимпания и напродания на полноми и получара с на сталиние и напрадание и на стали и на со на со на со со В заправлят на полити с полноми с тако конструкции и на стала и на тако на полноми на тако на полноми на со стали	+ AL 2019/10/2017/2017/2017/2017/2017/2017/2017/2
Froduct Noment	Spearman-S Rank Difference
r = 0.94	$r_{d} = 0.94$
$r_2 = 0.88$	$r_d^2 = 0.88$
Stress = 0.083	t = 15.96* with 34 d.f.
*Significant at 0.001 level	. Critical Value = 3.60

A close examination of Figure 6 reveals that the tentative labels which were assigned to the perceptual dimensions of the brand profile are generally appropriate. The vertical axis indicates a clustering of "many ingredients" and "extra strength" vs. "few side effects." This is the dimension of <u>strength</u> or <u>effectiveness</u>. Furthermore, it is evident that the strength of a remedy is associated with increasing side effects. The horizontal axis points out "speed of relief," which is interpreted as being correlated with high buffer content of alkalizers.

Interpreting the perceptual dimensions of the product profiles (Figures 1, 4, and 5) in terms of the above two axes, we can offer the following suggestions:

 Excedrin, Vanquish and Empirin are perceived as possessing more strength and less buffer.

- Alka Seltzer and Bromoseltzer are perceived in terms of both buffer and speed of relief; consequently less strength and side effects.
- 3) Anacin, Bufferin and Bayer are perceived as being somewhat below par in the amounts of both strength and buffer; with Bufferin showing more side effects than Bayer.

A review of the reasons given by the subjects for purchasing various headache and pain remedies led to similar results. Brand features considered by respondents were found to be generally in accord with the above prescribed axes. However, it should be noted that dimension interpretation is a subjective process. This task, even with the aid of "a priori" prescribed attributes, remains a critical phase of MDS.

Hypothesis 3:

A "monotone ascending or descending" relationship exists between stimulus-ideal point distances and actual brand shares. In other words, the ranking of the brands according to their proximity to the "ideal" point corresponds to the ranking of their actual market shares. The distance measure can be stated as:

 $d_{IJ} = \begin{bmatrix} n \\ \sum_{k=1}^{n} (X_{kI} - X_{kJ})^{2} \end{bmatrix}^{\frac{1}{2}}$

This hypothesis was examined by two different methods. For the first method, data consisting of ratings of brands on different characteristics were obtained for forty respondents. The weights of these characteristics, provided by subjects as importance criteria, were used

to build "ideal" brands. Inter-brand proximity measures were computed using an absolute distance formula.¹⁵ The resulting dissimilarities were averaged over forty respondents. They were subsequently rank ordered and submitted to TORSCA-9.¹⁶ Figure 7 exhibits the two-dimensional configuration. The Spearman rank order correlation from Table 8 is 0.97 indicating a good fit between the final configuration and the original data. The stress of 0.02 is regarded as excellent.

TABLE 8

CORRELATIONS--DERIVED DISTANCES TO ORIGINAL DATA "IDEAL" FOINT ANALYSIS WITH IMPORTANCE CRITERION

יים או איז	가지 수사가 드러 가지 않는 것 같은 것 같
Froduct Moment	Spearman-S Rank Difference
<i>ቘቔጞጞቝቚጞቒቔቚጞቚጜቘቚቘቘዀቘዀቔዀቘዀጞቔቔቘዀቚቔቔቘዀቚጞጟዸቘጟቚቘቘቜቔቚቔፙፙቘቘቚቘቚቘቚቘቚቘቚቘቚቘቚቘቚቘቚቘቚቘቚቘቚቘቚቘቚቘቚ</i>	₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩
r = 0.80	$r_{d} = 0.97$
$r^2 = 0.64$	$r_{d}^{2} = 0.94$
መሪያሳይ ነው የሚሰራ የሚሰራ የሚሰራ የሚሰራ የሚሰራ የሚሰራ የሚሰራ የሚሰራ	xxxx her tille dir versch Romannel i na tradiet in verschender van die Volkeling in die sonder war (2008 x 1996) (die 2006)
Stress = 0.023	t = 25.54* with 43 d.f.
*Significant at .001 level	Critical Value = 3.54

In the second method, the coordinates of the points (brands) of the average direct dissimilarity configuration (Figure 1) were obtained by a MDS solution from TORSCA-9. These coordinates, together with the preference scale values¹⁷ of forty subjects were inputed to Carroll and

15 Moinpour and Freedman, "INPUT."

17 The preference scales are shown in Table 20, Appendix B.

¹⁶The lower half matrix of rank order dissimilarities is shown in Table 19, Appendix B.





IDEAL POINT SOLUTION FROM ATTRIBUTES' WEIGHTS (for Average Subject)

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Chang's MDU algorithm. The results of the four levels (hierarchy of four models) of the generalization of the Coombs' unfolding model are presented in Tables 9 and 10 (for more detail review the Unfolding Model Algorithm section of Chapter 3).

TABLE 9

CARROLL AND CHANG UNFOLDING MODELS FOR THE AVERAGE SUBJECT

EXCEPTION CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR C EXPERIMENTAL CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR CONTRACTOR	al 19 a Taun an	አቀምር በተመመለከ የሚያስት የሚያስት የሚያስት የሚያስት በማስተኛ በማ በማስተኛ የተመረ መስከት የሚያስት	an gi Ole-Ma, wanginan ar Carago ay sak-Malak da san werta kermunikan panganan garan garan g Dani werta wanginan dari di kermunikan dari kermunikan kermunikan kermunikan kermunikan kermunikan kermunikan k	ar goog waar ah
	Corre	lations and F Ra	atios for Four	Models
۲۳۸۵۵٬۲۴۱ میلام میکومود وی چان بیکار کوروی مورد و ^{ری} موجه وروان میکور کرد.	Model 1	Model 2	Model 3	Model 4
Correlations				
of Models	0.96	0.96	0.96	0.63
F Ratios of	7.25	12.09*	20.14**	1.95
Mode ls	(5,3) d.f.	(4,4) d.f.	(3,5) d.f.	(2,6) d.f.
*Significant at .05	level	Critical Value =	= 6.39	₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩
**Significant at .01	. level	Critical Value =	= 12.06	

TABLE 10

COMPARISON OF CARROLL AND CHANG'S FOUR MODELS

979 MTL: 9 Saardalah Jumpin 9 dikani ndera dipunya 2971 dikani kang dari 1975 yang dipunya dipunya pada yang 2971 dikani kang dari 1975 yang dipunya dipunya pada yang d	1. Lan Lander M. Lander of State	Ratios Betwee	en Four Model	ganner (ikke adforderschießen bised i sedan eits Gyrnen det gen funds (ik beskeden eise diedig ei "S	an An - Sain an E Than A Shan an Anna an An Anna An
F 12	<u>F 13</u>	<u>F 14</u>	F 23	<u>F 24</u>	F 34
0.00	0.00	6.93	0.001	13.85*	34.63**
(1,3) d.f.	(2,3) d.f.	(3,3) d.f.	(1,4) d.f.	(2,4) d.f.	(1,5) d.f.
*Significar	nt at .05 leve	el Critica	al value = 6	.94	₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩

**Significant at .01 level Critical value = 16.26

Table 9 indicates high correlations for both Models 2 and 3. The fact that correlations for models 1, 2 and 3 are the same is an inherent

feature of the hierarchy of four models when operated on the average subject. From Table 10, however, it can be deduced that no evidence of statistical difference exists between Models 1, 2, and 3, while difference between Model 4 and Models 2 and 3 are statistically significant. This indicates that Models 1 and 2 are not adding anything to Model 3. Consequently the simpler Model 3 provides an adequate fit for the experimental data. It should be noted that while the above conclusion was reached in terms of the average subject, most of the individual cases were found to be in agreement with this result.

Model 3, it is recalled, is the simple Coombsian unfolding with two exceptions: First, preference scale values are related to squares of distances from "ideal" point; second, while different dimensions are weighed equally, negative weights are allowed. This, however, does not present a conceptual problem. It merely suggests that the axis which is negatively weighted presents a dimension of disutility (negative "ideal") rather than utility. Along this negative dimension, the closer the stimulus is to the "ideal" point, the least it is preferred.

Figure 8 shows the result of the preference mapping of the perceptual structure for the average subject. Notice that the inclusion of preference data has not left the stimulus configuration invariant. This follows from the rotation (almost 90°) and differential stretching (2, -1) which have taken place in Models 1 and 2. As a result, the original axes have been interchanged and weighted differently by factors of 2 and -1. This is highly significant since it implies that the perceptual dimensions have taken on different saliences in the context of

Vanquish 🕥 Excedrin 🕥				
Empirin O		Ideal	Alka Seltzer O	·.
Anacin O O Bufferin			Bromoseltzer 🔘	(negatively weighted)
Bayer				
Rexall aspirin				
	FIGURE 8			
RELATING PREFERENCE	TO PERCEPTION	FOR AVERAGE	SUBJECT .	

(Coombsian Unfolding)

preference. Following this initial rotation and differential stretching of the perceptual space Model 3 (simple Coombsian unfolding) which assumes equal weights for the dimensions is accepted as the appropriate model for the data. The second dimension of Figure 8, however, is negatively weighted. This means that along this dimension a monotonically ascending relationship exists between stimulus-Ideal distances and preference. To get a visual appreciation of this phenomenon, simply envision a reflection of the "ideal" point about the origin. Although the perceptual dimensions have changed in the context of preference, it can be surmised that the most highly preferred brands are those located in the third quadrant. These brands possess relatively less strength, but more buffer and fewer side effects.

To test the earlier stated hypothesis, all brand-Ideal distances for both methods (Figures 7 and 8) were examined.¹⁸ The ranking of these distances should correspond to the ranking of the actual brand shares. Measures of brand shares were arrived at by an examination of the actual purchases compiled from the respondents' records of obtained remedies. The result is presented in Table 11.

It can be seen from the above tabulated results that both methods are good predictors of the order of brands' market shares. Both methods accurately predict the first four brand leaders as a group; the second method is more exact in its prediction of the first four within this group. Both models fail to properly place Alka Seltzer. This is

The brand-Ideal distances of Figure 7 and 8 are shown in Table 21, Appendix B.

TABLE 11

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Ĕ₽ĊŸĔĨŀĨĬĊŊŢŊĹŊĊŴġŶĔŀŦŢŀŶŦĨĿĬĦĘŀĬġŸĿĿĿġĸĸĸĿĸŶŶſĔŀŶŗĿĸŊĸţĸĸ ŗ	999 747 979 97 97 19 19 20 19 19 19 19 19 19 19 19 19 19 19 19 19	Predicted	Rank Order
		Method 1	Method 2
Brand	Actual Rank Order	(built ideal)	(Coombs' ideal)
Bayer	1	1	1
Anacin	2	4	2
Excedrin	3	3	4
Alka Seltzer	3	7	8
Bufferin	. 4	2	3
Vanquish	5	5	7
Bromoseltzer	6	8	9
Empirin	7	6	5
Rexall aspirin	8	9	6
	Spearman Rank Order Correlation	$r_{d} = 0.74*$	$r_{d} = 0.61$ *

ACTUAL AND PREDICTED RANK ORDER OF BRAND SHARES

*Significant at .05 level Critical value = .600 partially attributed to the introduction of Alka Seltzer Plus at this time (Fall-Winter, 1969-70) and subsequent regional advertising which accounts for the increase in its market share. The second model seems more convincing in its prediction of Rexall aspirin and Alka Seltzer. It is believed that the high placement of Rexall aspirin is caused by its perceptual association with Bayer (and some private branding effect) and that Alka Seltzer is ridden down by its perceived similarity with Bromoseltzer; the pull exerted by Bayer and Bromoseltzer affecting in opposite direction. Therefore the second model is judged superior in predicting the rank order of actual brand market shares. The accuracy of both models serves as supporting evidence for Hypothesis 3.

Hypothesis 4:

The actual market shares (in %) for various brands can be calculated:

Formula 1) $S_{j} = \frac{1j}{\sum_{j=1}^{n} d_{j}^{2}}$; if monotone ascending

And, a direct relationship exists between the square of stimulus-Ideal point distances and the actual size of the brands' market shares:

Formula 2) $S_i = M f(d_{1i}^2)$; if monotone ascending The constant of proportionality, M, will be estimated by the least squares method.

To evaluate the above hypothesis, square of brand-Ideal point distances of the Coombsian unfolding solution were used. Formula 1 was employed to obtain predicted brands' market shares. These values were compared to actual market shares which were compiled from the respondents' records of obtained remedies. The results are presented in Table 12.

To utilize Formula 2, it becomes necessary to estimate M, the constant of proportionality. This is carried out by the least squares method. Simply stated, M is chosen so that the sum of the squared deviations between the actual and predicted brand shares is minimized. The procedure is as follows:¹⁹

¹⁹ The complete derivation of M is presented in Appendix D.

TABLE 12

		Fredicted	Market Shares (%)
Brand	Actual Market Shares (%)	Formula	1 Formula 2
Bayer	34.36	15.04	16.45
Anacin	14.87	14.18	15.51
Excedrin	14.36	11.30	12.36
Alka Seltzer	14.36	9.36	10.24
Bufferin	13.08	11.91	12.91
Vanquish	4.36	9.44	10.33
Bromoseltzer	2.31	7.95	8.69
Empirin	1.28	11.05	12.09
Rexall aspirin	1.03	9.89	10.82

ACTUAL AND PREDICTED BRANDS' MARKET SHARES

Let predicted values equal $\hat{S}_{j} = M (d_{1j}^{2})$ And actual values equal S_{j} Then the desired M is calculated from:

$$\frac{d}{dM} = \frac{\sum_{j=1}^{n} (S_j - M(d_{1j}^2)) = 0}{\sum_{j=1}^{9} S_j d_{1j}^2} = 2.50$$

$$\frac{9}{\sum_{j=1}^{9} d_{1j}^4} = 2.50$$

The square of brand-Ideal point distances and the above M were put in Formula 2 to predict market shares. The results are also shown in Table 12. It seems that both Formulas 1 and 2 adequately predict brand shares in middle ranges; but they fail to give accurate descriptions at either extremities. This is the result of an averaging process caused by the minimum dispersion of the stimulus points in the Coombsian unfolding model. This could in turn be the result of the nature of problem solving and the importance of the purchase decision (perceived risk) in this area of self-medication behavior. Furthermore, the incongruity of the concept of preference in the context of ill-being may have contributed to the insensitivity of the Ideal-brand distances.

While neither model (Formulas 1 and 2) provides conclusive results, they should be viewed as first approximations to the preservations of the hypothesized relationships. Other theorized constructs need certainly to be investigated in order to find the true marphology. However, it should be noted that any criticism of the models (Formulas 1 and 2) should be directed to the inputs (insensitive Ideal-brand distances), and not to the hypothesized relationships. Consequently, Hypothesis 4 is supported.

Individual Differences

While no direct attempt has been made to examine individual differences in perception, the preferential mapping of the perceptual space (hypotheses 3 and 4) did provide some meaningful insight. The evaluation of hypotheses 3 and 4 pointed out the simple Coombsian unfolding model as being the most appropriate for the data. It will be recalled

that this model assumes that the same set of dimensions of the stimuli configuration hold for all individuals. In other words, the underlying perceptual structure of the stimuli is the same for all individuals.

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CHAPTER V

SUMMARY AND CONCLUDING COMMENTS

Summary

Hypothesis 1:

The configuration of the stimuli set will be obtained in a space of low dimensionality (i.e., two dimensions).

Ranked dissimilarity data, representing expressions of the relative similarity of pairs of stimuli, for the average subject were obtained. The final solution consisted of the stimuli set (the nine brands) as points in a Euclidean space of two dimensions. In this configuration, the relative positions of brands indicate how similar they have been viewed by the average respondent. Four clusters were distinguished: Alka Seltzer and Bromoseltzer; Vanquish, Excedrin and Empirin; Anacin and Bufferin; and Bayer and Rexall aspirin. Two tentative labels of "Buffer" and "Strength" were assigned to the dimensions of the configuration. It was noted that the overriding amount of buffer in alkalizers may have caused the polarization of the product space.

To control for the nonhomogeneity of the product space, a reduced configuration of sevel brands (without alkalizers) for the average subject was also obtained. In addition, the effect of varying amounts

of information on the stimuli set was investigated. It was shown that the absence of information (brand awareness) causes the particular brand to be perceived less favorably than other products.

Hypothesis 2:

The configuration of the stimuli set will remain invariant over different kinds of data (direct vs. indirect similarity data).

Inter-stimulus proximity measures, for the average subject, were computed using ratings of brands on different characteristics. The derived indirect dissimilarities were obtained by an absolute distance formula (a special program was written for this). The stimuli set (the nine brands) was represented as points in a Euclidean space of two dimensions.

A comparison of this configuration (obtained from indirect dissimilarities) with the previously obtained configuration (resulting from direct dissimilarities) supported the above hypothesis. It was shown that while some of the points (brands) had altered their positions, the overall composition of the two configurations had remained the same. In particular, it was pointed out that both profiles exhibited similar polarization regarding alkalizers. Furthermore, the Vanquish-Excedrin-Empirin cluster was located in the same quadrants in both coordinate systems (configurations).

In addition, the effect of weights on different product characteristics was investigated. This was done by obtaining the stimuli configuration in terms of weighted attributes which was subsequently compared with the previously obtained unweighted case for congruence. The stimuli (brands) configuration remained invariant over both weighted and unweighted attributes. It was concluded therefore that consumers, when rating different products on different characteristics, take into account the importance of these characteristics (i.e., the salience is reflected in the scale value).

Interpretation of Dimensions

For a better understanding of the dimensions of the stimuli space, the configuration of the attributes set was constructed. This was done by computing distance measures, for the average subject, between different attributes. The solution comprised of the stimuli set (the nine characteristics) as points in a Euclidean space of two dimensions. The above configuration was used as a guide to interpret the perceptual dimensions of the original stimuli (brands) configuration. An examination of the attribute space indicated that the previous labels of "Buffer" and "Strength" were appropriate. While some degree of intercorrelations among the attributes were suspected, a review of the reasons given by the respondents for purchasing various brands led to similar results.

Hypothesis 3:

A "monotone ascending or descending" relationship exists between stimulus-Ideal point distances and actual brand shares. In other words, the ranking of the brands according to their proximity to the "ideal" point corresponds to the ranking of their actual market shares. The distance measures can be stated as:

 $\mathbf{d}_{\mathbf{Ij}} = \begin{bmatrix} \mathbf{n} \\ \sum_{k=1}^{n} (\mathbf{X}_{k\mathbf{I}} - \mathbf{X}_{k\mathbf{j}})^2 \end{bmatrix}^{\frac{1}{2}}$

where d_{ij} = distance between brand j and "ideal" point I

This hypothesis was tested by two different methods. For the first method, the importance criteria of product attributes provided by subjects were used to build "ideal" brands. Inter-brand proximity measures, for the average subject, were computed using an absolute distance formula. The stimuli set consisted of the nine real brands and the "ideal" brand; they were represented as points in a Euclidean space of two dimensions. In the second method, the coordinates of the original stimuli set (nine brands) previously determined by a MDS solution (the average direct dissimilarity configuration) were obtained. These coordinates together with the preference scale values of forty subjects were submitted to Carroll and Chang's MDU algorithm. The result of the Coombsian unfolding analysis was the representation of real brands and the "ideal" brand as points in a joint Euclidean space of two dimensions.

To test the above hypothesis, all brand-Ideal distances for both methods were calculated. The ranking of these distances were found to be highly correlated with the ranking of the actual brand shares. Measures of brand shares were arrived at by an examination of the actual purchases compiled from the respondents' records of obtained remedies. While both methods were good predictors of the order of brands' market shares, the Coombsian unfolding model was judged superior.

Hypothesis 4:

The actual market shares (in %) for various brands can be calculated:

Formula 1) $S_j = \frac{d_{Ij}^2}{\sum_{j=1}^n d_{Ij}^2}$; if monotone ascending

And, a direct relationship exists between the square of stimulus-Ideal point distances and the actual size of the brands' market shares:

Formula 2) $S_j = M f(d_{1j}^2)$; if monotone ascending where S_j = share of market for brand j; d_{1j} = stimulus-Ideal distance.

The constant of proportionality, M, will be estimated by the least square method.

To evaluate the above hypothesis, square of brand-Ideal distances of the Coombsian unfolding solution were employed. Formula 1 was used to predict brands' market shares. Also, after solving for M by the least square method, square of brand-Ideal distances were used in Formula 2 to predict brands' market shares. It was indicated that both formulas 1 and 2 adequately predicted brand shares in middle ranges; but they both failed to give accurate descriptions at either end. It should be noted that any criticism of the two models (Formulas 1 and 2) should be directed at the inputs (insensitive distances) and not at the hypothesized relationships. Furthermore, the above models should be viewed as first approximations to true morphology; other theorized constructs need to be investigated.

Individual Differences

While no attempt was made to examine individual differences in perception, the preference mapping of the perceptual space (in hypotheses 3 and 4) did provide some meaningful insight. The evaluation of hypotheses 3 and 4 suggested that Coombsian unfolding model was the most appropriate for the data. This model assumes that all individuals share the same set of dimensions of the stimuli configuration. Accordingly, the underlying perceptual structure of the stimuli set was assumed to be similar for all subjects.

Limitations

The limiting aspects of this research are twofold: The constraints inherent in the MDS techniques and those specific to this study. They are discussed in that order.

General Constraints

1. Perhaps the most important issue, a question still unanswered, is the implementation of MDS as a viable technique. The fundamental concern is with the underlying assumption that perceptual space is Euclidean in character. If the perceptual or cognitive structure of the stimuli

is in fact Euclidean in nature, then an appreciation of attributes configuration can be gained by appropriate employment of MDS techniques. However, if perceptual dimensions of the stimuli consist of several different attributes, with regard to which the stimuli vary simultaneously, then MDS is not the most applicable method. The appropriate structure may be an additive space model (such as Attneave's city block).

2. Criticisms have also been directed at the final solution of MDS algorithms. It has been suggested that the configurations can be generated randomly, and as such they bear no correspondence with the original data. This problem however can be contained by generating the final solution with random starting configurations in the iterative process.

3. It should be noted also that dimension interpretation is a subjective process. This task, even with the aid of "a priori" pre-

4. Another problem, not unique to MDS, is whether such nonmetric solutions provide an accurate account of all the information in the original data.

5. Finally, there is concern about the practical dimension of data collection techniques. If the stimuli set is increased, the needed experimental observations will become quite overwhelming in number. This, in turn, could lead to subjects' fatigue and consequent noise in the data.

Specific Constraints

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1. The randomness of the sample is not a critical concern in this study since the purpose of this research has been to evaluate a set of hypothesized relationships. It should again be noted that these relationships were tested in terms of a specific product category (headache and pain remedies), a relative small sample, and a specific geographic location.

2. Any predictive generalization of models tested in this study to other product groups should await the caliberation of the constant of proportionality, M, for the particular product category.

Future Research

Because of the importance of the MDS techniques in marketing, further research in this area is needed. As in all fruitful research, this study has provided meaningful questions which can serve as areas for future investigations. A few are offered in way of general directions:

- More studies are needed to obtain estimates of M, the constant of proportionality, for various product categories.
- 2. Investigation of the applicability of the model suggested in this study as well as other aspects of MDS techniques are highly desirable. These investigations should be carried out over both new and established products.

- Patterns of product use (both within and between product classes) over time need to be studied by obtaining perceptual maps of products (similar to panel designs).
- 4. This study has indicated a certain trade off between headache remedies and alkalizers. Of interest is a possible area of intersection between headache and pain remedies, cold remedies and alkalizers.
- 5. An understanding of how an individual's predispositions to behave are altered by situational factors and amounts of information can be highly significant to the area of advertising effectiveness. This can be examined by intelligent use of MDS in monitoring the process of information.
- Multidimensional unfolding as a predictive tool should be compared to other predictive models using preference scale values directly.
- 7. Judgments of similarity are used to obtain a perceptual structure on which judgments of preference are superimposed yielding a common space of objects and individuals. Are the dimensions of this space expressions of <u>psychologi</u>cal measure of utility?
- Efforts are needed to alleviate the burden of often long and tedious data collection instruments needed to input MDS algorithms.

9. One method for solving the problem of data collection may be found in the use of golvanic skin response (CSR) and pupil dialation (PMR) techniques in conjunction with MDS. The use of GSR and PMR for data collection to input MDS may also alleviate the symbolic limitations of verbal communication by providing for direct observation of the perceptual process.

APPENDIX A

QUESTIONNAIRE PACKAGE

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A1_____ Date

BRAND DATA QUESTIONNAIRE

Headache and Pain Remedies

Following are several questions concerning your "feelings" about certain products. Please answer each question about each product, EVEN IF YOU HAVE NOT TRIED THE PRODUCT OR ARE NOT CURRENTLY USING THE PRODUCT.

Following are several brands of headache and pain remedies; please examine this list carefully and indicate if you have <u>not heard</u> of any brand(s) by placing an \underline{x} next to the brand(s).

Rexall aspirin
Alka Seltzer
Empirin
Bufferin
Anacin
Bayer
Bromoseltzer
Excedrin
Vanquish

Following are pairs of headache and pain remedies brands you have just examined; please indicate how similar you believe the pairs of brands are by:

a. circling 1 if you think they are very similar,

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- b. circling 10 if you think they are very dissimilar, or
- c. somewhere in between depending on how similar you believe the brands are. (Circle one number for each pair of brands.)

			Similar								DISSIMIAAT			
Rexall	aspirin	-	Alka Seltzer	1	2	3	4	5	6	7	8	9	10	
Rezall	aspirin	-	Empirin	1	2	3	4	5	6	7	8	9	10	
Rexall	aspirin		Bufferin	1	2	3	4	5	6	7	8	9	10	
Rexall	aspirin		Anacin	1	2	3	4	5	6	7	8	9	10	
Rexall	aspirin	-	Bayer	1	2	3	4	5	6	7	8	9	10	
Rexall	aspirin	4-8	Bromoseltzer	1	2	3	4	5	6	7	8	9	10	
Rexal1	aspirin		Excedrin	1	2	3	4	5	6	7	8	9	10	

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	Similar						<u>r</u>	iss	imi	lar
Rexall aspirin - Vanquish	1	2	3	4	5	6	7	8	9	10
Alka Seltzer - Empirin	1	2	3	4	5	6	7	8	9	10
Alka Seltzer - Bufferin	1	2	3	4	5	6	7	8	9	10
Alka Seltzer - Anacin	1	2	3	4	5	6	7	8	9	10
Alka Seltzer - Bayer	1	2	3	4	5	6	7	8	9	10
Alka Seltzer - Bromoseltzer	1	2	3	4	5	6	7	8	9	10
Alka Seltzer - Excedrin	1	2	3	4	5	6	7	8	9	10
Alka Seltzer - Vanquish	1	2	3	4	5	6	7	8	9	10
Empirin - Bufferin	1	2	3	4	5	6	7	8	9	10
Empirin - Anacin	1	2	3	4	5	6	7	8	9	10
Empirin - Bayer	1	2	3	4	5	6	7	8	9	10
Empirin - Bromoseltzer	1	2	3	4	5	6	7	8	9	10
Empirin - Excedrin	1	2	3	4	5	6	7	8	9	10
Empirin - Vanquish	1	2	3	4	5	6	7	8	9	10
Bufferin - Anacin	1	2	3	4	5	6	7	8	9	10
Bufferin - Bayer	1	2	3	4	5	6	7	8	9	10
Bufferin - Bromoseltzer	1	2	3	4	5	6	7	8	9	10
Bufferin - Excedrin	1	2	3	4	5	6	7	8	9	10
Bufferin - Vanquish	1	2	3	4	5	6	7	8	9	10
Anacin - Bayer	1	2	3	4	5	6	7	8	9	10
Anacin - Bromoseltzer	1	2	3	4	5	6	7	8	9	10
Anacin - Excedrin	1	2	3	- 4	5	6	7	8	9	10
Anacin - Vanquish	1	2	3	4	5	6	7	8	9	10
Bayer - Bromoseltzer	1	2	3	4	5	6	7	8	9	10
Bayer - Excedrin	1	2	3	4	5	6	7	8	9	10
Bayer - Vanquish	1	2	3	4	5	6	7	8	9	10
Bromoseltzer - Excedrin	1	2	3	4	5	6	7	8	9	10
Bromoseltzer - Vanquish	1	2	3	4	5	6	7	8	9	10
Excedrin - Vanquish	1	2	3	4	5	6	7	8	9	10 ·

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Following are some brands of headache and pain remedies. Please indicate your preference by:

- a. circling 1 if, all things considered, the brand is most acceptable for use in your family
- b. circling 10 if, all things considered, the brand is most objectionable for use in your family
- c. or circling somewhere in between depending on how generally acceptable or unacceptable you believe the brand is. (Circle one number for each brand.)

	Acceptable						<u>Unacceptable</u>				
Rexall aspirin	1	2	3	4	5	6	7	8	9	10	
Alka Seltzer	1	2	3	4	5	б	7	8	9	10	
Empirin	1	2	3	4	5	б	7	8	9	10	
Bufferin	1	2	3	4	5	6	7	8	9	10	
Anacin	1	2	3	4	5	6	7	8	9	10	
Bayer	1	2	3	4	5	6	7	8	9	10	
Bromoseltzer	1	2	3	4	5	6	7	8	9	10	
Excedrin	1	2	31	4	5	6	7	8	9	10	
Vanquish	1	2	3	4	5	6	7	8	9	10	

Following are some attributes for the product category of headache and pain remedies. Now, in buying one brand of headache and pain reliever versus another, how important is each of the following to you?

- a. The lower the number you circle, the more important you think the attribute is;
- b. The <u>higher</u> the number you circle, the less important you think the attribute is. (Circle one number for each attribute).

	Impo	rtan	t	Unimportant				
Pleasant taste	1	2	3	4	5	6		
Low price	1	2	3	4	5	6		
Speed of relief	1	2	3	4	5	6		
Few side effects	1	2	3	4	5	6		
Easy to take	1	2	3	4	5	6		
Dissolves fast	1	2	3	4	5	6		
Extra strength	1	2	3	4	5	6		
Many ingredients	1	2	3	4	5	6		
Relieves headache and pain	1	2	3	4	5	6		

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Now I would like you to think about these attributes for each brand. Circle a:

- a. 1 if you think the brand is very satisfactory in the attribute (sat.),
- b. 6 if you think the brand is <u>very unsatisfactory</u> in the attribute (unsat.),
- c. or somewhere in between depending on how well you are satisfied with the brand in terms of the given attribute.

Please indicate your "feelings" about the brand even though you have not tried it or do not currently use it. (Circle one number for each brand.)

Pleasant taste

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Low Price

	Sat	•		U	Insa	t.		Sat	•		Ľ	Insa	t.
Rexall aspirin	1	2	3	4	5	6	Rexall aspirin	1	2	3	4	5	6
Alka Seltzer	1	2	3	4	5	6	Alka Seltzer	1	2	3	4	5	6
Empirin	1	2	3	4	5	6	Empirin	1	2	3	4	5	6
Bufferin	1	2	3	4	5	6	Bufferin	1	2	3	4	5	6
Anacin	1	2	3	4	5	6	Anacin	1	2	3	4	5	6
Bayer	1	2	3	4	5	6	Bayer	1	2	3	4	5	6
Bromoseltzer	1	2	3	4	5	6	Bromoseltzer	1	2	3	4	5	6
Excedrin	1	2	3	4	5	6	Excedrin	1	2	3	4	5	6
Vanquish	1	2	3	4	5	6	Vanquish	1	2	3	4	5	6
Speed of re	lie	f					Few side ef	fec	ts				
Rexall aspirin	-`	2	3	4	5	б	Rexall aspirin	1	2	3	4	5	6
Alka Seltzer	1	2	3	4	5	6	Alka Seltzer	1	2	3	4	5	6
Empirin	1	2	3	4	5	6	Empirin	1	2	3	4	5	6
Bufferin	1	2	3	4	5	6	Bufferin	1	2	3	4	5	6
Anacin	1	2	3	4	5	6	Anacin	1	2	3	4	5	6
Bayer	1	2	3	4	5	6	Bayer	1	2	3	4	5	6
Bromoseltzer	1	2	3	4	5	6	Bromoseltzer	1	2	3	4	5	6
Excedrin	1	2	3	4	5	6	Excedrin	1	2	3	4	5	6
Vanquish	1	2	3	4	5	6	Vanquish	1	2	3	4	5	6

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Easy to take							Dissolves f	ast				•	
	Sat	•			Uns	at.		Sat				Uns	at.
Rexall aspirin	1	2	3	4	5	6	Rexall aspirin	l	2	3	4	5	6
Alka Seltzer	1	2	3	4	5	6	Alka Seltzer	1	2	3	44	5	6
Empirin	1	2	3	4	5	6	Empirin	1	2	3	4	5	6
Bufferin	1	2	3	4	5	6	Bufferin	1	2	3	4	5	6
Anacin	1	2	3	4	5	6	Anacin	1	2	3	4	5	6
Bayer	1	2	3	4	5	6	Bayer	1	2	3	4	5	6
Bromoseltzer	1	2	3	4	5	6	Bromoseltzer	1	2	3	4	5	6
Excedrin	1	2	3	4	5	6	Excedrin	1	2	3	4	5	6
Vanquish	1	2	3	4	5	6	Vanquish	1	2	3	4	5	6
<u>Extra strei</u>	<u>ng th</u>	<u> </u>					Many ingred	ien	ts				
Rexall aspirin	1	2	3	4	5	6	Rexall aspirin	1	2	3	4	5	6
Alka Seltzer	1	2	3	4	5	6	Alka Seltzer	1	2	3	4	5	6
Empirin	1	2	3	4	5	6	Emp ir in	1	2	3	4	5	6
Bufferin	1	2	3	4	5	6	Bufferin	1	2	3	4	5	6
Anac in	1	2	3	4	5	6	Anacin	1	2	3	4	5	6
Bayer	1	2	3	4	5	6	Bayer	1	2	3	4	5	6
Bromoseltzer	1	2	3	4	5	6	Bromoseltzer	1	2	3	4	5	6
Excedrin	1	2	3	4	5	6	Excedrin	1	2	3	4	5	6
Vanquish	1	2	3	4	5	6	Vanquish	1	2	3	4	5	6
Relieves He	eada	che	an	d F	ain								
Rexall aspirin	1	2	3	4	5	6							
Alka Seltzer	1	2	3	4	5	6							
Empirin	1	2	3	4	5	6							
Bufferin	1	2	3	4	5	6							
Anacin	1	2	3	4	5	6							
Bayer	1	2	3	4	5	6							
Bromoseltzer	1	2	3	4	5	6							
Excedrin	1	2	3	4	5	6							
Vanquish	1	2	3	4	5	6							

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Now, just to sum up, I would like you to take another look at the brand names. This time I would like for you to rank the brands by marking a 1 next to your favorite brand, a 2 next to your second favorite brand, and so on. If your favorite brand is not listed please write it in the space provided. However, still rank the given brands in order of preference even if you are not currently using them.

> Rexall aspirin Alka Seltzer Empirin Bufferin Anacin Bayer Bromoseltzer Excedrin Vanquish Favorite brand:

Date____

C___

CONSUMER CHARACTERISTICS DATA

Please answer the following questions and provide the necessary information for each member of the household

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Name	Relationship to head of Household	Sex	Date of Birth	Marital Status: M,W,D, Sep., Never M	Highest grade of school completed: (enter number) 7) under 7 years 6) 7 to 9 years 5) 10 to 11 years 4) High school graduate 3) 1-3 years any college 2) College graduate 1) Post graduate
				a de la contra de la	
••••••••••••••••••••••••••••••••••••••					

1 , Would you give an estimate of the total family income for 1968 before deductions:

bel	ow \$5,000	(1)	SOUTH TOWNSHIP	\$12,500	- \$14,999	(5)
\$5 ,	000 - \$7,999	(2)	and the line offered lange	\$15,000	- \$24,999	(6)
\$8,	000 - \$9,999	(3)	annahan postanahaa	\$25,000	and over	(7)
\$10	,000 - \$12,499	(4)				

Who in the family does most of the actual drug purchasing?

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Husband Wife Grandparents Other

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Name	(of	Household	i):	₩₩₽₽₩ \$₩₩₽₽₽₩₽₩₩₽₽₩₽₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩₩
Addre	235:	ባለሚያ ነር ይነውውን ተርጉራ የአይንሥሙ		≈
Telep	hone	number:	-	

Date

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REMEDY INVENTORY

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Remedy Name (Brand)	Date Obtained	Amount Obtained	Price (if purchased)
1.			
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			

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Date

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RECORD OF REMEDIES OBTAINED

Fill out one of these forms every time a remedy is purchased or otherwise obtained by any member of the household. Put only one remedy on this page.

Name of remedy (use brand name):
Amount obtained:
Date obtained:
Price (if purchased):

What was the most important reason that this particular remedy was chosen?

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APPENDIX B

SUPPORTING TABLES

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THE LOWER HALF MATRIX OF RANK ORDER DISSIMILARITIES FOR FIGURE 1

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Carried ()									بمرسارية الأنام فيعاصل سريانك
	Rexall aspirín	Alka Seltzer	Empirin	Bufferin	Anacin	Bayer	Bromo- seltzer	Excedrin	Vanquish
Rexall aspirin									
Alka Seltzer	31								
Empirin	. 18	21							
Bufferin	14	25	9						
Anacin	15	29	8	2					
Bayer	1	32	14	7	6				
Bromoseltzer	33	3	27	25	23	30	Catalon .		
Excedrin	19	22	5	9	11	16	28		
Vanquish	20	24	13	10	12	17	26	4	

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TABLE	14
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THE LOWER HALF MATRIX OF DISSIMILARITIES FOR FIGURE 2

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Rexall aspirin	Empirin	Bufferin	Anacin	Bayer	Excedrin	Vanquish
11 .						
13	8		·			
14	7	2				
1	13	б	5			
18	4	8	10	15		
19	12	9	11	16	3	
	Rexall aspirin 11 13 14 1 18 19	Rexall aspirin Empirin 11 13 8 14 7 1 13 18 4 19 12	Rexall Ampirin Bufferin 11	Rexall aspirin Empirin Bufferin Anacin 11	Rexall aspirin Empirin Bufferin Anacin Bayer 11	Rexall aspirin Empirin Bufferin Anacin Bayer Excedrin 11

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THE LOWER HALF MATRIX OF RANK ORDER DISSIMILARITIES FOR FIGURE 3

			. ·						
	Rexall aspirin	Alka Seltzer	Empirin	Bufferin	Anacin	Bayer	Eromo- seltzer	Excedrin	Vanquish
Rexall aspirin									
Alka Seltzer	26								
Empirin	16	19							
Bufferin	10	22	15						
Anacin	9	21	11	1					
Bayer	4	23	13	1	2				
Bromoseltzer	26	3	20	28	6	27			
Excedrin	14	21	17	2	7	5	25	*****	
Vanquish	12	25	18	5	7	8	24	6	

TABLE	16
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THE LOWER HALF MATRIX OF DISSIMILARITIES FOR FIGURE 4

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	Rexall accirin	Alka	Empirin	Bufforin	Anacin	Bawar	Bromo-	Freedrin	Varquich
	aspirin	JEILZEL	Emp EL 211	_Durrer III	Anacth	Dayer	seitzei	Excedin	vanquisn
Rexall aspirin									
Alka Seltzer	24	*****							
Empirin	12	28	—			•			
Bufferin	14	27	6	6					
Anacin	20	15	10	3					
Bayer	13	16	19	5	l				
Bromoseltzer	29	2	23	35	21	26			
Excedrin	25	32	8	7	8	17	34		
Vanquish	18	31	4	9	11	22	30	1	
-									

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4									
	Rexall aspirin	Alka Seltzer	Empirin	Bufferin	Anacin	Bayer	Bromo- Seltzer	Excedrin	Vanquish
Rexall aspirin	Constants								
Alka Seltzer	26								
Empirin	16	27							
Bufferin	16	20	9						
Anacin	23	15	12	7					
Bayer	14	18	24	10	4	din 200			
Bromoseltzer	33	2	25	32	17	22			
Excedrin	21	30	5	б	8	19	28		
Vanquish	20	31	3	11	13	23	29	1	

THE LOWER HALF MATRIX OF DISSIMILARITIES FOR FIGURE 5

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			•	-					
الی کے دیکھی ایک میں ایک میں ہے۔ ایک کی کی ایک ایک میں ایک میں ہے کہ ایک ایک کر ایک میں ایک ایک کر ایک ایک ہی کے ایک کر ایک ایک ایک ایک کر ایک ک	Pleasant Taste	Low Price	Speed of Relief	Few side Effects	Easy to Take	Dissolves Fast	Extra Strength	Many Ingredients	Relaxes Headache and Pair
Pleasant taste									
Low Price	29	******						. ,	
Speed of Relief	20	19							
Few Side Effects	31	21	4						
Easy to Take	24	32	13	7	-				
Dissolves fast	30	22	10	4	15				
Extra Strength	28	26	6	16	25	13			
Many ingredients	27	17	11	14	26	12	2		
Relieves headache and pain	23	18	1	5	9	7	3	8	

THE LOWER HALF MATRIX OF DISSIMILARITIES FOR FIGURE 6

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THE LOWER HALF MATRIX OF DISSIMILARITIES FOR FIGURE 7

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	"Ideal" brand	Rexall aspirin	Alka Seltzer	Empirin	Bufferin	Anacin	Bayer	Bromo- Seltzer	Excedrin	Vanquish
"Ideal" brand										
Rexall aspirin	42									
Alka Seltzer	41	24								
Empirin .	40	12	28							
Bufferin	38	14	27	6						
Anacin	35	20	15	10	3					
Bayer	36	13	16	19	5	3				
Bromoseltzer	43	29	2	23	34	21	26			
Excedrin	37	25	32	8	7	8	17	33		
Vanquish	39	18	31	4	9	11	22	30	1	6 j>

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	Rexal1	Alka	· · · · ·				Bromo-		
Subjects	aspirin_	Seltzer	Empirin	Bufferin	Anacin	Bayer	seltzer	Excedrin	Vanquish
1	c	0	1.	0	5	7	-7	-1	5
1 2	10	10	ې ۱0	о 2	J	2	10	<u> </u>	ر د
2	6	2	<u>ح</u>	<u>ب</u> ح	7	2	10	4 5	ך ר
5	1	5	5	5	7	2	5	5	5
5	<u> </u>	± 7	1	ך ז	6		8	1	2
5	-+	10	4	4	С 4		10	L Li	С 4
7	7	1	5	4	2	1	2	2	
8	7	5	ī	7	1	1	5	1	1
Ģ	2	1	3	1	1	7	1	5	2
10	8	3	7	2	2	2	5	1	- 1
11	1	1	, 1	1		1	1	1	7
12	1	ī	5	1	1	3	ĩ	1	1
13	1	1	1	-	- 1	1	1	ĩ	ĩ
14	5	2	2	2	2	1	5	2	2
15	10	2	1	2	2	10	2	- 1	ī
16	3	5	8	5	- 7	3	5	$\tilde{2}$	Ļ.
17	5	5	5	2	5	1	5	10	10
18	3	10	3	2	1	2	10	1	3
19	1	4	1	1	1	1	1	$\overline{1}$	1
20	10	1	-	5	1	5	2	ī	1
21	1	1	1	1	1	1	1	1	1
22	1	10	3	3	3	1	10	2	3
23	2	7	2	2	2	1	9	1	2
24	8	10	3	1	1	1	10	1	4
25	3	3	5	3	3	1	1	3	3

THE PREFERENCE SCALE VALUES

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ىرىكى بەر بەر يەر بەر مەلەر <u>بەر مە</u> لەر <u>بەر مە</u>	Rexall	Alka	•		فندا فاز بالكر في بين محم محمد با	<u></u>	Bromo-		
Subjects	aspirin	Seltzer	Empirin	Bufferin	Anacin	Bayer	seltzer	Excedrin	Vanguish
26	10	2	10	10	2	1	1	10	10
27	1	1	5		1	1	10		
28	5	7	5	2	2	ī	1	1	8
29	2	10	2	2	2	1	10	-	2
30	1	1	2	1	1	1	2	7	. 7
31	5	1	5.	1	1	1	5	5	5
32	5	. I	6	1	1	1	1	10	7
33	5	8	2	1	1	1	8	4	5
34	2	1	2	1	1	1	1	1	1
35	2	1	9	1	ī	1	4	1	3
36	1	4	2	2	2	1	4	6	6
37	1	1	3	1	1	1	7	8	6
38	1	1	5	1	1	1	1	1	1
39	10	7	7	4	1	1	3	5	5
40	8	1	6	3	1	1	5	1	3
Average	3.825	3.975	3.950	2.525	1.875	1.700	4.750	3.100	3.900

Brand	Brand - Ideal Distance Figure 7	for Figures 7 and 8 Figure 8*
Rexall aspirin	2.311	-4.327
Alka Seltzer	2.190	-4.096
Empirin	2.168	-4.834
Bufferin	2.005	-5.163
Anacin	2.031	-6.203
Bayer	1.996	-6.580
Bromoseltzer	2.302	-3.477
Excedrin	2.019	-4.943
Vanquish	2.122	-4.132

THE BRAND - IDEAL DISTANCES

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*Negatively weighted square distances.

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APPENDIX C

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INPUT, A FORTRAN PROGRAM

INPUT, A Fortran 4 Program for computing Interstimulus proximity measures from a set of attribute scores, Reza Moinpour and Richard J. Freedman, The Ohio State University, January, 1970.

Description: For n objects rated in terms of m weighted and/or unweighted attributes, this program finds an ordered vector of n(n-1)/2proximity measures via an absolute value distance formula:

$$d_{ij} = \sum_{k=1}^{m} W_k \left| X_{ik} - X_{jk} \right|$$

Where d_{ij} = distance between any two objects i and j X_{ik} = the scale value of attribute k for object i X_{jk} = the scale value of attribute k for object j W_k = the weight of attribute k; $W_k = 1$ if attributes are weighted equally.

This program also offers two additional features: Same distance formula is used to generate an ordered vector of m(m-1)/2 proximity measures for m attributes; and a composite attribute score for each object is provided:

$$c_i = \sum_{k=1}^m W_{k_i}$$

Where $C_i = \text{composite score for object C (C: 1,...n)}$

k = attributes for object i (k: 1,...m)
W = weight of attribute k

Input: Input for this program consists of m attribute scores (weighted or unweighted) for n objects.

Output: The output consists of:

1. n composite scores, c,, for N subjects

- N ordered vector of n(n-1)/2 proximity measures (weighted attributes); for N subjects.
- An average ordered vector of n(n-1)/2 proximity measures (weighted attributes)
- 4. N ordered vector of n(n-1)/2 proximity measures (unweighted attributes); for N subjects.
- An average ordered vector of n(n-1)/2 proximity measures (unweighted attributes)
- N ordered vector of m(m-1)/2 proximity measures of attributes; for N subjects.

Limitations: N=40; n=9; and m=9. However, these boundaries can easily be adjusted to accommodate desired results.

Execution Time: Computer time depends on level of N, n and m. On the IBM System/360-75, less than one minute is needed when N=40, n=9, and m=9.

APPENDIX D

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DERIVATION OF M

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Derivation of Constant M.

Let predicted brand's market share be given by

$$\hat{S}_{j} = M(d_{1j}^{2})$$

And actual brands' market share equal S.

Then the value of M which minimizes $\sum_{j=1}^{n} (s_j - s_j)^2$ is calculated as follows:

$$\frac{d}{dM} = \sum_{j=1}^{n} \left[(S_j - M(d_{1j}^2)) \right]^2 = 0$$

$$\sum_{j=1}^{n} 2 \left[S_j - M(d_{1j}^2) \right] \left[-d_{1j}^2 \right] = 0$$

$$\sum_{j=1}^{n} \left[-2S_j d_{1j}^2 + 2M(d_{1j}^4) \right] = 0$$

$$-2 = \sum_{j=1}^{n} S_j d_{1j}^2 + 2M = \sum_{j=1}^{n} d_{1j}^4 = 0$$

$$-2 = \sum_{j=1}^{n} S_j d_{1j}^2 = -2M = \sum_{j=1}^{n} d_{1j}^4$$

$$M = \frac{\sum_{j=1}^{n} S_j d_{1j}^2}{\sum_{j=1}^{n} d_{1j}^4}$$

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