PSYCHOMETRIKA—VOL. 49, NO. 2, 277–280
JUNE 1984
REVIEW

REVIEWS

Susan S. Schiffman, M. Lance Reynolds, and Forrest W. Young *Introduction to Multidimensional Scaling: Theory, methods and applications.* New York: Academic Press, 1981. 413 p., $29.50.

In the preface to this book, the authors state that they "have attempted to provide both a handbook and a scientific text," one that "may be used by the newcomer to MDS" (p. xvi). With the rapid increase in applications of multidimensional scaling (MDS) in behavioral and social science research, there is certainly a need for an authoritative teaching and reference text.

In 1982, I used this book, along with Kruskal and Wish's (1978) more concise handbook, as texts for a graduate level course in multidimensional scaling. Students in the course were from several subdisciplines of psychology and from other social science disciplines. Some of my comments in this review are based upon student reactions to the contents.

The book is organized in three major sections: I. Basic Concepts and Data Bank; II. Methods and Applications; and III. Theory, with a total of 16 chapters. Each of these sections will be discussed in turn.

The four chapters in section I. introduce the basic logic of MDS techniques, the design of experiments for MDS, methods for collection of proximities data, and an overview of the models and programs that are covered in subsequent chapters. A disturbing unevenness in breadth and depth of coverage is apparent from the outset. The first two chapters assume no prior familiarity with work in the field and contain a very elementary treatment of such topics as "What MDS can do," "How MDS differs from factor analysis," "How to get subjects to understand what to do," and the like. In contrast, Chapter 4 launches into data theory, measurement issues, and topics in model fitting. Although much of the material in this chapter is useful and important, the preceeding chapters do not give the reader a proper foundation for understanding and appreciating many of the finer points which are presented.

There are numerous misleading and/or vague assertions about MDS techniques and methodology in the first section of the volume. In Chapter 1, for example, the authors state that "dimensions that cannot be interpreted probably do not exist" (p. 12). In my experience, when there is a clear statistical basis for retaining an extra dimension, uninterpretability is usually because of a lack of insight or ingenuity on the part of the investigator. Here and in several other instances, the authors stop just short of assuming that the dimensions derived via MDS have some sort of existence that transcends subjects and investigators.

Later in Chapter 1, the authors contend that MDS is not always useful for revealing the structure of a stimulus domain. While this statement is quite true, no discussion of *when* or *why* this might be the case is presented, in spite of the fact that several theorists have had much to say about the matter.

Another section of the same chapter concerns the differences between MDS and factor analysis. The treatment of this topic is sufficiently vague and incomplete that the unsophisticated reader will likely come away confused. No references are given to the excellent discussions of the similarities and differences between MDS and factor analysis by MacCallum (1974) and McKeon (1960). The authors point out that unidimensional attribute ratings ("the type of data normally analyzed by FA") can be converted to derived proximities for subsequent analysis by MDS. No rationale is provided for this suggestion, nor are the pitfalls and problems associated with this approach discussed.

In the section on "How many dimensions and what do they mean?", brief mention is made of using Monte Carlo methods "to set upper limits on the number of dimensions" (p. 11), but no references are provided to the extensive literature on this topic.

Chapter 2 covers data collection methods for MDS experiments. Although the authors emphasize methods suitable for investigating taste and smell, sorting and rank order methods are briefly discussed as well. Judging from the reactions of students in my course, much of the advice in this chapter will be misunderstood. For example, the authors assert that "an ideal multidimensional scaling experiment involves gathering ... similarity judgments among all pairs of stimuli" (p. 19). The implication here is that direct similarity judgments are somehow superior to triadic choice data, confusion data, discrimination reaction times, and other types of proximity data commonly used as a basis for MDS. Another peculiar recommendation is that "no more than 55 verbal or visual judgments be attempted in one session" (p. 20). In a typical study using trait adjectives, product names or other short verbal labels as stimuli, 55 judgments would require only 10–15 minutes. Depending on the nature of the stimulus domain, most college students can comfortably and reliably judge 200 pairs in an hour, with a few short breaks interspersed.

In a discussion of reproducibility of results, the authors state that "programs provide some measure of fit which is of course a guide to the reliability of their judgments" (p. 25). Although unreliability of judgments is one source of poor fit, a model can fit poorly because of systematic (and reliable) violations of model assumptions; or, in the case of INDSCAL and other individual differences models, poor fit to any subject's data may result from the fact that the retained object space dimensions do not include one or more dimensions used by that subject.

Chapter 3 presents experimental procedures, information on stimulus set composition, etc., for eight experiments involving seven different stimulus domains. The stimulus sets include cola drinks, food flavors, chemical compounds, musk odors, filter cigarettes, and blended foods. Data from these experiments are used to illustrate and compare six MDS programs in subsequent chapters. For the reader desiring more substantive or methodological details, most of the studies summarized in this chapter have been published elsewhere. A list of references to the original papers is provides at the end of the chapter.

An overview of MDS models and programs is given in Chapter 4. The discussion of the six programs (i.e. MINISSA, POLYCON, KYST, INDSCAL, ALSCAL, and MULTISCALE) is organized according to the concepts of a "data theory," developed by F. W. Young. The theory has three organizing concepts: shape of the data matrix, number of ways or modes, and the nature of the MDS model (i.e., data sources weighted or unweighted). These facets define six cells which correspond to six types of MDS. Although readers who are familiar with other classification schemes for data and models (e.g. Carroll & Arabie, 1980; Coombs, 1974; Shepard, 1972) may find this approach helpful, the "newcomer to MDS," to whom the text is avowedly directed, will probably find it bewildering. Likewise, the sections at the end of the chapter are likely to confuse the non-specialist; they cover such topics as Measurement Level, Measurement Process, and Measurement Conditionality, and the bearing of these factors on selection of models and programs. Here, as in many other sections of the text, very few references are provided, so the curious reader is left without assistance to pursue questions about the material.

Chapters 5–10 discuss, in turn, each of the six computer programs for MDS. For each one, stimulus and subject limits, data preparation, deck setup, and interpretation of output are discussed. Each chapter presents two or more applications of the program to the data sets described in Chapter 3. Material in these chapters should be helpful to anyone shopping for MDS computer programs and to first time users having difficulty understanding the users' manuals supplied with the programs. More experienced users will not wish to depend upon the abbreviated documentation.

The six MDS programs are compared in Chapter 11. The comparisons are primarily on the basis of computing efficiency, measures of goodness of fit, and similarities among stimulus and subject spaces for a set of 10 soft drinks. Focusing on the Weighted MDS (WMDS) programs, the authors conclude that: (a) all three programs (i.e., INDSCAL, ALSCAL and MULTISCALE M3) "provide similar solutions when the data are not excessively noisy" (p. 251); (b) "as the noise level rises INDSCAL is the first to break down" (p. 251); and (c) under these conditions, ALSCAL "seems to extract more information" (p. 251). Comparisons of subject weights estimated by the three programs revealed substantial disagreements; the authors attribute these to "excessive noise" in the data, but noise is never defined and criteria for deciding if noise is excessive are not stated. Lacking systematic empirical comparisons over a range of stimulus and subject sample sizes, error, and other parameters relevant to WMDS modeling, it is premature to assert such shaky conclusions such as those stated at the end of this chapter.

Chapter 12 presents models and methods for interpreting stimulus spaces, including preference analysis via PREFMAP, property fitting, and canonical regression. The authors provide a clear and concise explanation of the conceptual and mathematical foundations of vector and ideal point models for relating preferences to MDS stimulus spaces. The use of PREFMAP for performing preference analysis is illustrated using preferences for liqueurs and physicochemical properties of chemical compounds.

The application of directional statistics to interpretation of subject spaces derived by WMDS methods is discussed in Chapter 13. The techniques presented can be used to test whether a designated group of individuals differ from one or more other groups in salience attributed to stimulus space dimensions. As the name implies, directional statistics analyze differences in the directions of the weight vectors, ignoring lengths. Inasmuch as only the orientations of subjects' vectors are meaningful, i.e., represent the differential saliences of dimensions, the use of directional statistics for significance tests would seem to be appropriate. However, a forthcoming paper by C. L. Jones (1983) discusses some problems with the proposed directional technique and concludes that the correct treatment of this type of directional data is simply to treat them as if they were linear, rather than directional. The method, originally proposed by Batschelet (1975), involves analysis of the inverse tangents of the ratios of subject weights.

Chapter 14 concerns the analysis of rectangular (viz., two-mode) data matrices, e.g. attribute ratings of stimuli. Noting that factor analysis is the classical approach to reduction of rectangular matrices and that a factor model "has problems" when there are fewer subjects than variables, the authors present two alternative approaches. The first involves transformation of the original rectangular matrix to a (square) matrix of profile distances, followed by MDS. The second approach is essentially the same as Carroll's (1972) MDPREF analysis, except that Carroll's method is intended for preference data, whereas Schiffman *et al.* propose applying it to any type of attribute ratings. Application of the method to three-mode (i.e., scales *x* stimuli *x* subjects) data results in a joint space, with adjective scales and stimuli represented by vectors. In my opinion, the most natural and powerful method for analysis of such three-mode data matrices is three-mode factor analysis (Tucker, 1966; Kroonenberg & De Leeuw, 1980). This approach analyzes and represents the structure of both stimuli and scales, analyzes individual differences, and gives an account of the interrelationships of the three modes. Alternative methods such as those presented in Chapter 14 should only be used when assumptions of the three-mode model are violated and when specific, cogent reasons can be given to justify the alternative analysis.

Chapter 15 discusses the use of MDS methods for assessing product images and as a basis for new product development.

The sections of Chapter 16 ("How Multidimensional Scaling Programs Work") are contributions by the six authors (F. W. Young, E. E. Roskam, J. C. Lingoes, J. D. Carroll, and J. O. Ramsay) of the MDS computer programs documented in Chapters 5–10. Each section describes the iterative algorithm for fitting the model(s) whose parameters are being estimated, their initialization and convergence routines, and related topics such as model assumptions and goodness-of-fit. All of the sections in this chapter are well written and informative, but the technical level is substantially more advanced than in preceding chapters. Notations for data, model distances, transformation functions, etc., differ among authors (and from the main text), and are likely to confuse beginning students. The book would have profited from a careful editing to standardize notation.

In contrast to the first 14 chapters (which contain only 39 distinct references to methodological and applications research by other authors), the sections of Chapter 15 are more thoroughly documented.

Unfortunately, *Introduction to Multidimensional Scaling: Theory, methods and applications* does not satisfy the need for a reference handbook and scientific text. In spite of the promising title, the coverage of MDS theories and methods tends to be superficial and lacking in substantive scholarship. To much space and effort are devoted to documentation and illustration of computer programs for MDS, and not enough to exposition of MDS models, methods of data collection, interpretation, examination of model assumptions, and other topics likely to be of value to a serious student of these techniques. Moreover, virtually all of the applications are to data from odor and taste experiments. While these applications are likely to be of interest to a budding psychophysicist or consumer psychologist, this emphasis makes it difficult for the typical reader to appreciate the potential scope and power of MDS methods for investigating other types of social and behavioral science phenomena.

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