dents and as a reference for those researchers embarking on running their own designed experiment, provides thorough coverage of a wide variety of topics for a number of experimental situations. The book assumes familiarity with basic statistical methods such as sampling, multiple linear regression, simple tests of hypotheses, confidence intervals, and analysis of variance, for which background can be readily found from a wide variety of introductory statistics books.

The book's strength is found in the breadth of its appeal. It begins with good coverage of the basics, such as completely randomized designs, linear models, hypothesis testing, power, and blocking, which will help those who have not had much exposure to design of experiments gain confidence with the basic principles and goals of a well-designed study. In addition to this clear introduction to the basics, the book examines a broad range of design types, focused almost exclusively on designs for variables with categorical levels and a corresponding analysis of variance. With a primary emphasis on design, not analysis, the book includes many details about a breadth of design types but does not place a strong emphasis on analysis or on finding optimal combinations of factors through multiple comparisons or other approaches.

With an accompanying website (*http://www4.stat.ncsu.edu/˜gumpertz/ggdata*) to provide electronic copies of the data and SAS code for examples and exercises in the book, using the book as a graduate textbook is straightforward, and most students will find the book readable and helpful for grasping the important ideas. Because there is much more material in the book than can be covered in a one- or two-semester course on design of experiments, the instructor should have flexibility to focus the course on a subset of topics most relevant to the class. A handful of exercises at the end of each chapter involve both design and analysis for applications in agricultural, engineering, and biological applications. For a practitioner, the well-organized format and style of presentation makes finding and understanding the relevant chapter easy.

Chapters 1–5 provide an introduction to design of experiments, completely randomized designs, linear models, hypothesis testing, choice of sample size appropriate for desired power, and the advantages of blocking. These chapters are clearly written and go through the basics in a comfortable and nonnotationally rich approach. Throughout the book, the authors provide alternative notations for describing designs, which will make using this book in conjunction with other resources more straightforward.

Although the ordering of the more advanced topics in the remainder of the book is a bit nonstandard, a vast collection of possible designs is described. Chapter 6 looks at latin squares, greco-latin squares, and variations of these designs. Chapter 7 gives a nice overview of split-plot and strip-plot designs with further variations, including how covariates can be incorporated in these designs. Chapter 8 and 9 consider incomplete-block designs and repeated-treatment designs. Chapters 10 and 11 deal with 2^N and 3^N factorial designs.

The short Chapter 12 discusses analysis techniques for experiments without a measure of pure error. Chapters 13 and 14 build on the basics of factorial designs presented in Chapters 10 and 11, with discussion of blocking and confounding issues for these cases, fractional factorial designs, and selecting between different aliasing structures.

Chapter 15 is one of the few chapters that considers continuous factor levels through the basics of response surface designs. It would be beyond the scope of this book to provide a more detailed coverage of the material; if this were an area of interest, then Myers and Montgomery (2002) would likely be the most appropriate reference.

Chapter 16 presents Plackett–Burman Hadamard designs, and Chapter 17 considers p^N and nonstandard factorial designs. Chapter 18 discusses designs where run order is important (or restricted), and Chapter 19 examines sequences of fractions of factorial designs that involve foldover techniques or augmentation. Chapters 20–25 discuss an assortment of other designs, including factorial experiments with quantitative factors, supersaturated plans, multistage experiments, orthogonal arrays, and computer experiments. Each of these chapters provides an introduction to broad areas. The authors should be commended for their inclusion of these topics into a graduate-level text and for their clear presentation of the basics.

The book does an excellent job showing the reader how to construct a design of a given type for a wide variety of factors and levels and providing the mechanics of the analysis to determine if factors have an effect. The authors could have done a better job developing how to take the analysis one step further to determine the nature of relationships, how to optimize the process, or how to draw conclusions about what has been observed, but perhaps this is just too big a mandate for a single book.

Given the wide variety of choices presented throughout the book, there is relatively little on how to choose between competing categories of designs for a particular situation. Including a section on design assessment through formal optimality criteria or subjective measures would have been a welcome addition, and would have helped the practitioner designing an experiment to make judicious choices and better understand the trade-offs between designs. For a practitioner suddenly faced with a very large collection of tools from which to choose, little intuition or insight is provided about how to select a design most appropriate for a given number of factors, with restrictions on how the data can be collected.

Finally, I think the authors might have emphasized how the different designs naturally put limitations on what types of models are possible and what types of relationships between factors and responses can be considered. Because considering such issues is a natural starting point for choosing a design, these are important shortcomings.

Overall, this book is an excellent reference for statisticians and practitioners who would like to gain broad exposure to the tools available for studying relationships between qualitative and quantitative factors and the observed responses. The book does a nice job of discussing the designs in a context of a planning phase, an execution phase, and an analysis phase. It also includes an extensive list of references to guide the reader to supplementary materials and literature on the topics for which only an introduction could be provided.

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REFERENCE

Myers, R. H., and Montgomery, D. C. (2002), *Response Surface Methodology: Process and Product Optimization Using Designed Experiments*, New York: Wiley.

Applied Longitudinal Analysis.

Garrett M. Fitzmaurice, Nan M. Laird, and James H. Ware. Hoboken, NJ: Wiley, 2004. ISBN: 0-471-21487-6. xix + 506 pp. $89.95.

Having published in this area myself, I can assert without hesitation that this book has been written by world-renowned, extremely knowledgeable experts in the fields of longitudinal and incomplete data for both continuous and noncontinuous outcomes. It is well written, with a consistent writing style. The book will be most useful to those looking for general and specific insight into parametric modeling for longitudinal data and to those seeking to apply this body of methodology in practice. Thus, clearly the book is neither a theoretical monograph nor (fortunately) a cookbook. A more theoretical treatise is, for example, the book by Searle, Casella, and McCulloch (1992). The authors complement their methodological developments with a number of case studies, larded with tables and graphical displays. In addition, they provide guidance on how to use SAS for fitting the methods presented to real data applications. This is done without turning the book into a software manual, and those readers not interested in the particular software tool used by the authors will be able to read the book without being bothered by the software sections.

The book is very well organized and logically structured. After a conceptual and notational introduction, the authors continue with the case of continuous outcomes. The build-up of concepts is gentle, with a good amount of early attention devoted to data exploration, classical methods such as those rooted in ANOVA concepts, and mean and covariance modeling. Then it moves into the general linear mixed model—undoubtedly the main and most popular model for the analysis of Gaussian longitudinal data at the present time. I would not have minded had this chapter devoted more space to this topic. The presentation of the continuous case concludes with a discussion of residual analysis.

The linear mixed-effects model, although simple and intuitive in principle, is surrounded with a number of less-than-straightforward issues. For example, a fully hierarchical formulation of the model implies a marginal one, but the reverse is not true. Careful development by the authors ensures that these concepts are introduced intuitively and accessibly, but without compromising on methodological rigor. Another such problem is the testing for variance components. In several situations, this problem is nonstandard, and mixtures of chi-squared distributions then replace standard chi-squared distributions. This problem is tackled cautiously, without scaring off the reader with technical details.

The authors move on to non-Gaussian longitudinal data, with binary data given a prominent place. The case of counts is given attention as well, however.

This area is a little more complicated than the Gaussian one, because there is no such unifying concept as the multivariate normal distribution. To begin with, there is the important distinction between marginal and random-effects models. The authors succeed in providing a good perspective on both of these, with particular emphasis on generalized estimating equations (GEEs) and generalized linear mixed models (GLMMs). Specific issues surrounding GEEs, such as the choice of a working correlation matrix, are described in a clear fashion. The discussion on the difference between correlations and odds ratios in this context is perhaps a little brief, but the most important thing is that the reader will understand how to use standard GEEs as well as alternating logistic regressions. The authors provide a good perspective on the similarities and differences between marginal and random-effects models. Chapter 13 presents a comprehensive, yet concise view of the relationships that exist between both models, while at the same time not leaving unanswered the practical question as to when to choose from which model family.

In the special topics part, the missing-data chapter takes a prominent place. Even though relatively short, this chapter develops essential terminology and a perspective on what is typically done in practice, including complete-case analysis and last value carried forward (LVCF), which the authors rightly do not recommend. They then discuss the feasibility and ease of likelihood methods under the missing-at-random assumption and indicate how weighting methods work. There is a general feeling that weighting methods are complicated, and some of the finer points of the semiparametric weighting theory, including weighted GEE, happens to be technical. However, the reader will painlessly acquire a good working knowledge of this methodology from Chapter 13, even though its conciseness may imply that some further reading may be necessary.

Another topic treated is design aspects. The authors also provide a clear perspective on multilevel models. There is quite a bit of confusion as to the relationship between this modeling framework, longitudinal data, and mixed-effects models, for example. Although there are strong relationships and even overlaps, there are differences as well. The authors do a good job clarifying these interrelationships. In particular, they intuitively explain how longitudinal data can be seen as a specific instance of clustered or correlated data, and how many models for longitudinal data can be formulated within the general multilevel modeling framework.

The authors successfully use a very pedagogical and didactic writing style. The many case studies and illustrations are tremendously useful to enhance understanding. The inclusion of problems at the end of every chapter is very useful as well. *Applied Longitudinal Analysis* should be on the shelf of everyone interested in acquiring a modeler's or practitioner's perspective on longitudinal data analysis.

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REFERENCE

Searle, S. R., Casella, G., and McCulloch, C. E. (1992), *Variance Components*, New York: Wiley.

Generalized Latent Variable Modeling: Multilevel, Longitudinal, and Structural Equation Models.

Anders SKRONDAL and Sophia RABE-HESKETH. Boca Raton, FL: Chapman & Hall/CRC, 2004. ISBN: 1-58488-0007. x + 508 pp. $89.95.

This book encompasses the major developments in the theory and practice of generalized latent variable modeling. It has two fundamental features that make it one of the most comprehensive reference books in the field: an up-to-date guide to multilevel and structural latent variable modeling and estimation, plus a multidisciplinary set of illustrative examples from biology, medicine, psychology, education, sociology, political science, economics, marketing, and other areas. These are extremely enlightening for experienced practitioners in the many areas in which latent variable modeling can be used to analyze data. As a complementary toolkit, the authors' Stata package GLLAMM (generalized linear latent and mixed models) and associated datasets, which are available for free download, can be used to replicate the examples in Chapters 9–14.

As the authors state in the Preface, the interplay between methodology and applications is particularly valuable. The book is organized in such a way the intended reader can always find illustrations of methodology by skipping forward to the application chapters, and statistical background for applications is obtainable by skipping backward to the methodology chapters, with technicalities always kept at a reasonable minimum. There are cross-references between the statistical and the illustrative sections merging the two parts of the book, plus a set of complementary readings at the end of each chapter. However, most of the text is self-contained, so the reader rarely needs to make immediate reference to the cited literature.

The first three chapters offer an introduction to the book's modeling approach. As stressed in Chapter 1, latent variables pervade modern statistics and are becoming more and more transversal as they are used to represent different phenomena, such as true variables measured with error, hypothetical constructs, unobserved heterogeneity, missing data, counterfactuals, and latent responses underlying categorical variables. Chapter 2 describes a wide set of possible response processes, ranging from generalized linear models to latent response models. This chapter is the building block of the illustrative examples reported from Chapters 9–14 and may serve as a general guide to the different types of response processes modeled later in the book. Chapter 3 provides a swift overview of classical latent variable models such as, among others, multilevel regression models, structural equation models, and latent class models. Even if the book presupposes a reasonable amount of knowledge of econometrics, statistics, and matrix algebra, the understanding of some topics, such as the statistical matrix notation of two-level and three-level random-coefficient models, is notably simplified by a set of illustrative displays; these are useful devices also for later chapters.

Chapter 4 merges the introductory section with later materials. It unifies in a general framework both the response processes described in Chapter 2 and the models described in Chapter 3. The framework mostly corresponds to the generalized linear latent and mixed models of Rabe-Hesket et al. (2004), where the general model formulation involves the specification of a set of hierarchical conditional relationships unifying multilevel, structural, and latent class models. It accounts for a wide set of possible regression structures between factors and random coefficients at different levels, and for a wide set of responses and flexible specification of latent variable distributions that can be estimated using nonparametric methods. The Stata program GLLAMM can estimate all of the models discussed in the chapter; but, as the authors stress, the multivariate normal distribution is the only continuous latent variable distribution currently available.

Chapters 5 and 6 focus on the identification and estimation of the statistical models analyzed in the introductory chapters. Chapter 6 offers a rather nontechnical overview of frequentist and Bayesian estimation methods and lists some of the available software. Chapter 7 analyzes the empirical Bayes prediction methods and the maximum likelihood methods commonly used for assigning values to continuous latent variables, as well as the empirical Bayes modal method, which is used for discrete latent variables. Finally, Chapter 8 examines the steps needed for correct model specification and inference.

Comparable books are those of Bartholomew and Knott (1999), who focus on latent variable models and factor analysis; Bollen (1989), who focuses mainly on structural equations with latent variables; and Wansbeek and Meijer (2000), who analyze factor and structural equation models. To my knowledge, the present book is the first to provide a truly unifying generalized approach to latent variable modeling.

I did not identify any glaring omissions in the topics covered in the methodology section, although an issue just marginally mentioned by the authors in Section 3.2.2 is witnessing an increasing amount of new research: even when the endogeneity of latent variables with respect to covariates is accommodated by a structural approach, there may still exist a correlation between residuals and covariates at some level of the hierarchical structure. Such correlations reflect different forms of interactions and externalities (Brock and Durlauf 2001). Particularly in the field of social sciences, the importance of such externalities has led researchers to define different concepts of membership and neighborhood effects that rely on notions of spatial and social distance (Anselin 2003). For example, Durlauf (1996) considered the effects of residential neighborhood on education and income inequality. In these models, income inequality across individuals is determined, at least in part, by characteristics of the neighborhood in which each individual grows up; but it also depends on the characteristics of other surrounding neighborhoods. Although the former type of dependence can be easily accommodated by a structural approach, this is not the case for the latter. The presence of such interactions is more than a nuisance, and the biases introduced in parameter estimation may be of concern.

In the application chapters, the authors analyze general Bayesian methods that may accommodate the case where one believes that spatial and social effects may render the distribution of random effects non-Gaussian. Modeling