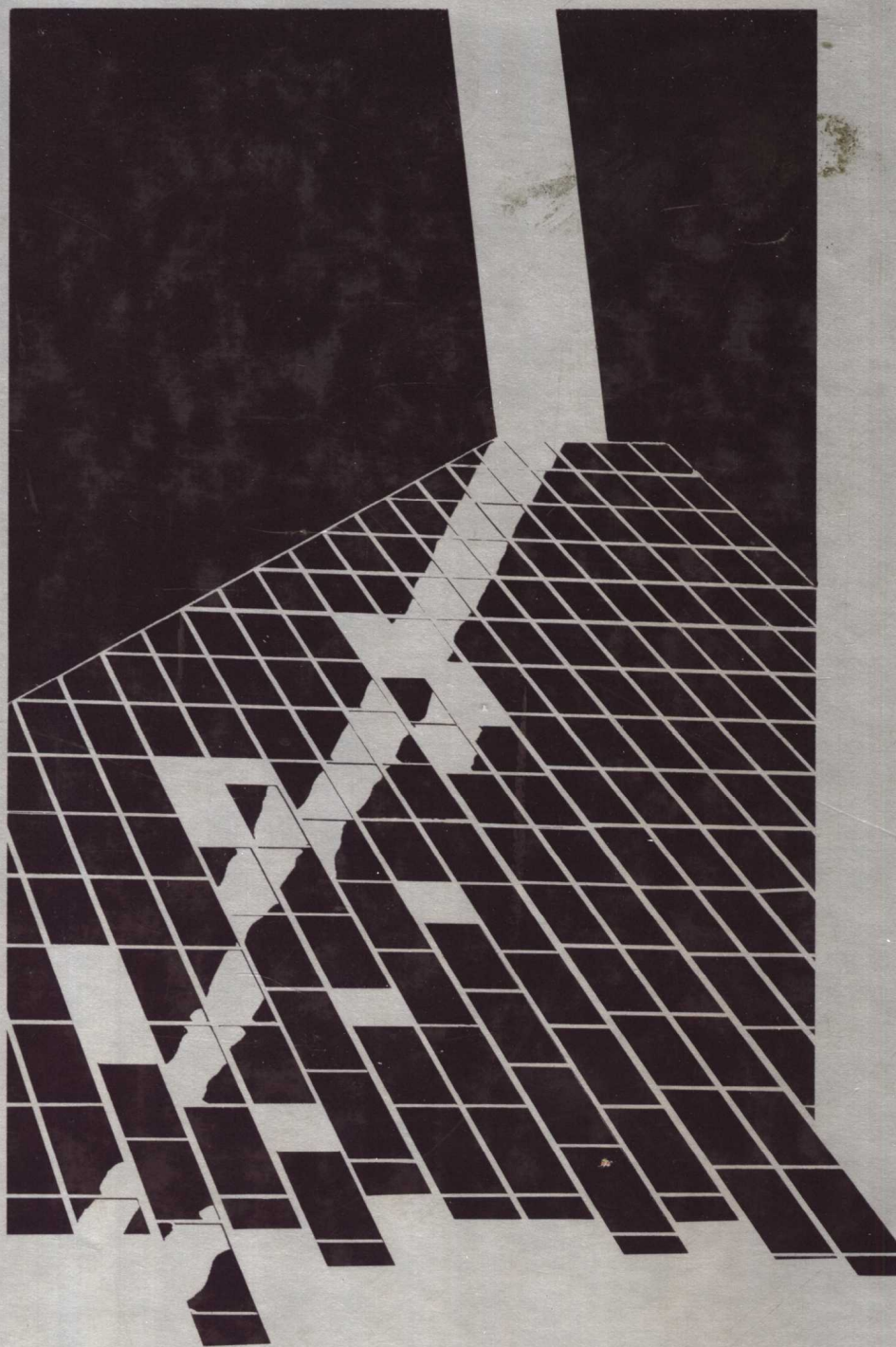


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Multidimensional Scaling

CONCEPTS AND APPLICATIONS

MULTIDIMENSIONAL SCALING

Concepts and Applications

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PREFACE

The earlier version of this book (P.E. Green and F.J. Carmone, *Multi-dimensional Scaling and Related Techniques in Marketing Analysis*, Allyn and Bacon, 1970) was devoted to examining the applicability of multi-dimensional scaling and related techniques to substantive problems in marketing. Now almost twenty years later we have been joined by Scott Smith to bring these procedures into the age of microcomputers. Although most of the techniques discussed in the original book were developed (beginning in 1962) by researchers in the behavioral and life sciences, marketing research practitioners and academics have found them very useful.

The large number of articles appearing in the last twenty years in the professional marketing journals—such as the *Journal of Marketing Research* and the *Journal of Marketing*—using these techniques, attests to their usefulness. This edition continues to provide an applied approach to the presentation of the theory and is more self contained—that is, a selected suite of computer programs is included and discussed in some depth to enable the reader actually to use versions of the algorithms on a personal computer.

It is appropriate to repeat here a statement made in the original text, "... the experience of working in the rapidly evolving field has been both exciting and frustrating. It has been exciting because it seems to us that multi-dimensional scaling methodology provides a new prospective for approaching some particularly thorny behavioral research problems. It has been frustrating because, as this Preface is being written, we are aware that our statement will soon be obsolete—such is the pace with which technical developments in the field are occurring." Almost twenty years later, these comments remain true except we have learned that some of the earlier techniques have not been rendered completely obsolete by later developments. What seems to be happening is an evolution from the isolated, stand-alone algorithms and their associated computer programs to more highly refined decision support systems in the form of computer programs linked together by a common program structure and philosophy. These decision support systems, such as POSSE (Green, Carroll, Goldberg, 1981) and MDS(X) (University of Edinburgh) represent many man years and thousands of dollars in development and, thus, are not readily available to the majority of the student, researcher, or more casual professional users.

This edition of the text, which includes programs for microcomputers, is an attempt to continue to disseminate information about MDS to an ever-increasing group of students, teachers, and practitioners in marketing. The selection of specific computer programs for inclusion was governed by what is publicly available. Most of the older programs are in the public domain and could be converted for use on microcomputers. These versions were originally distributed (for reproduction costs) by Bell Telephone Laboratories, Marketing Science Institute, Forrest Young, James Lingoes, and others. The newer, more integrated and conceptually enhanced versions of these programs are not as easily available and certainly not priced at reproduction cost.

Throughout the text, the reader will note repeated references to computer methodology. Although the technical level of our presentation is not high, the methodology described owes its existence to the types of computation and complex data handling provided only by computer-based algorithms. The increased availability of microcomputers has made this methodology more accessible and useful.

Because we try to write in a simplistic, nonmathematical and easy to understand manner, more advanced readers will probably want to supplement this text with more theoretical books, such as *The User's Guide to Multidimensional Scaling* by A.P.M. Coxon or *Introduction to Multidimensional Scaling: Theory, Methods and Applications* by Susan S. Schiffman, M. Lance Reynolds, and Forrest W. Young; *Multidimensional Scaling* by Joseph B. Kruskal and Myron Wish; *Three-Way Scaling and Clustering* by Phipps Arabie, J. Douglas Carroll, and Wayne S. DeSarbo; and *Multidimensional Scaling* by Mark L. Davison—all published since our earlier edition of this book. These texts contain more detailed discussions of enhanced multidimensional scaling algorithms and their associated computer programs. Detailed comparisons with the programs discussed in these more recent texts are not made here. It is our feeling that the programs included with this book are sufficiently comprehensive to handle the more common types of data collected by marketing research academics and practitioners.

We close this Preface with a reiteration of two caveats regarding the book's scope. First, we did not intend the book to be a state-of-the-art description of the applied MDS field; exposure to newer developments should come from the current journal literature and the books cited above. Second, we have frequently traded off technical precision in favor of intuitive discussions that are more easily grasped by beginning students whose primary interests are applications oriented.

Acknowledgments: In the earlier version of this text, we mentioned a number of our colleagues, friends, and students who had an influence on our thinking about this topic. Many of these individuals have continued to serve as a source of inspiration and encouragement. When possible we have attempted to incorporate their insights and suggestions in this edition. We

especially wish to thank Dr. J. Douglas Carroll, Bell Telephone Laboratories, for his continued creativity and patience with the neophytes and Professor Arun Jain, State University of New York at Buffalo, and Professor Larry Richards, University of Oregon, for their detailed and constructive criticism. Proofreading was ably carried out by Jinho Kim, doctoral student, University of Pennsylvania; Dau-Chao Chang, Khalid Dubas, Margaret Liebman, Mary Shoemaker, and Catharine Tang Wong, all doctoral students, Drexel University; and Erica Carmone. Even with all this help, any errors remaining are attributable to the authors.

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PART I

Overview

Introduction and Problem Setting

The purpose of this text is to acquaint or update marketing practitioners, teachers, and students with a continually evolving methodology for analyzing choice behavior: multidimensional scaling and related techniques. While some of these techniques can be broadly classified under the traditional rubric of "attitude or image research," the methods extend well beyond the traditional rating scales, semantic differentials, and other such devices used in the measurement of perception and preference.

For the most part, the techniques were developed in the 1960s. Since that time, a sufficient body of research literature has been generated to suggest their great value in modeling both consumer and industrial marketing choice behavior. In this text, we describe a selected subset of these procedures and their implications for marketing analysis. In addition, since the methodology is probably unfamiliar to many readers, we have included a variety of data sets and a detailed case study of soft-drink positioning. These data are used with the following microcomputer programs, which are also included with the text: CLUSTER, CORRESP, INDSCAL, KYST, MDPREF, PREFMAP, PROFIT. In Appendix A we list other computer programs, how they can be used, and their availability.

While our continued enthusiasm about the potential of these techniques is seldom concealed, it should be made clear that the methodology itself continues to evolve, and though much empirical application has been made, more is required if it is to become a "standard" statistical tool. This text has been prepared to further that aim by providing the following:

- A discussion of analytic techniques heretofore scattered over a variety of journals and unpublished working papers not normally perused by either the practitioner or academic
- A set of readings identifying the current state of the art in multidimensional scaling
- A suite of programs to experiment and learn with in studying this methodology

FORMAT OF THE TEXT The main body of the text consists of three parts plus appendixes. In Part II, Section 1 sets the stage for later discussion by

reviewing some of the fundamentals of measurement theory and some historical background on multidimensional scaling. In addition, a description of several potential applications of scaling methods is presented for consideration in subsequent chapters.

Section 2 introduces the more formal characteristics of scaling methodology and provides a classification system, due to Coombs (1964), for the analysis of behavioral data. Section 3 describes the analysis of similarities data, including metric, nonmetric conditional, and nonmetric unconditional data analysis. Section 4 introduces the analysis of preference data, including vector and ideal point models. Unfolding analysis and correspondence analysis are also discussed.

The final section in Part II presents reduced space analysis (principal components analysis) and clustering methods. These methodologies, while not multidimensional scaling, are frequently used in conjunction with MDS procedures in many research projects and are thus included for completeness.

Part III of the text includes some of the current literature that reviews and identifies current research in multidimensional scaling (Section 6), correspondence analysis (Section 7), and cluster analysis (Section 8).

Part IV of the text presents case study material for illustrating selected data collection procedures and the running of computer programs included with the text.

There are three appendices: Appendix A contains a listing of available computer programs; Appendix B contains the questionnaire and data set for the soft drink case study; and Appendix C contains a listing of sample data, data matrices from the sample data, and a sample program command file.

HOW MULTIDIMENSIONAL SCALING IS

USED IN MARKETING Two ideas in marketing—the marketing concept and market segmentation—continue to provide the basis for both marketing practice and research. The marketing concept, as evidenced in product positioning strategies, emphasizes the firm's role in developing a uniqueness in the mind of the consumer. In principle, the firm is attempting to better satisfy the needs and wants of a target market segment. This perspective directs corporate research and development, production, finance, and personnel activities to be customer-oriented. As such, the marketing concept is integrative in nature; all activities of the firm are ultimately connected with the identifying and satisfying of the customer. These efforts take place in a variety of competitive and cooperative environments, are intended to create and retain customers, and are expected to lead to growth and profits for the firm.

Market segmentation is the application of the marketing concept. Buyer perceptions are measured, products are developed, and information systems track each segment's response to the various marketing strategies. As such, segmentation is disaggregative in nature; the firm attempts to shape its

marketing strategy so as to appeal to specific segments within the diverse market. In so doing, it is assumed that total profits can be increased. Market research applications are founded largely in the identification of relevant segments and the prediction of consequences stemming from the employment of different strategies for the relevant segments.

Perceptions and Preferences in Market Segmentation

Research The analysis of buyer perceptions and preferences of products and services is integral to product positioning and market segmentation research. The scaling of perceptions and preferences can provide operational measures of how the product or service is perceived and evaluated by the firm's clientele—whether actual or potential. Furthermore, that neither perceptions nor preferences need be homogeneous over buyers can suggest opportunities for segmentation strategy. As we shall show, perceptual and preference measurement can provide an operational procedure for implementing both concepts.

Perception and preference are two fundamental phenomena of all human behavior. As we move through the decision-making hierarchy that extends from problem recognition to repeat purchase behavior (problem recognition—product awareness—information search—evaluation—purchase intention—trial—repeat postpurchase evaluation), we are constantly making perceptual judgments about similarities and differences among the myriad of stimuli with which we are confronted. Is Classic Coke more similar to the new Coke than it is to Pepsi? How does Burger King compare to McDonald's for the single head of household who eats fast food three or more times per week? If I'm a Republican from the Midwest running for president of the United States, and I am in favor of farm support, farm products import tariff, increased military spending, but against deficit spending, increases in federal taxes and federal financing of health services for the elderly, will you vote for me? Our perceptions of various entities are the result of our evaluation processes. Perceptions are a necessary part of our choice behavior.

Preferences are no less ubiquitous. Buyers may perceive products or services similarly while displaying differences in preferences. For example, Diet Coke, Diet Pepsi, and Tab could be perceived similarly by two individuals, yet one could prefer Diet Pepsi and the other could prefer Tab. The fact that consumer product markets are rarely dominated by one brand or supplier is partial evidence of the heterogeneity of buyer preferences.

BASIC CONCEPTS OF MULTIDIMENSIONAL

SCALING Multidimensional scaling and related techniques are concerned primarily with the spatial representation of relationships among behavioral data—in our case, buyer perceptions and preferences. While we shall be presenting a somewhat more formal description of multidimensional scaling

methods in succeeding chapters, the basic concepts are presented here at an intuitive and content-oriented level.

Attribute Space Any product or service can be visualized as composed of both physical (objective) and perceived (subjective) attributes or “dimensions.” A firm may conduct extensive laboratory tests on its brand, leading to an objective description that employs chemical or physical terms. Such objective attribute “spaces” identify the various brands as points positioned somewhere in the space, where the dimensions of the objective space are defined by the objective measures. The objective space will not necessarily agree with the buyer’s perceived space. The perceived space, in contrast, consists of brand or supplier positions that are related to the dimensions reflecting the buyer’s perception of the product or service class—those attributes used in making discrimination judgments among brands or suppliers (Boulding, 1968).

Two characteristics of perceived space, and its relationship to objective space, should be mentioned. First, the dimensions of the perceived space need not agree with those of the objective space. Second, even if they do agree with (some subset of) the set of objective dimensions, the projections of the points on the various dimensions may not agree with their objective counterparts. That is, the two configurations of points may differ even if the dimensions agree.

Thus, a set of more or less common stimuli—such as brands of soft drinks, banking services, electric motors, automobiles—can be described in both objective and perceptual space. The perceptual “maps” of brands or specific suppliers of services may, of course, vary both across individuals and over time and context within the same individual. Moreover, the dimensionality of this space—the “richness” of the typical perceptual map—may vary over stimulus classes.

In some settings, such as industrial product applications, the perceived configuration of brands may agree rather closely with an objectively constructed configuration. Measurements of such characteristics as size, speed, efficiency, and reliability can be made rather straightforwardly. In other instances, such as brands of shampoo, headache remedies, toothpastes, and many other consumer-packaged goods, the perceived dimensions may differ markedly from the physical and chemical characteristics of the products. This disparity, of course, is partly a reflection of such factors as advertising content, supplier reputation, and other “external” influences that contribute to the buyer’s overall image of the brand or service.

Nonetheless, from the viewpoint of the consumer, the perceived dimensions are the relevant ones in making a product choice; clearly, brands that are physically and chemically identical may be perceived differently and, conversely, chemically and physically distinct brands may be perceived similarly. This possible disparity between objectively measured and perceived attributes suggests the need to consider not only perceptual dimen-

sions but “objective” dimensions, as well and the techniques by which one set can be related to the other.

Ideal Points Individuals may be characterized as having an ideal stimulus in a perceptual (subjective) attribute space. If so, what is the interpretation? One rather compelling interpretation is that individuals prefer one particular combination of values on the perceived product or service dimensions to all other combinations that are available in the product–service class. Stimuli, such as brands or service suppliers, that are “closer” to an individual’s ideal point will tend to be preferred to those farther away. Moreover, the individual may differentially weight the dimensions in terms of their relative importance in the evaluative context. If such is the case, the distance of specific brands or services from the ideal point is assumed to reflect the differential “stretching” that is applied to the dimensions of interest, often termed the importance of the dimensions, as now considered in evaluative space.

As the reader will probably gather, the concept of attribute space is central to market segmentation and product position, research and strategy, and the techniques to be described in this book. In a positioning strategy sense, the “nearness” of any two brands or services in this space can be formulated as an operational measure of their competitiveness. Stimuli, or products, can be developed for positioning within an attribute space (either perceptual or objective). This strategy may be interpreted as reflecting segment ideal points—that is, the combination of attribute levels that the market segment buyer would tend to prefer to all other combinations. Finally, buyers can be positioned in an evaluative attribute space as well, with the interpretation usually being construed as their respective ideal points—that is, the combination of attribute levels that for a given buyer would tend to be preferred to all other combinations.

The analytical power of the multidimensional scaling techniques is derived from the above, rather simple geometric notion of attribute space. As we have noted, however, several types of spaces are relevant:

1. The “objective” attribute space in which brands or services are positioned in terms of hard data, such as physical and chemical composition, price, number of service suppliers, and so forth.
2. The set of subjectively determined perceptual attribute spaces that reflect perceived dimensions of the stimuli (brands or suppliers). These may vary:
 - Over individuals at any point in time
 - Over time for any specific individual
 - Over individuals and time by specific situations; for example, how the product is used
3. The set of subjectively determined evaluative attribute spaces that reflect

a common perceived position of stimuli (brands or suppliers). The saliences and/or ideal point positions of individual subjects are not, however, necessarily the same. That is, there exist similar perceptions and corresponding positioning of the brands, but different preferences. These “evaluative” spaces may vary, again:

- Over individuals at any point in time
- Over time for any specific individual
- Over individuals and time by specific situations

Finally, one requires the linking of selected distances in perceptual (evaluative) attribute space to brand preference. In one type of model formulation, this might be accomplished by a function that relates measures of probability of choice to an MDS-produced measure of distance between the stimulus (brand or service) and a buyer’s ideal point in evaluative space.

Consequently, predictions of buyer response to corporate policy variables (changes in product, package, promotion, price, and distribution) would thus proceed through a sequence of steps:

- Objective attribute space
- Perceived attribute space
- Evaluative attribute space of stimuli and ideal points
- Choice response function
- Aggregation over individual types of buyers and specific purchase situations

SUMMARY In this introductory section we have tried to outline, at an intuitive level, the notion of attribute space and its relevance to the spatial description of stimuli. Our interest from a content standpoint primarily consists of the measurement of perceptions and preferences. In so doing, we must distinguish between objective and perceived attribute spaces. Finally, the concepts of attribute importance and ideal point enter as a means of portraying, geometrically, preferred combinations of “scores” on the evaluative dimensions by which stimuli are compared.

In principle, then, the methodology could be used to predict the effect of stimuli changes (in objective space) on: (a) stimuli (brand) positions in perceived space, (b) ideal point or stimulus positions in evaluative space, and ultimately (c) share of brand choices. The remainder of this book will be largely concerned with the implementation of this predictive model and the analytical procedures that are relevant in this implementation.