BOOK REVIEW

Research Methods for Multimode Data Analysis

Henry G. Law, Conrad W. Snyder, Jr., John A. Hattie, and Roderick P. McDonald (Eds.)
New York: Praeger, 1984, 686 pp., approx. $49.95.

The purpose of this book, stated clearly in the editors' preface, is to collect various papers dealing with the analysis of three-way data. This is certainly a useful enterprise. There is as yet only one book on three-way data analysis, by Kroonenberg (1983), and it can hardly be said to give complete coverage of the area. On the other hand, what exactly *is* the area? Three-way data occur in many of the sciences, and some of the techniques for analyzing them have been around for a long time. There are many versions of the linear model which can be used, and if the data are in the form of counts, contingency table methods can be applied. The book is not about these classical models, but about other classes of models, developed mainly in psychometrics.

The editors use an essentially historical criterion to classify the contributions to the book. In the first place there have been three-way developments in factor and component analysis, mainly through the work of Tucker and Harshman. More recently this has come to include various models for the analysis of multiple covariance structures, proposed by Jöreskog, McDonald, Bentler, and others. There have also been parallel developments in individual differences multidimensional scaling (MDS), beginning with the seminal work of Carroll and Chang. The book tries to unify the factor analytic and MDS traditions. Unfortunately, it does not really succeed. The classification based on these historical organizational principles does not really work well. Why?

From the mathematical point of view the difference between component analysis and MDS is not large. Whether models are formulated in terms of inner products or Euclidean distances is not very essential, because the two are so closely related. There is, consequently, a considerable overlap between the two fields, which overlap is readily exemplified by the contributions of Carroll, Tucker, Kruskal, and Harshman. Whether research is done in the factor analytic or in the MDS tradition is often merely a question of emphasis, a question not so much of models but of algorithms. And there is only one paper in this book which emphasizes distances, the one by Young. Another weak point of the classification used by the editors is that covariance structure analysis and component analysis differ in very important respects, but both are classified in the factor analytic tradition. McDonald has emphasized, time and again, that the analysis of covariance structures works with falsifiable models, while component analysis is a tautological data reduction technique. Even if this distinction is largely illusory, it is still true that component analysis is much more like MDS in this respect. These are some of the reasons why the organizational principles of the book do not work. They are based on the accidental development of certain schools within psychometrics, not on clear methodological distinctions. Thus the book remains a mere collection of papers, some of which are new and some of which have been published before. Most of the papers are certainly worthwhile, but the editors seem to have missed the opportunity of organizing them in an informative way.

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Another unsatisfactory aspect of at least some parts of the book is its peculiar emphasis on the role of psychology and psychometrics in the discussion of the various techniques. It is true, of course, that many useful multivariate data analytic techniques have been discovered by psychologists. In many instances statisticians have been unnecessarily skeptical about the usefulness of these techniques, and this has tended to isolate psychometrics from the mainstream of data analysis. Nevertheless it does not seem to be the correct policy to accept this isolation, and to make it even worse by adopting peculiar terminology, or by making grandiose claims about the capabilities of the technique. This has also occurred many times in the history of factor analysis, and we still suffer the consequences. It seems to me that a data analysis technique, once it has been created, exists and can be discussed independently of the discipline in which it originated. This actually happens in most of the contributions in the book. Some of the papers in the book, however, seem to take the point of view that there is something special about psychology and psychological data, which make *ordinary* data analysis techniques quite inappropriate. This reviewer disagrees.

From the perspective that there is nothing very special about three-way data, and therefore nothing special about psychological three-way data, there is a simple unifying principle from which almost all of the contributions in this book can be discussed. Such a general model can be constructed by starting with the usual ANOVA model for multifactor experiments, introducing the classical distinction between fixed and random effects, and allowing for the possibility of multilinear decomposition of the interactions. The techniques described in this book are thus all variations on one theme. Many such variations are possible, because there are different types of multilinear decompositions, and because fixed and random effects can be combined in many ways. Emphasizing the basic similarity and unity, however, seems considerably more fruitful and interesting than presenting a long list of acronyms, with corresponding computer programs, diagrams of three-way matrices, sequences of summation signs, and the magic of the Kronecker product. Serious attempts to arrive at a more satisfactory overall description of the situation are undertaken in the contributions of Harshman and Kruskal.

J. B. Kruskal has contributed, with his usual clarity and attention for detail, an admirable piece on multilinear models. It is unfortunate, however, that throughout his treatment of such models, no distinction is made between variables and parameters (or, it could also be said, between fixed and random effects). Kruskal mentions that the statistical and data-analytical literature is usually unclear about this distinction. This is quite true, but that is no excuse for ignoring it. The rest of the book shows how important this distinction really is. Kroonenberg illustrates the use of his TUCKALS program by analyzing an example from attachment theory. This is done in a clear and generally quite satisfactory way, with due attention to data analytical and interpretational details.

An important aspect of the book is that it contains various contributions of Richard Harshman. He has been very productive in the area of three-way scaling and factor analysis since the early seventies, but unfortunately most of his research is in unpublished notes or in papers which are not readily available. Harshman has contributed more than 200 pages to this book, and consequently has corrected the situation. Actually reading Harshman is somewhat of a mixed blessing. Although there are many good ideas and much useful advice in his papers, they are poorly organized and much too long. Both Kruskal and Kroonenberg pay attention to the important issue of preprocessing, defined in terms of removing main effects and scale factors. Harshman goes on and on about the same issue, and although his recommendations are useful and appear sound, an almost superhuman effort is required to unearth them. Nevertheless, I strongly advise anybody who is regularly applying three-way component analysis techniques to make this effort, because it will almost certainly be worthwhile.

In addition to the contributions of Kroonenberg and Harshman, the "Factor-Analytic Tradition" section of the book includes papers by Bloxom, McDonald, and Swaminathan on fitting three-way models

using structural covariance techniques. This involves a flattening of the data-box and isolating one mode, usually the individuals, which is treated as a random effect. By taking expectations over this mode, the model is reduced to covariance form, and by making the usual multinormal assumptions, maximum likelihood theory and such programs as LISREL or COSAN can be used. This is an eminently useful procedure, whenever it applies. The last paper in this section is by Cattell, Blaine, and Brennan. It contains a peculiar mixture of multivariate analysis, personality theory, and monte carlo, often in rather obscure terminology.

The "Multidimensional Scaling Tradition" section contains nice papers by Carroll and Pruzansky reviewing the CANDECOMP-CANDELINC series, and by Young on PROC GEMSCAL, a very general three-way method for possibly asymmetric distance matrices. The Carroll-Arabie INDCLUS and the Lingoes-Borg PINDIS papers are reprinted from *Psychometrika*. Takane has contributed a paper on fitting weighted additive models, which is quite different from the rest of the book in that it combines maximum likelihood and least squares. Because it concentrates on additive models it is quite fundamental, and it should have been in a more prominent place. It is probably in the MDS section because Takane has also published about that topic.

The "Reflections" section of the book contains a curious contribution by Gould, who discusses the contributions of Heidegger and Habermas to the area. The editors rewrite the contribution of Cattell et al. in such a way that it fits into LISREL or COSAN. They also make a last valiant, but fruitless, attempt at unification. Their conclusion is that the methods are rich, diverse, sophisticated and powerful, but the chapter shows clearly that thinking in terms of computer programs and their acronyms is a very poor basis for integration.

The appendices contain a very useful contribution by Gower on various plotting procedures for displaying MDS solutions. Harshman discusses the possible diagnostics that can be used in combination with three-mode methods. The main conclusion seems to be that everything that has ever been developed in statistics and data analysis is useful in this context too. Harshman and DeSarbo present a marketing application of PARAFAC, paralleling Kroonenberg's TUCKALS example. On the whole this application is very well done, and it can be used as a nice introduction to the whole approach.

In summary, the book contains some very useful papers, which are indispensable reading for anyone actively involved in multivariate data analysis. The book has no satisfactory structure, the techniques are not properly integrated into the whole body of data analysis, there are far too many acronyms, some papers use secret languages, and some authors are very verbose. The book is too thick and too heavy. But despite these flaws, because of the high percentage of original contributions, and because of their high average quality, I reluctantly recommend it.

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Reference

Kroonenberg, P.M. (1983). *Three-mode principal component analysis*. Leiden, The Netherlands: DSWO-Press.