PSYCHOMETRIKA—VOL. 57, NO. 3, 455–457
SEPTEMBER 1992
REVIEWS

P. Arabie, J. Douglas Carroll and Wayne S. DeSarbo. *Three-Way Scaling and Clustering*. Newbury Park: Sage Publications, 1987, ISBN 0-8039-3068-2, 92 pp. (Quantitative Applications in the Social Sciences #65.)

Since the majority of the applications of multidimensional scaling techniques are based on the INDSCAL model proposed by Carroll and Chang (1970), a monograph on this topic in the well-known Sage University Paper Series *Quantitative Applications in the Social Sciences* was long overdue (as well as this review of it). *Three-Way Scaling and Clustering* is intended to fill this gap and complements an earlier monograph in the same series, *Multidimensional Scaling*, by Kruskal and Wish (1978). *Three-Way Scaling and Clustering* is written by three knowledgeable researchers who have each made major contributions to the field of multidimensional scaling.

The book constitutes an introduction to the INDSCAL model and primarily focuses on fitting the INDSCAL model by means of the SINDSCAL program. (SINDSCAL is an implementation of the original CANDECOMP algorithm for fitting the INDSCAL model devised by Carroll and Chang.) In addition, the book treats one particular three-way clustering technique, namely INDCLUS, the three-way generalization by Carroll and Arabie (1983) of the ADCLUS model proposed by Shepard and Arabie (1979).

Introducing a methodology like multidimensional scaling based on the INDSCAL model in a 90 page booklet is far from easy. Without being too technical, one likes to make sure that the reader has a thorough understanding of the model and that he or she can carry out an INDSCAL based analysis independently, and interpret the solution adequately. The authors introduce the model via an illustrative application on some well-known data gathered by Rosenberg and Kim (1975). The example convincingly demonstrates the potential benefits of three-way multidimensional scaling. At the same time, it allows the authors to point out some potential pitfalls in interpreting the results of an INDSCAL analysis. For example, the so-called unique orientation of the dimensions in the common space or object space does not hold for planes where all subjects weigh the two dimensions equally. This point is fully discussed in the next section where the INDSCAL model is treated more formally. In this section, the authors mention the problem of negative subject weights only passingly ("The problem, of course, with negative weights having a larger absolute value is that they have no substantive interpretation" p. 18) and fail to point out that in the presence of negative weights the INDSCAL model does not define distances anymore. The section on the INDSCAL model is terminated with another illustrative application using the well-known Miller-Nicely data (Miller & Nicely, 1955). While this example constitutes a truly nice application of the INDSCAL model, it requires considerable substantive knowledge of acoustics to appreciate it fully. I would not be surprised that most readers of the *Quantitative Applications in the Social Sciences* series lack this knowledge.

In the next section, the authors discuss the practical issues involved in carrying out an INDSCAL based analysis. There are several algorithms for fitting the INDSCAL model; none of which can be considered as a de facto standard. However, because of space limitations and the introductory nature of the book, it was impractical to discuss all of them. Instead, the authors selected a single algorithm, namely the CANDECOMP

method developed by Carroll and Chang (1970), and a single implementation of this algorithm, namely the SINDSCAL program distributed by AT&T Bell Laboratories. The nitty-gritty of setting up the input for SINDSCAL is covered in great detail. While a choice like that is always hard to make, I would be surprised that SINDSCAL is nowadays the prevailing software that is used for fitting the INDSCAL model. To make up for this somewhat one-sided choice, the authors include a section entitled "Other three-way MDS spatial representations" in which a discussion of other *methods* for fitting INDSCAL is confounded with some other *models* for three-way multidimensional scaling. This section is far from representative and some parts, such as the discussion of TUCKALS3, are far more technical than the rest of the book. In Appendix C two other widely used methods for fitting the INDSCAL model (besides the CANDECOMP algorithm that is described in Appendix B) are discussed in some detail, namely the maximum likelihood method developed by Ramsay (1977) and implemented in MULTISCALE II, and the ALSCAL procedure devised by Takane, Young, and de Leeuw (1977) and made available through statistical packages as SAS and SPSS. An important method that is missing here is the SMACOF approach to fitting the INDSCAL model as proposed by de Leeuw (1980) and implemented by Heiser and Stoop (1986).

In the last major section, an expository introduction to the INDCLUS model (Carroll & Arabie, 1983) is given. The fact that such a three-way clustering procedure should be considered as a complement to an INDSCAL based analysis is nicely illustrated on the Rosenberg-Kim data previously analyzed using INDSCAL. The mathematical programming procedure developed by Carroll and Arabie for fitting this model is briefly described. The discussion of both the model and the method are rather cursory and it can be questioned whether it was wise to include such a chapter in this volume. Given the space limitations it might have been more worthwhile to fully discuss some important aspects of INDSCAL based three-way scaling that are now hardly dealt with at all. One such aspect concerns nonmetric fitting of the INDSCAL model. On page 10, the authors state that the distinction between metric and nonmetric approaches has proved quite valuable for two-way multidimensional scaling, but that it seems empirically less so for three-way MDS. Not only do the authors not provide any references to substantiate this assertion, but they also neglect to mention that some methods for fitting the INDSCAL model like ALSCAL and SMACOF allow for ordinal data, while a procedure like MULTISCALE II enables estimation of optimal parametric monotonic transformations of the proximity data. Another issue that deserves more attention is the correct analyses of subject weights. While the authors mention that the recommendation by Schiffman, Reynolds, and Young (1981) to use directional statistics has been undermined by recent research by Jones (1983) and Hubert, Golledge, Constanza, Gale, and Halperin (1984), they fail to provide the reader with specific guidelines on how to compare the weights of different groups of subjects correctly.

Summing up, it can be concluded that *Three-Way Scaling and Clustering* is a highly needed addition to the *Quantitative Applications in the Social Sciences* series. The monograph provides a highly readable introduction to the INDSCAL model and should be useful for a very broad audience. However, the reader should realize that not all aspects of three-way multidimensional scaling based on the INDSCAL model are represented equally well.

UNIVERSITY OF GHENT, BELGIUM *Geert De Soete*

References

Carroll, J. D., & Arabie, P. (1983). INDCLUS: An individual differences generalization of the ADCLUS model and the MAPCLUS algorithm. *Psychometrika, 48,* 157–169.

Carroll, J. D., & Chang, J. J. (1970). Analysis of individual differences in multidimensional scaling via an *N*-way generalization of "Eckart-Young" decomposition. *Psychometrika, 35,* 283–319.

de Leeuw, J. (1980). Majorization algorithms for individual differences in multidimensional scaling. Paper presented at the Symposium on Multidimensional Scaling and Interindividual differences held at the XXIInd International Congress of Psychology, Leipzig.

Heiser, W. J., & Stoop, I. (1986). *Explicit SMACOF algorithms for individual differences scaling* (Report RR-86-14). University of Leiden, Department of Data Theory.

Hubert, L. J., Golledge, R. G., Constanza, C. M., Gale, N., & Halperin, W. C. (1984). Nonparametric tests for directional data. In G. Bahrenberg, M. M. Fischer, & P. Nijkamp (Eds.), *Recent developments in spatial data analysis* (pp. 171–189). Aldershot, England: Gower.

Jones, C. L. (1983). A note on the use of directional statistics in weighted Euclidean distances multidimensional scaling models. *Psychometrika, 48,* 473–476.

Kruskal, J. B., & Wish, M. (1978). *Multidimensional scaling*. Beverly Hills: Sage Publications.

Miller, G. A., & Nicely, P. E. (1955). An analysis of perceptual confusions among some English consonants. *Journal of the Acoustical Society of America, 27,* 338–352.

Ramsay, J. O. (1977). Maximum likelihood estimation in multidimensional scaling. *Psychometrika, 42,* 241–266.

Rosenberg, S., & Kim, M. P. (1975). The method of sorting as a data-gathering procedure in multivariate research. *Multivariate Behavioral Research, 10,* 489–502.

Shepard, R. N., & Arabie, P. (1979). Additive clustering: Representation of similarities as combinations of discrete overlapping properties. *Psychological Review, 86,* 87–123.

Schiffman, S. S., Reynolds, M. L., & Young, F. W. (1981). *Introduction to multidimensional scaling*. New York: Academic Press.

Takane, Y., Young, F. W., & de Leeuw, J. (1977). Nonmetric individual differences multidimensional scaling: An alternating least squares method with optimal scaling features. *Psychometrika, 42,* 7–67.