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Book Reviews

G.A.F. Seber, *Multivariate Observations*, New York: John Wiley, pp. xx + 686.

Contents

Summary

This book is a major contribution to the literature on multivariate analysis. The author sets himself an enormous task: to provide an up-to-date treatment of both classical multivariate statistics and modern data analysis; to cover the spectrum from erudite theory to feet-on-the-ground pragmatics; to present formal inference procedures alongside pithy practical advice.

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To be all things to all men is an impossible task and any criticisms below are to be read with this in mind. It is better to have strived for an ideal and failed than not to have tried at all. The present reviewer warmly welcomes this volume both as a graduate text and as a reference work. Overall the bias is towards the theoretical end of the theory — applications continuum and the technical prerequisites for reading it are correspondingly high.

General Remarks

As the chapter titles make clear, here is a book with a very broad scope. The reader will find modern data — analytic methods (glyphs, Chernoff faces, bi-plots, multidimensional scaling, Procrustes analysis, cluster analysis, density estimation, robustness, outliers, ...) treated side-by-side with procedures of classical statistics (multivariate linear models (many dependent variables), multivariate analysis of variance and covariance, discriminant analysis, canonical correlations, principal components, ...). To cover this ground, even within 700 pages, is no easy task since as the preface states "entire books or monographs on topics covered by single chapters of this book are beginning to appear on the market." This inevitably leads to omissions and even to the occasional uncharacteristic slip in an area with which the author is not entirely familiar. Put briefly, the author seems more at home with the classical than the modern methods. Some of these minor deficiencies are noted below. That said, overall the author succeeds admirably in pin-pointing the essentials of each topic and communicating them succinctly along with references for further study.

His style is clear and informative. Readers of his previous books will know what to expect: solid algebraic development followed by illuminating examples and a critical discussion. Exercises (and outline solutions) are provided. The references, which run to over a thousand, are a particularly helpful feature of the book as are the lengthy appendices. These include an excellent resumé of matrix algebra and an extensive (over 70 pages) set of multivariate statistical tables which greatly enhance the usefulness of the book in practice.

The prerequisites for reading this book are fairly stated in the preface: "a good knowledge of matrix algebra and an acquaintance with the multivariate normal distribution, multiple linear regression, and simple analysis of variance and covariance models."

Some Detailed Remarks

Generally, the author's treatment of the classical methods is masterly. In particular the lengthy chapter on discrimination (allocating a new individual to one of several categories) gives an excellent modern treatment of

the subject. There follows a few more detailed remarks on chapters 5 and 7 which contain the bulk of the modern methods covered in the book.

Chapter 5

The treatment of principal components analysis (5.2) is good and clear with sound practical advice on scale effects and on the method's lack of robustness to outliers: see also Critchley (1985). Nonlinear PCA is treated briefly but the important reference de Leeuw (1982) is omitted. Correspondence analysis and latent structure analysis are given but passing one-line references (on pages 209 and 216 respectively). The author tries to be both hard-headed and fair in his treatment of factor analysis (5.4). Both metric and non-metric multidimensional scaling are covered (5.5), although essentially just in the two-way case (INDSCAL makes a brief appearance on pages 246-8). Takane's name is spelt incorrectly in the text and in the list of references. The work of the Dutch school (e.g., Gifi [1981]) is largely overlooked. This is particularly noticeable for example in 5.7 on canonical analysis.

Chapter 7

To attempt a broad overview of cluster analysis in less than 50 pages is an impossible task. That said, the author makes a valiant attempt. Particularly good are his discussions of the problems associated with the initial scaling of variables before computing proximity measures and of the relative merits of the various hierarchical methods. However, reference to the vast French contribution to this area is strangely lacking. Some uncharacteristic technical slips also creep in. On page 351, we are told that a dissimilarity matrix "is positive definite" (which is false) where "has strictly positive off-diagonal elements" is meant and on page 352 the necessary condition $p \geqslant 1$ is omitted in defining the Minkowski metric.

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D. Canter, (Ed.), *Facet Theory: Approaches to Social Research*, New York: Springer-Verlag, 1985, pp. 306.

Facet theory and the facet approach to research design, measurement, and data analysis are the major topics of this book. In the Preface, Canter states that the purpose of the book is to make facet theory, and the approach to research that derives from it, more accessible to behavioral and social scientists. The authors of the twelve chapters are all devotees of the facet approach to social science research. Their contributions include discussions of the basic concepts of facet theory, recent methodological developments, and applications of the facet approach to problems in child development, social values, environmental psychology, intelligence, self-esteem, and the analysis of reasons for slimming and weight loss. The book is divided into three sections: I. Concept and Theory of Facets, II. Illustrations and Applications of the Facet Approach, and III. Methodological Developments. The present review will focus on the material in sections I and III and on methodological aspects of the applications described in section II.

In the editor's introductory chapter ("The road to Jerusalem"), the reader is informed that Guttman, in a 1977 paper, has "thoroughly and roundly discredited" inferential statistics and that he "demonstrates the weaknesses of many uses of multivariate statistical procedures," i.e., principal components analysis and factor analysis. Later on, we are told that "a worthwhile scientific framework which will replace the current one" has been developed by Guttman, i.e., the facet approach. Thus, having dismissed classical inferential statistics, item analysis, ANOVA, Thurstone scaling, etc. as "hocus-pocus," "arbitrary," "illogical," and/or unscientific, the author tells us of the existence of a "Hidden College" whose iconoclastic members have embraced facet theory and analysis, "a truly general approach to scientific activity." Canter contends that the facet approach is relatively unknown because of the "technical density" of the relevant literature, the unpreparedness of many social and behavioral scientists to work in abstractions, and the diffuseness of the literature in which facet material has been published. One can't help but admire Canter's zeal and enthusiasm. However, his explanations for the relative obscurity of the facet approach are not convincing. Speaking as one with considerable patience for wading through technical material and having read numerous published and unpublished applications of the facet approach, I believe that the primary reasons for its lack of acceptance lie elsewhere. For example, facet theorists and researchers tend not to acknowledge relationships between their methods

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and models and those developed by others working in the mainstreams of social and behavioral science. The failure of the authors of chapters in this book to cite relevant work in multidimensional scaling as it relates to Smallest Space Analysis and other "facet analysis" techniques is a case in point. Although specialists may be aware of the relationships between the two classes of methods, the uninitiated to whom this book is directed are likely to be confused and misguided.

The second chapter "An Introduction to the Uses of Facet Theory," by Jennifer Brown, attempts to illustrate the general principles of facet theory and its applications via a review of research that has used facet designs and analyses. Early in the chapter, Brown mentions that multidimensional scaling (MDS) methods "have attracted attention because of their ability to apply powerful mathematical techniques to understanding the data generated by (social science) research." Here, I expected a discussion of the relationships between work in multidimensional scaling and unfolding and facet analysis techniques such as Smallest Space Analysis (SSA) and Multidimensional Scalogram Analysis (MSA). Instead, the author simply mentions that interpreting MDS solutions is a problem and that facet theory is "...a way of dealing with the input and output stages of research as an integrated whole," the implication being that facet theory can somehow be of use in interpreting MDS solutions. Several pages later, Brown mentions that SSA is a type of MDS procedure and that a "good fit" is indicated by a coefficient of alienation smaller than .15, a criterion suggested by Guttman (1968). Given the fundamental similarity between the algorithms underlying SSA and other nonmetric MDS programs (e.g., KYST-2A), the relationship between the coefficient of alienation and stress (Coxon 1982), and the fact that nonmetric MDS and SSA methods typically yield results that are indistinguishable, Brown's mention of this rule of thumb is remarkable and disconcerting. Numerous studies have demonstrated that stress and related goodness-of-fit measures are affected by the number of objects being scaled, dimensionality of the solution, measurement error, etc., so that assessing quality of fit requires more than reference to one rigid rule of thumb. Throughout the chapters in this volume, numerous applications of MDS appear, but as noted above, none of the authors acknowledge or make use of the large literature on MDS theory and methodology, including relevant work on systematic methods for interpretation, assessment of goodness-of-fit, hybrid models, and analysis of individual differences, to mention a few.

Brown presents several published examples from the research literature to illustrate the use of the facet approach for organizing research areas and as a framework for formally stating and clarifying social science theories. For the most part, these examples suggest that facet designs and the process of formulating mapping sentences are useful devices for theory building. Specifically, these procedures encourage researchers to consider carefully the constructs to be included in a theory, the nature of the relationships

between variables, as well as how these variables might be represented as a set of questionnaire items. Brown and some of the other authors of chapters in this volume mention that facet theory is an approach to research, originating out of concerns with the selection of items in test construction and with the weaknesses of factor analytic and item analysis procedures as methods for guiding test construction and refinement. To the extent that facet theory encourages researchers to appreciate the relationships among theory construction, research design, measurement, and data representation and analysis issues, I agree with the authors that it is a valuable enterprise.

Brown's chapter contains several interesting examples of the use of facet notions to examine and systematize research areas thereby providing a framework for identifying important variables and directions for future research. Runkel and McGrath (1972) discuss this aspect of the facet approach and provide a detailed discussion of the process of specifying facets and their elements; this use of facet logic, labeled "facet metatheory" by Brown, represents a type of meta-analysis. As such, a facet theory can be used to advantage in reviewing disjointed research areas, with an eye toward identifying important variables or combinations of variables that should be investigated. In field research that relies on the self-report questionnaire as the primary means of data collection, it seems plausible that item construction guided by a facet design will be more systematic and eventually fruitful than the somewhat haphazard and atheoretical approach employed in most survey research. Moreover, the use of SSA, MSA, and other multivariate techniques to investigate the structure of relationships among facets and their elements should generally be more illuminating than the unguided cross-tabulation of variables that is so often the cornerstone of the analysis and interpretation of survey data. Having acknowledged the value of the facet approach for the construction and analysis of aptitude tests, opinion surveys, and the like, I remain unconvinced that the general facet approach has any particular merit as a general paradigm for virtually all areas of social and behavioral science research, a claim made by several of the authors in this volume. Finally, I see nothing about facet design and analysis methods that explains why Guttman and the other adherents to these methods are so willing to abandon more traditional multivariate techniques, let alone ignore modern developments in multidimensional scaling, cluster analysis, conjoint analysis, and optimal scaling.

Although Brown mentions a few specific criticisms of the facet approach, neither she nor any of the other authors discuss its general strengths and limitations, especially the range of research problems where facet design and analysis might offer special advantages over other paradigms and data analysis methods. For example, a wide variety of problems in human perception and cognition have been investigated using multidimensional scaling and cluster analysis models of similarity judgments or other measures of psychological proximity. It is not evident how facet

design and analysis, as portrayed in this book, would result in comparable, let alone more profound, understandings of these phenomena.

In Chapter 3, Levy presents a detailed account of facet theory and the process of expressing social science theories in the form of mapping sentences. The author characterizes SSA as a method that treats each variable as a point in a Euclidean space in such a way that the higher the correlation between two variables, the closer they are in space. Further, each facet of the domain of the variables corresponds to a partitioning of the SSA space into as many regions as there are elements to the facet. Three major kinds of partitions are axial, polar and modulating. Having several domain facets, each with its own role, leads to intersecting partitions that generate such geometric structures as simplexes, cylinders, cones, or rectangular parallelopipeds. Hypotheses about dimensionality of the SSA space depend upon the types of roles ascribed to each of these facets.

Several examples are given in which such facets as reference group, time, and behavioral modality are discussed in terms of their modulating roles. However it is unclear from these examples how these roles can be identified *a priori.* Moreover there is no discussion of methods that might be used to test systematically for hypothesized structures, e.g., cone vs cylinder, or for the presence of distinct regions within such structures. In spite of Levy's disclaimer that regions are not necessarily clusters, it seems reasonable that cluster analysis might be useful for detecting the presence of interrelated variables.

In Chapter 4, Shye discusses the analysis of behavioral action systems using SSA, Partial Order Scalogram Analysis (POSA), and Lattice Space Analysis (LSA). According to Shye, scientific lawfulness may be defined as the "correspondence between a conceptual framework for empirical observation and various aspects of the analysis of these observations," a definition likely to qualify virtually any results as scientifically "lawful." Shye applies SSA and LSA to investigate the structure of action systems using Parson's general theory as a framework and basis for hypotheses, e.g., testing for expressivity versus conservativity in personality and in new curricula in schools.

Chapters 5-10 present applications of the facet approach to a variety of aptitude, personality and attitude measurement problems. In each application, the author presents a mapping sentence specifying the subject, item and response facets constituting the framework for the research. The mapping sentence is used to generate questionnaire items embodying combinations of facet elements (or to organize existing items). From a consideration of the moderating role likely to be exerted by each facet, predictions about the structure of the empirical observations (i.e., item response profiles) are derived. The subjects × items matrix of subject responses is used to derive an items × items matrix of correlations that is subjected to SSA. Then, the dimensionality and structure of the resulting configuration

is compared (visually rather than analytically) to the hypothesized structure; specifically, an attempt is made to characterize the overall shape of the structure, and it is examined to determine if there are distinct subregions corresponding to the facet elements specified in the mapping sentence. Depending upon the nature of the facets, the subregions are examined to determine whether or not they occur in specified order. To the extent that the obtained structure visually resembles the structure predicted by the mapping sentence, the theory is supported. Inasmuch as there is no error theory associated with the model and because the process of comparing predicted and obtained structures is largely subjective, theory testing and revision via the facet approach is not as objective as its proponents suggest. None of the contributors cite or make use of recent work on constrained MDS models.

Chapter 11, "How to be a Facet Researcher," by Canter, describes the stages of a questionnaire-based research project, starting with the formulation of a mapping sentence, item construction, data analysis using SSA, and analysis of individual differences via Multidimensional Scalogram Analysis. The author provides a computer program, "SUGAR," designed to generate structuples, i.e., the elements of questionnaire items, from facet elements.

One of the weaknesses of the facet approach as portrayed in this book is that no provision is made in the research design for assessing reliability of responses, or in the modeling to take measurement error into account. However, at two points in Chapter 11 (pp. 269 and 271) the author acknowledges that "noisy data" may cause problems.

Partial-Order Scalogram Analysis (POSA), an ordinal factor analysis method, is discussed by Shye and Amar in Chapter 12. POSA is essentially a factor analytic method that starts with a subjects $\times$ items data matrix, where each row is the profile of a subject's responses to a set of items. The purpose of the analysis is to represent subjects' score profiles (the scalogram) in a space of minimum dimensionality. An algorithm and computer program (POSAC/LSA) are described in considerable detail. Inclusion of an application of the method to an appropriate data set would have helped the interested reader better understand the technique and its uses.

Most of the contributors to this volume describe facet design and analysis as though they were confirmatory rather than exploratory methods. Typically, having devised a mapping sentence describing the major facets of the theoretical domain, the researcher specifies the "role" of each facet, and from a consideration of the joint effects of these roles then postulates a structural hypothesis describing the spatial structure of the points representing the items (or other entities) embodying the facet combinations. Thus, the facet researcher is in a position to specify the dimensionality and shape of the configuration resulting from the Smallest Space Analysis of the interitem correlations, as well as the shape and other structural characteristics of the configuration, e.g., locations of items representing various facet combinations, adjacency of regions subsuming sets of items, etc. Unfortunately,

the modeling techniques neither incorporate any constraints corresponding to these predictions nor are "confirmatory" methods used to compare systematically the predicted and obtained structures. Instead, the researcher inspects the SSA-derived configurations to detect the existence of the predicted regions, the shape of the configuration, e.g., cylinder versus cone, and other features of interest. When the obtained configuration is three-dimensional or higher, or when the hypothesized structure is complex, it is difficult to decide whether the obtained results agree with predictions. In several of the examples presented in this book, the authors' assertions about the structural characteristics of obtained configurations struck me as far-fetched and arbitrary. In the literatures of factor analysis and multidimensional scaling, models and methods are presented that could be used to provide a more systematic, confirmatory approach to the problem.

In the majority of applications of the facet approach presented in this book, the data matrix is an items × subjects matrix, where each column is a score profile for a subject. The input to SSA is typically an items × items correlation matrix, formed by computing Pearson correlations between all pairs of profiles; in some instances, Guttman's monotonicity coefficient is used instead. None of the authors provide a rationale for the choice of a measure of profile similarity, in spite of the fact that other reasonable measures exist. Alternative measures may be non-monotonically related so that different structures would result from SSA analyses based on these measures. Choice of a profile similarity measure should be justified using the measurement characteristics of the data, distributional properties of the variables (e.g., a Pearson correlation is not, in general, the best choice for dichotomously scored aptitude test items), and the research question. There are numerous discussions of this topic in the literatures of cluster analysis, factor analysis, and MDS, yet none of the contributors to this book cite these papers or exhibit any awareness of the issues involved.

In summary, Canter and the other authors of this book have provided a wide-ranging, non-technical introduction to facet theory and analysis. Unfortunately, the authors have fallen short of their objective to make the facet approach more understandable and accessible to social science researchers. In their collective enthusiasm for the approach they have overestimated its range of applicability, failed to recognize its limitations, and failed to acknowledge relationships with other, better established research paradigms and modeling techniques.

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Michael Smithson, Paul A. Amato, Philip Pearce, *Dimensions of Helping Behavior*, New York: Pergamon Press, 1983, pp. vii + 164. (Volume 6 of the International Series in Experimental Social Psychology)

This well written and concise monograph aims at organizing the research on helping that is mainly based on experimental social psychology. As an introduction, the main theoretical approaches to the study of helping (social learning, cognitive development, equity theory, sociobiological approach, attribution theory) are sketched, and a fair and balanced summary of the empirical research is given. It is shown that no single theory is able to explain all findings, and that information is lacking on how to generalize from one form of helping to another. To remedy the situation and integrate the field, a taxonomic approach to theory construction is chosen.

Some basic questions have to be answered for every empirical taxonomy. A fundamental one is the choice of the unit of analysis. The authors use people's judgments of helping episodes, and reject an alternative of using such "objective" features of the helping situation as the presence or absence of others in the situation, the age of the participants, etc. The selection of the episodes ("cognitive representations of stereotypical interaction sequences") provides an implicit definition of helping in general, while the judgments of the participants - mainly similarity ratings - carry the burden of differentiating between various kinds of helping.

The authors are well aware of arguments against their choice. They claim that while people might have limited access to their cognitive processes, subjects were asked to judge only cognitive manifestations in the numerous studies of this book. Further, it is a kind of an axiom in the social sciences that individuals react to their own construction of social reality. The subjective criteria of similarity judgments on helping episodes are thus assumed to be relevant for helping behavior, and Chapter 6 provides some empirical evidence supporting this assumption. But Smithson, Amato, and Pearce are not radical enough to draw the conclusion and undertake to collect and analyze the data for every person individually. All analyses reported are on aggregated data. On the other hand, several comparisons between different groups of subjects are reported in Chapter 4, e.g., between students preparing for a professional helping career and other students.

Another fundamental question of every empirical taxonomy is how to derive the differentiating criteria. The authors use with sophistication a

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variety of methods and concepts (e.g., from fuzzy set theory and clustering) while relying mainly on multidimensional scaling. The interpretation of the dimensional space is aided by employing contour maps and by fitting bipolar scales as vectors via regression procedures. Several replications with different methods and on various samples confirm what might be seen as one major result, the four parameters for defining the situational differences (p. 49):

"1. the perceived affective quality of help being given (personal vs. anonymous);
2. the motivational basis for helping (internal vs. external);
3. the prior relationship between helper and helpee (whether friends or not); and
4. the cognitive familiarity of the helper with the situation."

A further question to be answered is where to obtain the episodes. The first search covered publications in social psychology. But the authors doubted that the episodes sampled from this literature were representative of all kinds of helping occurring in everyday life. They therefore resorted to a method used in early research on personality theory: studying a dictionary for words and phrases describing various helping actions. Subjects then rated episodes from the psychological references on how good an example each was of the terms in the list of dictionary phrases. For some phrases, there was no good example in research. Neglected varieties of helping were thus identified, and further analyses revealed that these neglected situations may be characterized as personal, internally motivated, occurring only between friends, and cognitively unfamiliar.

Thus, referring to language was successful, but this method offers no guarantee in general of finding all episodes taking place in the natural habitat. In the cumulative process of research, some further episodes may be found. As the authors are aware, cross-cultural replications, using samples which differ more than the Australian and US students mainly used here, are desirable. Perhaps the book would have profited from employing facet theory (Guttman 1957) which has proven well suited as an instrument for integrating research fields with apparent inconsistencies.

The value of a taxonomy may be determined, among other things, by the relevance of the criteria employed for material not used when constructing the taxonomy. The book provides several examples supporting such a claim. Subjects listed occasions during the last week in which they had helped someone. They then applied the taxonomic scheme to their own behavior. Several interesting results were obtained, e.g., two thirds of the occasions belong to the personal forms of helping, a form seriously underrepresented in the helping literature. In another study, subjects reported for specific episodes how obligated they would feel to offer help (social norm) and how often helping was expected to be given by other people. Analyses

of variance show that a moderate proportion of variance of the norms and expectations is accounted for by these factors. There was also high agreement between the frequencies of self-reported helping and the norms and expectations. Subjects were consistent in recall of their own behavior and in their norms for helping — certainly a result having high social desirability. To rule out the interpretation that social desirability created at least a major part of this agreement, actual behavioral observations in the field are indispensable.

The book is undoubtedly a good contribution to research on helping, as it is a valuable introduction to the field and provides systematization and integration. The use made of "the taxonomic approach" provides a helpful example for other applications, showing a flexibility and sophistication in methodology and a well-documented contribution to empirical research which will be useful beyond social psychology.

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Edwin A. Fleishman and Marilyn K. Quaintance, *Taxonomies of Human Performance*, Academic Press, Inc., 1984, pp. 514.

Improving the quality and efficiency of human performance is perhaps the most serious challenge faced by today's business world. Human performance is intricately related to industrial productivity, and if we are to enhance productivity, it is important that we understand how various aspects of human performance relate to different concepts and measures of productivity.

Since Frederick Winslow Taylor created his system of Task Management almost eight decades ago, scientific study of human performance has been the centerpiece of research for many noted psychologists. Edwin Fleishman has certainly been one of the pioneers in this area. Fleishman's research, especially his work on taxonomy of human performance, has contributed a great deal to our understanding of specific skills, abilities and knowledge required for various classes of human tasks. Now, in collaboration with Marilyn Quaintance, Fleishman has produced another book which summarizes contemporary taxonomic developments in the area of human task performance.

Taxonomies of Human Performance has 15 chapters. It also has 4 appendices dealing with definitions of task functions and descriptions of ability categories and rating scales for task characteristics. The first three chapters discuss the role of taxonomy in science and some complex taxonomic issues in classifying human task performance. Chapter 4 includes some methodological considerations for the development of both qualitative and quantitative classifications of human performance, and some criteria for their evaluation. Chapters 5, 6 and 7 cover three specific classification systems based respectively on Behavior Description, Behavior Requirements, and Abilities and Task Characteristics. Chapter 8 describes some important human performance data bases. Chapters 9 through 13 describe five different taxonomic systems developed in a research program directed by Fleishman and his colleagues. They are respectively called the Criterion Measures Approach, the Task Strategies Approach, the Ability Requirements Approach, and the Task Characteristics Approach. Chapter 14 reviews some recent taxonomic developments in other fields of psychology and Chapter 15 contains some concluding remarks by the authors.

The authors consider this book as a "primer" on taxonomic developments in the area of human performance. In the opinion of this reviewer, they have done an excellent job in writing a comprehensive book on this

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subject. The reader can learn not only about the latest state of the art of various classificatory systems dealing with human performance, but also about various research issues and methodological considerations addressed by taxonomists. For example, significant efforts have been made by the authors to describe, explain and evaluate four conceptual bases for human task description, namely, behavior description, behavior requirements, ability requirements and task characteristics. The book will help the reader develop a good understanding of the relationships between various dimensions of task requirements like skills and abilities, and personnel resources like selection and training. It's a well written book, but I would recommend it primarily as a resource and a reference book for advanced students. Research scholars dealing with classification of human performance will find the book to be quite helpful, bringing together for the first time most significant findings in human performance taxonomy.

Although Chapter 14 includes some discussion of taxonomic work in other areas of psychology, it omits one important area of human performance, which is leadership and managerial behavior. Although significant experimental research is lacking in this area, recent work reported by Maccoby, Bennis and Nanus, Bradford and Cohen and others have identified some distinct leadership types and styles that influence managerial and organizational effectiveness. A discussion of how leadership behavior is conceptually related to other dimensions of human performance would have been very helpful in stimulating further thinking and research in this area, a critically important dimension of organizational behavior.

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E.C. Pielou, *Interpretation of Ecological Data: A Primer on Classification and Ordination*, New York: John Wiley and Sons, 1984, pp. 263.

This text fills a critical void for newcomers to the mathematical analysis of community structure. The widespread availability of packaged computer programs for multivariate analysis has spurred a dramatic increase in the use of cluster analysis and multivariate statistics by community ecologists. But as Pielou points out in her preface, "packaged programs are a mixed blessing. While they make it possible to analyze large bodies of data quickly, accurately, and in a way that best reveals their ecological implications, they make it possible for inadequately trained people to go through the motions of data analysis uncomprehendingly." (I might have substituted "unwittingly"!) Consequently, Pielou set out to produce a guide that explains the methodology in adequate detail but is still comprehensible to biologists with relatively limited mathematical backgrounds. She has succeeded admirably.

After a brief introduction to basic terminology, the book begins in earnest with a treatment of agglomerative hierarchical clustering methods. Although the coverage is fairly typical (the usual single- and complete-linkage, average linkage in several variants, and "minimum variance"), the descriptions are thorough and detailed, with heavy emphasis on computational mechanics. There are worked examples for all methods. This chapter also includes a review of the proximity measures commonly used in ecological studies, with an evaluation of the strengths and weaknesses of each. Somewhat surprisingly, almost no attention is paid to nonhierarchical approaches; the "composite clustering" method of Gauch (1980) is the only one discussed, and in considerably less detail than the hierarchical procedures.

Most of the remainder of the book deals with ordination techniques of one kind or another. A preliminary chapter provides a more-than-adequate introduction to the linear algebra and statistics needed for a basic understanding of the methodology. Principal components analysis (PCA), principle coordinates analysis (PCO), correspondence analysis (CA), and canonical variates analysis are then treated in turn. (Unfortunately, Pielou adopts the usual tendency of ecologists to refer to CA as "reciprocal averaging," a term that I find best reserved for one particular algorithm and not for the method in general.) The discussion of PCA seems particularly well suited to new students, as the algebraic and geometric concepts are smoothly integrated, unlike some other introductory texts that present these as

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alternative, rather than complementary, ways of visualizing the problem. The mathematics of PCO are well explained, but the comparison of PCA and PCO fails to recognize the equivalence of ordinations produced by these methods when the PCO is performed on a matrix of Euclidean distances (Gower 1966). Although Pielou is no doubt aware of this property, the reader is left with the erroneous impression that it is, in general, impossible for a PCO ordination to project the sample points so that the distance between each pair of points perfectly matches the corresponding values in the original distance matrix.

Unfortunately, in her discussion of correspondence analysis, Pielou carries on the misconception that this is the only ordination procedure that provides simultaneous ordinations of sites (objects) and species (variables). The biplot display (Gabriel 1971) provides such a capability to PCA, but has been nearly ignored by ecologists. On the positive side, however, Pielou's comparison of CA and PCA is much more balanced than that of another recent (and influential) text (Gauch 1982). In particular, "detrended correspondence analysis" (DCA) is recognized for what it is: "overt, systematic data manipulation, carried out in order to force the ordination into a form that accords ... with intuitive expectations" (p. 195). Although this property does not exclude it as a reasonable method, it certainly deserves to be recognized. Gauch (1982) listed several advantages of DCA with no hint of its weaknesses; Pielou, on the other hand, reminds the reader that "overzealous correction of supposed 'defects' may sometimes lead to the unwitting destruction of ecologically meaningful information" (p. 197).

Pielou's coverage of divisive classification methods is brief, being principally confined to the use of minimum spanning trees and methods for partitioning ordinations. The book closes with a cursory description of canonical discriminant analysis. [Since the technique is referred to as "*discriminant ordination* (Pielou, unpublished)," naive readers may be misled into thinking that this is a novel approach.] This is clearly the weakest section of the book — it almost seems to have been tacked on as an afterthought. For instance, although the extraction of eigenvalues and eigenvectors was covered in considerable detail in preparation for the chapter on ordination methods, here the reader is sent elsewhere to learn how to invert a matrix. Her statement that "for our purposes it suffices to not that ... most computers have a function for obtaining" the inverse of a square matrix (p. 226) seems at odds with an earlier remark: "anyone who uses a ready-made program ... should be capable of doing the identical analysis of a small, manageable, artificial data matrix entirely with a desk calculator ... Nobody can claim to understand a technique completely who is not capable of doing this" (p. 11). Furthermore, the method she describes for performing the "discriminant ordination" is actually a canonical correlation analysis between the species abundance variables and a set of dummy variables coded from the grouping variable (region). Although this is a perfectly

legitimate way to perform a canonical discriminant analysis, a brief acknowledgement of the approach used and a statement of the equivalence of these methods would have been appropriate. Finally, in sharp contrast to earlier presentations, there is no discussion of the *dis*advantages of discriminant techniques; the difficulties in interpreting the meaning of the axes (canonical variates) when the original variables are intercorrelated are not even mentioned.

It is always easy to single out things that have been omitted from a text of this sort, as it would be impossible for the book to cover all facets of a diverse subject and still retain its general utility. This aside, I was somewhat surprised by the absence of any discussion of multidimensional scaling in a book concerned largely with ordination methods. Also lacking was any mention of canonical correlation, which could profitably be applied in many studies that examine the relationship between environmental variables and species abundances, but is all too often forgotten.

In spite of its few minor flaws, this is an excellent contribution. It should be especially helpful to researchers vaguely familiar with the procedures discussed in the book but wanting to become more conversant with the details. There no longer need be any excuse for using these methods without understanding them. Teachers of graduate courses in quantitative community ecology will also find the book useful; it bridges the gap nicely between the mathematical rigor of Orloci's (1978) *Multivariate Analysis in Vegetation Research* (which often frightens away unprepared students) and the simpler, but computationally inadequate, *Multivariate Analysis in Community Ecology* by Gauch (1982).

Illinois Natural History Survey David L. Swofford

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Journal of Classification 3:153-157 (1986)

Mark S. Aldenderfer and Roger K. Blashfield, *Cluster Analysis*, Sage University Paper series on Quantitative Applications in the Social Sciences, series number 07-044, Beverly Hills and London: Sage Publications, 1984, pp. 88.

This monograph is part of the very useful series that provides brief introductions to many topics in social science research. This particular volume is not the best of this series; however, the introduction of cluster analysis techniques to the armamentarium of the social researcher is a major boost to the status of clustering. Overall the book is modestly successful. Its weaknesses are primarily in the areas of emphasis and omission.

The book starts by discussing how clustering methods are used, presenting two data sets that are used as examples, and presenting a few cautions. It then discusses similarity measures, clustering methods, and validation techniques; it winds up with a discussion of software and literature.

The book is aimed at two audiences, those who want an up-to-date guide, and those with no background in cluster analysis. The book could serve as a refresher for those to those with prior acquaintance with the concepts of clustering. It doesn't always keep the second audience in mind. At several points it digresses onto esoteric topics without putting them in context. For example, there is a discussion of whether similarity coefficients are metric without any explanation of why it is important that they be so. It also uses terms that are highly specialized without adequate definition. Inadequately explicated terms include: metric, non-metric, ultrametric, monotonic, non-monotonic, Trace W, etc. Adding to this problem is the fact that a glossary is not included.

There are many areas that are omitted or are incompletely developed.

The notion of a profile is not adequately developed. In most instances, the idea of considering the scores for a case as a set can help organize information greatly. Graphic presentation of the concept of profiles has proven to be one of the best ways of communicating the nature of cluster analysis to audiences of non-scientists such as policy officials and managers.

The discussion of how clustering methods can be useful in diverse disciplines could easily have been more comprehensive. The inclusion of

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The opinions expressed in this review are solely those of the reviewer. They should not be interpreted as the official position of the Program Evaluation and Methodology Division or the U.S. General Accounting Office.

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topics related to policy applications, social indicators, and education, which were known to at least one of the authors, would have broadened its appeal and shown its utility. Other very useful areas to discuss include criminal justice applications, and the exploration of voting blocks in the U.N. General Assembly, the U.S. Senate, and other legislative bodies.

The concept of using clustering as an aid in theorizing, as well as a data reduction tool, is not brought forward. For example, there has been a long controversy over the merits of "open" vs "traditional" classrooms. The finding that a two group classification is inadequate explains why previous results were sometimes contradictory, and has important consequences for policy decisions and future research.

There is little attention to clumping methods, e.g., Lorr (1963), and the many methods by McQuitty (1957, 1961, 1963, 1968). In social science applications, researchers are usually looking for a clumping rather than a hierarchical arrangement. In fact in social science complete trees from hierarchical methods are seldom used, rather, the tree is usually "cut" at some point and the clustering represented at one level of the tree is retained for interpretation.

The determination of the number of clusters to retain is one of the major considerations in clustering. However, this topic does not appear until late in the text. It would seem that this should appear early in the text along with different meanings and uses of clusters. The discussion on the number of clusters leaves the reader with the impression that looking for "elbows" etc., provides no information. Although these techniques don't allow the analyst to say, "There are exactly three clusters in this data.", they do help to locate the approximate number of clusters. It is possible to say, "there are about 2 to 4 clusters in this data." The choice of the number of clusters is *not* totally capricious.

The authors point out that Ward's method is highly sensitive to profile elevation. This can be a problem in some applications, but in describing some types of units elevation may have theoretical and practical policy implications. For example, in work by the U.S. Bureau of the Census (1977) "hard core" Appalachian counties had a very similar profile to other Appalachian counties, but had more extreme values on many scores.

Considerations related to sampling are inadequately discussed. There is no mention of the fact that many clustering techniques are often limited by practical considerations to rather small N's. The book fails to mention any of the ways to overcome this limitation such as performing clustering on smaller samples, and then using the resulting profiles as input to another round of clustering. Further, the discussion implies that the data are necessarily a sample from a larger population. In fact, many of the potentially most fruitful policy-related applications involve situations where all of the cases in the population are included in the analysis. The discussion of outliers implies that apparent "outliers" are likely to be due to poorly

represented types due to sampling. However, there are applications where the appearance of a case as a relative outlier helps to validate the cluster solution. For example, in a cluster analysis of counties in Western (U.S.) states (U.S. Bureau of the Census, 1980), the plausibility of the solution is enhanced when it is found that Los Angeles County is the only county in its cluster.

Clustering is frequently done to obtain abstract "pure types." These are often merely useful cognitive constructs. Many methods of clustering do not merely place a case in a single cluster, rather cases are assigned scores indicating a degree of membership in each of the clusters in a solution. Individual cases may be at different distances from the centers of different "pure types," and each case may have a mix of relations analogous to the way that items may not load cleanly on a single factor in factor analysis. A given patient may exhibit both psychotic and neurotic behaviors. A small isolated city may be like a big city in some ways and like a rural village in others.

The section on validation says that the application of MANOVA or Discriminant Function Analysis (DFA) is statistically inappropriate, and the way it is used in the example given, the use of *the significance tests* is inappropriate. However, the use of other parts of a DFA output are highly useful in understanding and interpreting the results of a cluster analysis. This is particularly true of the classification phase of a DFA. This allows inspection of how well each case fits into the analysis. Those cases with a poor fit (low conditional probability of being in a particular group) can be considered "unclassified" and allowed to float to see where they fit best when a reanalysis is performed. In addition, although the significance of F tests is meaningless, the comparative magnitude of the F values themselves is very useful in understanding the contribution of the variables to the separation of the groups obtained.

The section on validation does not discuss the combination of solutions from methods of clustering that have different properties. One very powerful way to arrive at a useful and plausible solution is to use the concept of "core clusters." A core cluster is a group of cases that have been placed together by a number of distinct clustering methods. Cases that do not meet the criteria for inclusion are considered "unclassified." The classification phase of a DFA can be used iteratively to refine the solution and place the "unclassified" cases into clusters.

Validation can also be done by less formal means. For example, the results of clustering counties based on their social characteristics can be mapped, and the relative locations of the cluster members can validate interpretation. In some of the work of the Bureau of the Census (1977,1979), mapping the results showed that counties containing central city areas were more like each other than they were like the ring of counties around each of them. Another way to informally validate solutions is to ask

substantive experts to determine whether the types make sense. This is analogous to the practice of checking face validity of the grouping of items onto a factor in factor analysis.

Although the section on software mentions the plans that SPSS had, and which were implemented before the book became available, the authors did not bother to check into the details of those plans. Insofar as the inclusion of a set of methods into SPSS is a landmark in the availability, utility, and acceptability of those methods, this omission is a major weakness. SPSS is the package which is the best documented, most versatile, widely used and available, and most in line with the needs and practices of social scientists. Inclusion of clustering in SPSS, then, is an event that bodes well for the field of clustering.

The reader is given the impression that quality control procedures were not applied. It seems as if the authors failed to have a knowledgeable "cold reader" go through the text. There are several examples of minor details that would cause no problem for a reader already familiar with the field, but which could cause misunderstanding on the part of a novice. These include the confusion of R analysis and Q analysis on page 16, the confusion between absence of a measurement on a variable and a value of a variable representing absence of a characteristic (feature) on page 28 ff., the use of "search for an N by N similarity matrix" rather than "search (through) an N by N similarity matrix," and the use of the term "independent variables" in the discussion of validation techniques on page 62.

The lack of checking of the document is further indicated by the fact that some citations are not present in the references. While the reviewer did not take the time to check systematically for absence of references, it was annoying to look in the references for something that sounded interesting but that could not be found. This includes the first citation in the text (page 7), one on the next page, and one on page 74 on validation.

In summary, the production of this monograph does provide a rough introduction to the field of cluster analysis. The inclusion of cluster analysis in this series does advance the field of numerical taxonomy. However, the omissions of substantive concepts lower the value of the book considerably. The omissions mentioned above could have been remedied without a great increase in the length of the book. At least one of the authors knew of the work and concepts that have been mentioned in this review, so it is difficult to understand why many of the omissions occurred. This monograph did not take sufficient advantage of a solid opportunity.

U.S. General Accounting Office Arthur J. Kendall

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Journal of Classification 3:158-162 (1986)

Mark L. Davison, *Multidimensional Scaling*, New York: John Wiley, 1983, pp. xiv + 242.

Contents

Summary

In his preface the author states that this book "was designed primarily as a textbook for graduate students in the behavioural sciences, the social sciences, and statistics" and "also as a reference for researchers in the social and behavioural sciences." The present reviewer feels unable to recommend it for either of these audiences. The book contains numerous errors, misleading remarks and dangerous half-truths which make it unsuitable for the primary audience. These same deficiencies seem to also rule it out for the other audience. Catch 22 applies. The necessary and sufficient condition for these deficiencies not to be a barrier to learning is that the reader can correct them. (This requires both a fairly deep acquaintance with multidimensional scaling methodology and a higher mathematical accomplishment than the book assumes.) If this condition is not met, the deficiencies remain. If it is, the reader scarcely needs the book!

General Observations

The extensive review by Carroll (1985) expresses well many of the present reviewer's opinions about this book. For the sake of brevity, and to avoid repetition, the present review overlaps minimally with this earlier one to which the reader is warmly referred.

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On the positive side:

1. The author has chosen his material well. The scope of the book seems about right. In particular, multidimensional scaling (MDS) is taken in the narrower sense of spatial distance models, other methods such as factor or cluster analysis being already widely treated as the textbook level.
2. The final chapter contains a nice if elementary comparison of MDS with these other methods.
3. Chapter 3 is a laudable attempt at providing useful practical information on "planning research and collecting data in studies that use MDS." In this sense, it is rather reminiscent of Torgerson (1958). In particular, sample and population are distinguished for both subjects and stimuli. (However, the author does not distinguish between this, the classical statistical paradigm, and the modern data-analytic situation in which the sample *is* the population.)
4. Illustrative examples (both real and artificial) and student problems and answers are provided.

On the negative side, the book contains substantial deficiencies which mean that I cannot recommend it. Carroll (1985) has itemized a variety of these. Some more are detailed in the following section.

Finally, the review by Carroll (1985) contains a very useful final paragraph describing the relative merits of the other available books on MDS. In particular, I share his view that Kruskal and Wish (1978) provides an excellent, inexpensive, non-technical and succinct introduction to the area.

Detailed Criticisms

The following are a sample of detailed criticisms which overlap minimally with the important ones already noted in Carroll (1985). They are given below in order of appearance rather than importance.

1. The distinction between the *necessity* and the *sufficiency* of (a set of) conditions is not clearly drawn. For example, on page 2, not only are the metric axions wrongly stated, but it is also not made clear that they are necessary *but not sufficient* conditions for a Euclidean distance function. Again on page 23, the author writes:

   "A unique inverse $(B' B)^{-1}$ in Eq. (2.5) will exist only if the number of columns in B is as small as or smaller than the number of rows."

This is true but is only part of the truth. The primary audience envisaged are unlikely to know this and so for them this half-truth is rather dangerous as the condition stated is necessary *but not sufficient* for the existence of the inverse. (It also confuses existence with uniqueness. More helpful would have been the separate statement of the fact: If a matrix has an inverse, it is unique.)

2. The author appears unaware of several well-known results in the area. On page 5, he considers the dissimilarity measure $\delta_{ij} = \{2(1-r_{ij})\}^{\frac{1}{2}}$ where r_{ij} is a correlation coefficient. In expressing doubt as to whether δ_{ij} would obey the triangle inequality, he seems unaware that, in the product-moment correlation case, this is certain to be the case. (Moreover, the δ_{ij} are then *Euclidean* distances between points on the unit sphere.) Again on page 69, the author writes:

"Torgerson's method is one ... in which the fit measure plays little or no role in deciding how many dimensions are required ... There is however a series of eigenvalues ... that do play a role in dimensionality decision."

This is simply false, the author being unaware that the measure of fit he cites is the sum $\sum_{k>K} \lambda_K^2$ of the eigenvalues he uses.

Moreover, it is not reported that Torgerson's method also optimizes other measures of fit. These are dual to the optimality properties of principal components. See, for example, Critchley (1980) and Okamoto (1969).

3. There are the inevitable howlers which can most charitably be interpreted as typographical inexactitudes. For the person meeting matrices for the first time, the following classic will prove a little troublesome (p. 14):

" Any R by C matrix can be considered composed of R column vectors or C row vectors."

4. At several places, rules of thumb for key decisions are stated without sufficient caveats, for example about their precise empirical basis and their correspondingly limited range of applicability. In some cases, caveats are dispensed with entirely. On pages 42 and 43, we are exhorted — without explanation — to use "the geometric mean (or less frequently the median)" when averaging over subjects

performing a magnitude estimation task but "the arithmetic mean (or less frequently the median)" when in a graphic rating scale context. Why? It is not at all clear to me that any such generalizations *can* be made and entirely clear that, if they can, their sphere of applicability needs circumscribing. Again (p. 91/2), the guidelines stated for using stress values to decide upon dimensionality seem inadequately particularized. In particular, they make no reference whatsoever to the number of points relative to the number of dimensions.

5. As Carroll (1985) observes, there are some important omissions. On page 52, having correctly made the observation that symmetrizing a data matrix can ignore important effects, the author fails to reference any of the literature on methods for the analysis of asymmetry: see, for example, Constantine and Gower (1978). Again, on page 83, the necessary condition $p \geqslant 1$ is omitted in defining the Minkowski distance function.

6. The advice offered is sometimes positively misleading. The most serious case appears to be on page 101, where, in a nonmetric MDS context, the author write:

   "When a degenerate solution is encountered, it should be discarded. Sometimes, a degenerate solution means that the solution should be sought in a higher dimensionality."

   The form of degeneracy referred to occurs when (and only when) the stimuli can be divided into clusters in such a way that all the within cluster dissimilarities are less than all the between cluster dissimilarities. Far from being discarded, this essentially perfect clustering of the stimuli may be the most important feature of the data! The researcher may however already know about this clustering. In any event, the within-cluster structure can still be analyzed by applying MDS separately to the sub-matrix of dissimilarities corresponding to each cluster of stimuli. Certainly, as Carroll (1985) notes, *increasing* the dimensionality is exactly the wrong thing to do. Such degeneracies can simply re-occur. Rather, a tighter model is needed either by reducing the dimensionality or by adopting a more restrictive form of relationship between distances and dissimilarities than the fully ordinal one used in nonmetric MDS.

7. Occasionally the author's description of a topic is inadequate. For the primary audience, the brief description of hierarchical cluster analysis offered in Chapter 9 seems insufficient and, in places, is

simply wrong. In particular, it contains the following sentence (the italics are mine):

"A stimulus cluster is *any* subset of stimuli."

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Journal of Classification 3:163-164 (1986)

M. O'hEigeartaigh, J.K. Lenstra, and A.H.G. Rinnooy Kan, Eds., *Combinatorial Optimization: Annotated Bibliographies*, Chichester: John Wiley & Sons, Ltd., 1985, pp. viii + 204.

Combinatorial optimization is concerned with finding optimal solutions to discrete problems that have a finite number of feasible solutions. Since this field is currently quite active, and since it has a pronounced multidisciplinary aspect, interested researchers may have trouble penetrating it or keeping up with its recent advances. The book I'm reviewing addresses these problems by providing researchers with annotated bibliographies of twelve basic subareas in combinatorial optimization.

These bibliographies, having been completed between June 1983 and July 1984, are as up-to-date as one could reasonably expect. They usually cite background and survey material; they often are structured by problem type or solution technique; and they typically include recent material that, at the time the bibliographies were completed, was only available in technical report form. Four bibliographies concentrate on essentially theoretical topics: "Polyhedral Combinatorics" by M. Grötschel, "Duality for Integer Optimization" by G.L. Nemhauser, "Discrete Packing and Covering" by L.E. Trotter, Jr., and "Submodular Functions and Polymatroid Optimization" by E.L. Lawler. Three bibliographies concern application areas that have been the stimulus for, and the beneficiary of, basic advances in combinatorial optimization: "Location and Network Design" by R.T. Wong, "Vehicle Routing" by N. Christofides, and "Sequencing and Scheduling" by J.K. Lenstra and A.H.G. Rinnooy Kan. In "Software," S. Powell presents a rather too brief survey of commercially available programs for the mixed integer programming problem.

The remaining four bibliographies concern computational issues and may be particularly relevant to readers of this *Journal*. C.H. Papadimitriou presents, in just thirteen pages, a nicely balanced view of the prehistory, history, and state of research in the area of "Computational Complexity." In "Probabilistic Analysis," R.M. Karp, J.K. Lenstra, C.J.H. McDiarmid, and A.H.G. Rinnooy Kan concentrate on probabilistic analyses concerning the running time of the algorithm, the difference between approximate and optimal solutions to a problem, and the relative frequency with which a heuristic algorithm obtains optimal solutions to a problem. In "Randomized Algorithms," F. Maffioli, M.G. Speranza, and C. Vercellis survey the literature about combinatorial algorithms that are equipped with a coin tossing

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state. Finally, in "Parallel Algorithms," G.A.P. Kindervater and J.K. Lenstra review advances in parallel computing that are relevant to the theory of combinatorial optimization.

The field of combinatorial optimization will have relevance to readers of this *Journal* as long as interesting classification and clustering problems can be approached from a combinatorial point of view. This book should appeal, then, to readers who seek to exploit the theory and techniques of combinatorial optimization in the investigation of such problems.

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Journal of Classification 3:165-166 (1986)

Michael J. Greenacre, *Theory and Application of Correspondence Analysis*, London: Academic Press, 1984, pp. vii + 364.

Dedicated to Jean-Paul Benzécri, a leader of the French school of data analysis, this book presents very comprehensively a method of data reduction and graphical display which is used extensively in France but not so much elsewhere.

The publication of this book is thus an important event for it provides a large audience access to many works available until now only in French. Note that this book is not the only one devoted to this topic in English since, by a lucky coincidence, a translation of a book by Lebart and Morineau also was published recently.

After a short introduction, Chapter 2 is devoted to a presentation of the geometrical concepts used in the book. The mathematical treatment is simple and the stress is put upon weighted Euclidean spaces and the chi-square distance.

Chapter 3 is of the same style and simply presents the output of a correspondence analysis of a contingency table.

Chapter 4 deals with the mathematics of correspondence analysis: it is of special interest both historically and methodologically. Connections with various techniques (canonical correlations, dual scaling) are shown, and the reader will be convinced that correspondence analysis is one of the main statistical methods. The fundamental formulae were discovered very early (in the thirties) but its use as a powerful tool of data analysis stems from the graphical potentialities emphasized by Benzécri. Section 4.6 provides useful comments on various mathematical properties.

Chapter 5 presents multiple correspondence analysis, an extension of correspondence analysis to multivariate nominal data using only bivariate marginals; though well documented this Chapter suffers from some gaps. The pioneering work of Guttman (1941) quoted in Chapter 4 should have been presented here as well as a list of optimal properties of the components. The work of the Dutch group in homogeneity analysis is also ignored. A useful reference for the interested reader is Tenenhaus and Young (1985) but the most important gap concerns the use of supplementary variables, which is one of the main features of the French style for analyzing questionnaires (see Lebart, Morineau and Warwick 1984).

Chapters 6 and 7 deal with nonstandard uses of correspondence analysis (preference or rating data, regression, discrimination, clustering) and

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demonstrate its relevance in various contexts, though the superiority claimed for correspondence analysis over classical techniques might be discussed at greater length.

Chapter 8, "Special Topics," is a compendium of less-known properties and applications. The most original points are about stability and statistical inference by using jackknife and bootstrap techniques. It can be argued whether the best way of examining the variability of graphical displays is the use of convex hulls for the replicates, since the hulls are not at all robust.

One of the charms of this book is in the great variety of worked examples presented. Chapter 9 gives in addition eleven case-studies of correspondence analysis in various fields. However, the reader might get the erroneous impression that two-dimensional displays are always sufficient. Advice for choosing the right number of dimensions is also missing.

An extensive list of references (nearly 300) ends the book, but the choice of the French ones is surprisingly biased: they all belong to the Benzécri team (83 references from the *Cahiers de l'Analyse des Données!*) though numerous books and papers (some in English) have been written by authors from other schools. In particular, the approach based on the duality diagram due to Cailliez and Pages (1976) is ignored.

In summary, this book is a welcome one and I recommend it to anyone willing to learn what is behind correspondence analysis and how to use it.

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Gilbert Saporta

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Journal of Classification 3:167-168 (1986)

V.H. Heywood and D.M. Moore, Eds., *Current Concepts in Plant Taxonomy,* The systematics Association Special Volume No. 25, London: Academic Press, 1984, pp. 432.

This volume contains papers presented at the International Conference on Current Concepts in Plant Taxonomy held at the University of Reading, U.K. 7-9 July, 1982. It is very much about the discipline of Plant Taxonomy, and not very much about the concepts or methods of general classification. As a volume in which plant taxonomists discuss for each other the problems with, and hopes for, their declining field of professional specialization, it meets its purpose well.

In my opinion, the centerpiece of this work is the contribution by J. Cullen of the Royal Botanic Gardens in Edinburgh, Scotland. He bluntly states that the major service of plant taxonomy is identification: what is it called and where does it grow. The task of making an inventory of the world's plants (reviewed in this volume by G.T. Prance) is far from complete, and the manner of presenting the results of the inventory thus far made to other than professional plant taxonomists is largely ineffective. Cullen suggests that about 90% of taxonomic work is done for other taxonomists, with no account taken of any other possible user. He likens the profession to a mystery cult with its arcana, its sacred texts and rules of procedures, its priesthood and prophets, its orthodoxy, heretics, and schisms. An excellent example of the incantation of orthodoxy is provided to the volume by C.J. Humphries and V.A. Funk. Cullen goes on to suggest that publications of plant taxonomists are not for the understanding of the uninitiated, so they are written in special language under the restriction of evil-eye-averting formalities. Cullen believes, as do I, that plant taxonomy has something important to contribute to science and society, but the way in which plant taxonomists typically practice fails to make that contribution and thus erodes the support of science and society for its continuing practice. Cullen suggests, and I agree, that we must simplify the code; coordinate our activities internationally; and make use, rapidly and on a large scale, of the database management and communication equipment and technology currently available. This last is reviewed in this volume by F.A. Bisby and also by V.H. Heywood.

I believe that there is another missing element that is essential to the revitalization of plant taxonomy as a foundation for plant science more broadly construed; plant taxonomists must participate themselves in the practice of scientific method to use the results of their craft to test and argue the differential credibility of hypotheses to explain pattern, process,

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adaptation, mechanism, geographic distribution, history, etc. If knowing what things are called and where they live is really important to science, let those who know these things best demonstrate how they can be used to treat ideas that have compelling intellectual content.

Most of the contributions to this volume discuss various sources of data that could be considered when a taxonomist is trying to decide how to delimit taxa, and do not really address the problem of how to make plant taxonomy more vital to science. However, the discussion of infraspecific variation by R.W. Snaydon does speak to the interface between plant taxonomy and science. On the other hand, some contributors clearly evidence the lack of understanding more typical of their peers, as revealed by this quote: "This is also true of the mathematical population geneticist, who is likely to study a group of organisms only if it has characteristics that appear to be particularly suitable for mathematical analysis or are related to the results of mathematical modelling." page 182. I look forward to encountering the key lead that asks whether the plant to be keyed out is particularly suitable to mathematical analysis.

As a contemporary statement of the problems and challenges (and possible approaches to their solutions) of the discipline of plant taxonomy itself, this volume has potential to contribute to the revitalization of plant taxonomy as one of the important foundations for the future practice of plant science on which we depend for our food, fuel, environmental quality, and understanding of the natural environment in which we live.

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Heinz Peter Ohly, Hans Herman Bock and Donald Bender, *Software zur Clusteranalyse, Netzwerkanalyse und Verwandten Verfahren: Eine Commentierte Dokumentation*, Bonn: W. Germany, Informationszentrum Sozialwissenschaften. 1983, pp. 166.

This volume seeks to provide a systematic guide to the computer programs for cluster and for network analysis which are available to the international social science community. It contains three major sections: (1) a guide to the appendices, together with short expositions of cluster and network analysis techniques, (2) author and keyword indices to the computer programs, (3) systematic descriptions of some sixty-four programs. Section (1) is written in German. Sections (2) and (3) are in English.

The book is intended as a reference for researchers with substantive research problems seeking computer software to perform cluster analysis and structural analysis of network data.

It seeks to foster increased communications between program authors and their users. The authors note that not only is there increasingly rapid progress in computers, but also that algorithms for clustering and for structural analysis have become advanced. They note that there are increased demands for this type of program by researchers whose objectives are substantive, rather than methodological and who wish to avail themselves of the best in research technology.

The importance of clustering techniques in improving measurement is pointed out and it is observed that high quality network analysis software is critical for analysts who seek to incorporate relational information into their research designs. It asserts that since cluster analysts and network researchers often use the same algorithms, it is logical to incorporate both in a single overview of available programs. In addition, they seek to advance statistics by the development of a typology of statistical tools in these areas.

The data in the volume are based on a literature search, correspondence with users of programs, and correspondence with program authors, carried out mostly during 1982. The authors did not attempt to document every cluster analysis and network program available, only those found useful by a community of researchers.

A typology of software is presented, and the characteristics of each program are used to locate the program in this multidimensional space. The typology has the following main categories (some of which are further subdivided into very fine partitions): (A) Input-output management and

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variable generation capabilities, (B) Descriptive statistics, (C) Statistical tests, (D) Multivariate causal analysis, (E) Time series, (F) Multivariate dimensional analysis, (G) Simulation, mathematical programming and input-output analysis, (H) Exploratory methods, (I) Sampling and test design aids, (K) Network, graph methods, and sociometry, (L) Item analysis, (M) Linguistic analysis and text processing, (Z) Other. (There is no category J.) The current volume contains only programs which have at least some capabilities in categories F and/or K.

Category F (Multivariate reduction/dimensional analysis) is further sub-divided into factor analysis, multi-dimensional scaling, cluster analysis, pattern recognition, and other. Category K is divided into graph generation procedures, data reformatting procedures, point and line set manipulation, procedures for dealing with valued graphs and multigraphs, clique detection and blockmodeling, computation of indices for points, position and role determination, graph isomorphisms and time series, statistical tests and inferences, and other.

In the keyword index of programs, the categories are listed in order with all of their detailed sub-classes. The names of all of the programs which fall into a particular sub-class are then attached. A program is listed under each sub-class to which its capabilities apply. For example, a person seeking an agglomerative cluster analysis program (F.3.1.1) using complete linkage methods would be referred to CAM, HICLAN, STRUCTURE and YGRPG and could then turn to the individual program description sections to get the rest of the information about each of these programs needed to make an intelligent selection. The prospective user then contacts the program distributor and makes an arrangement to get a copy of the program.

The following types of information are provided about each program: type of program, authors names, a summary of what functions the program can perform, technical information about the program, availability status, application references, citations to literature in which the program was used, a listing of what documentation is available, names and phone numbers for obtaining further information, costs and licensing information, references to similar programs, and the name and address of the person supplying the information about the program.

In many instances the person supplying the information about the program is a user or someone else who knew about the program, not the original author. Alternatively, it may be someone who has modified the original version. The advantages of this are that at least the program gets reported (authors all too often don't respond to requests for information about programs they have written). In addition, the prospective user has access to at least one node in the existing network of users of that software as a technical resource. Moreover, the person acquiring the program can have some confidence in the program because someone else other than the author has, in fact, been able to make effective use of it.

The disadvantage is that information supplied by a user may be out of date; newer and better versions of the program may be available; or, the informant may be unaware of bugs in the program that have since been fixed. Prospective users of the guide would be well advised to be in contact with all of their potential sources of information about an individual program.

From an economic perspective this type of statistical software is still being produced as a "cottage industry" product (Sonquist 1984). This is the state that conventional "statistical packages" were in, back in the early 1960's (Francis and Sedransk 1979; Muller and Wilkinson 1976). Many of the programs were written for the author's own personal use, rather than for distribution. The authors' principal concern was to get their own research done, not to write a "user-friendly" program, and documentation was often a hastily scribbled and sometimes incomplete set of notes. Distributing one's program brought no rewards, and so responses to long distance phone calls from desperate new users were sometimes terse at best. Moreover, providing good user-support services over long-distance phone lines is a trick mastered by all too few of those whose profession is service, let alone a busy author whose attention is now elsewhere. The results then, as now, are that acquiring a program and adapting it to meet one's own needs is a task fraught with problems.

This is not to say that the authors of the programs reported in this volume will be ungracious when copies are requested of them. Prospective users do need to know, however, that they are likely to face problems of inadequate documentation and poorly designed human interfaces. They will be well-advised to have a competent programmer on their staff and plenty of slack time in their research schedule if they plan to import a program and use it with their own data. However, locating a prospective program is somewhat easier thanks to this volume.

Messrs. Ohly, Bock, and Bender have done two services for us in bringing this volume together. They have provided the researcher seeking to use these techniques with some valuable leads in locating programs of potential use to them and they have facilitated the sometimes painful process of a discipline's review of how its technology is produced and distributed.

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Ramkrishna Mukherjee, *Classification in Social Research*, Albany, New York: State University of New York Press, 1983, pp. 255.

The ways in which other cultures classify their family structures can be extremely complex, and anthropologists have made a considerable subspecialty of studying kinship classification systems. Readers of this journal may be acquainted with H.C. White's *An Anatomy of Kinship* (1963), (oddly missing from the eclectic bibliography of this book), in which matrix algebra is used to summarize the kinship rules of certain North American Indian groups. Mukherjee's own research has been concerned with family structures in the many cultures on the Indian sub-continent. His book claims to be an extension of this work to the general problem of classification, especially the classification of sentient beings who might have their own notions of the ways they should be grouped. However the examples are all from the study of Indian family structure. The literary style of the book is discursive and allusive in the extreme, so that in spite of favorable quotes from such authorities as Zenner and Alker, it is difficult to see how Mukherjee's method might be applied beyond the context in which it was originally developed.

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