

Book Review

An Introduction to Latent Variable Growth Curve Modeling: Concepts, Issues, and Applications

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There has been a marked resurgence of interest in longitudinal data analysis in the social and behavioral sciences over the past 10 or 15 years. A broad class of methods that has received particular attention is often referred to as *growth curve models*. There are a variety of statistical approaches currently available for estimating growth curve models (e.g., hierarchical linear modeling, general estimating equations, generalized mixed modeling), but the most popular form used in psychology clearly appears to be the structural equation-based *latent growth curve model* (LGM).

The inception of the LGM can be traced to the seminal work of Meredith & Tisak (1984, 1990). McArdle (e.g., 1988) also played a critical role in the early development of LGMs and has extended Meredith and Tisak's ideas in numerous important and creative directions. This initial work, combined with contributions by several other key individuals, allowed for the recent increase in the use of these modeling techniques across nearly all areas of behavioral research.

There is much literature about the technical developments of LGMs and their applications to substantive research questions. However, it is difficult to organize and synthesize this literature because it is scattered across book chapters, technical reports, and journals ranging from statistical and psychometric to psychological and educational. One great frustration encountered upon trying to learn these techniques is that there is no single, organized resource that summarizes the key concepts of LGMs combined with accessible applied examples using real empirical data. *An Introduction to Latent Variable Growth Curve Modeling* is the first resource to begin filling this void.

The book consists of 11 chapters totaling 142 pages of text. There is also a 37-page appendix that contains 18 different LGM examples using three commercially available SEM software packages: Version 8 of LISREL, Version 5 of EQS, and Version 3.6 of AMOS. The book is well-written and accessible to a wide range of readers. The material is primarily organized around the application of a variety of LGMs to evaluate different questions about developmental trajectories of alcohol and drug use in adolescents. Each chapter opens with a summary of the issues involved with the particular type of LGM under consideration, followed by one or more applied examples to illustrate various related points.

Although the book has many strengths, there are also several limitations. For example, a strength of the book is its organized presentation of a variety of topics commonly encountered in longitudinal research. A limitation is the relatively small number of pages, which restricts the amount of detail presented on each topic. Similarly, although readers can fully replicate all of the diverse sample applications using data and computer code provided in the text, the information is inherently time-

limited, given the release of new programs and newer versions of existing programs since the book's publication. The clear and accessible presentation of many of the basic equations involved in LGMs is another strength, but a limitation is that the notational system changes throughout, making it difficult to track from simple to more complex models. Overall, the book provides a well-organized general introduction to LGMs, coupled with detailed examples using empirical data and a comprehensive summary of key references to which readers can turn for more information about any specific topic of interest.

Chapter 1 is a general introduction. It presents challenges encountered in the analysis of longitudinal data, briefly reviews the software packages used, and provides a comprehensive collection of references relating to LGMs.

Chapter 2 addresses issues of LGM specification and underlying assumptions; it is the longest chapter. It opens with a simple growth model for two time points, and this model is extended to include additional time points and up to three growth factors. There is an accessible presentation of the underlying assumptions and model equations, and this is augmented with several path diagrams and sample computer code. This chapter serves as a launching point for the remainder of the book.

Chapter 3 highlights the link between LGMs and repeated measures ANOVA. This chapter is important because the strong links between these newer analytic methods and their more traditional counterparts are often overlooked. The authors present an interesting model in which the constant, linear, and quadratic components of adolescent alcohol use mediate the relation between age and later problem behavior. This model highlights several powerful potential applications of LGMs, although greater attention is paid to issues of model estimation relative to the substantive interpretations of the resulting parameters.

Chapter 4 addresses the estimation of LGMs in multiple populations. The chapter opens with a summary of the various invariance hypotheses that can be evaluated in a multiple population framework. This is followed by an applied example of a multi-sample model for the analysis of change. The interaction between trajectories of adolescent alcohol use and gender is examined, and the authors demonstrate how these models can be applied in other research settings.

Up to this point, only growth in a single construct over time has been considered. Chapter 5 provides a review of several types of interesting multivariate LGMs for evaluating the relation of the growth processes among two or more constructs over time. To demonstrate these approaches, three separate growth models are estimated using four repeated measures from a sample of adolescents who reported on their use of alcohol, tobacco, and marijuana. The modeling strategy begins with a general associative growth model followed by a comparison of McArdle's (1988) higher-order factor-of-curves and curve-of-factors growth models. The authors use these various models of change to highlight that different types of models can provide different insights into the same data.

Chapter 6 addresses the promising but underutilized cohort-sequential, or accelerated longitudinal, design. Here, two or more short-term longitudinal designs are linked together to approximate a single long-term longitudinal design. The authors show that the LGM framework is well-suited for this type of model estimation. The cohort-sequential LGM is applied to data from four groups of adolescents, ranging in age from 12 to 16 years, in which only one of the four groups was measured at all five time periods.

Chapter 7 is highly intriguing. It addresses ongoing work that the authors have pursued on testing interaction effects in LGMs. This chapter is more technically rigorous than most others in the book, given the presentation of many equations and parameter matrices, and several examples are presented using simulated data. But readers are left with the sense that the results are rather preliminary and that more work is needed prior to using these methods widely in applied research settings.

Chapter 8 is dedicated to the analysis of missing data in LGMs. Simple listwise deletion of partially missing data is becoming much less acceptable in longitudinal analytic settings. This chapter presents several recently developed powerful alternative approaches for missing data. The chapter contains a concise review of different types of missing data structures, followed by several applied missing data examples using both Muthén's multiple-group approach (Muthén, Kaplan, & Hollis, 1987) and raw maximum likelihood estimation (which is available in several SEM software packages).

Chapter 9 is one of the strongest chapters in the book, exploring various approaches to estimating LGMs within multilevel settings in which time is nested within individual, but individual is nested within some higher structure such as family or classroom. This chapter is more statistically rigorous than the others. An interesting example is presented in which changes in alcohol use over four time points are examined in a sample of families in which there are 2, 3, or 4 members nested within each family.

Chapter 10 is another strong chapter. It presents several alternative approaches to estimating statistical power within the LGM framework. The chapter opens with an overview of power estimation in LGMs. Several detailed examples are provided using both single- and multiple-group approaches to computing power of both close and exact model fit. The clear description of the methods, accompanied with a variety of sample computer code, provides readers with enough information to estimate statistical power for their own research projects.

Chapter 11 concludes the book with a general review of the advantages and disadvantages of LGMs. This is followed by an appendix with many specific examples in EQS, AMOS, and LISREL. The appendix provides an excellent resource for applied researchers, many of whom will be familiar with at least one of the three programs. However, given the need to focus on a manageable number of specific programs, other important software packages must be unavoidably omitted given space constraints.

An Introduction to Latent Variable Growth Curve Modeling provides a concise and well-written general introduction to the many variations of LGMs. Significant advantages include the breadth of topics addressed, the accessibility of the material to a wide readership, and the focus on a variety of substantive applications accompanied with detailed computer code. Given the breadth of topics addressed, the level of detail for any given topic is necessarily limited, but the reader can turn to other recommended resources for further information about the specific topics presented. This book will likely be of interest to anyone desiring an initial introduction to the numerous variations of LGMs and the issues and challenges often encountered when applying them in practice.

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Book Review

Innovations in Computerized Assessment

Fritz Drasgow and Julie B. Olson-Buchanan (Eds.)

Mahwah NJ: Lawrence Erlbaum Associates, 1999, 266 pp.,

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In the past two decades, the notion of computerized assessment has become a ubiquitous research topic for educational and psychological measurement specialists. Numerous presentations at annual research conferences, journal articles, technical reports, and a few books have been devoted to this topic. Given the increasing popularity of computerized assessment, there is a surprising lack of textbooks that can be used for both pedagogical and reference purposes. *Innovations in Computerized Assessment* is a book that attempts to fill this void.

The book is divided into 12 chapters. The first and last chapters were written by the editors, Drasgow and Olson-Buchanan, and the remaining chapters were written by contributing authors. The preface explains that one of the primary goals of the book was to help answer the question, "How do I develop a computerized test?" (p. x). Although it goes a long way toward answering that question, the book should not be considered a "how-to" book. Instead, detailed examples are offered of how others have developed computerized assessments for a variety of purposes.

History of Computerized Assessment

Chapters 1–6 focus on the history of computerized assessment and outline the development of several assessment programs that were started during the early 1990s. Without being labelled as such in the book, and without attempting to trivialize their importance, these chapters can be called historical. They allow the reader to gain an incredible amount of knowledge; they also provide the framework for the second half of the text.

Chapter 1. Drasgow and Olson-Buchanan introduce the topic of computerized assessment and mention that, "unfortunately, traditional texts such as Nunnally's (1978) *Psychometric Theory* and Guilford's (1954) *Psychometric Methods* have only limited relevance to the development of innovative computerized assessments" (p. 4). Researchers should seriously consider this before they begin to develop a computerized assessment.

Chapter 2. Zickar, Overton, Taylor, and Harms discuss the development of an assessment tool for selecting computer programmers and analysts for State Farm Insurance Company. This chapter provides an excellent account of the development of a computerized adaptive test (CAT) and focuses on important issues, such as concurrent and predictive validity. In discussing the pros and cons of their efforts, the authors state that "increased, rather than decreased, testing time and the failure to improve validity were the most notable disappointments" (p. 31). Although they ultimately conclude that "State Farm generally had a positive experience with computerized testing" (p. 32), these limitations are not trivial.