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BOOK REVIEW

An Introduction to Latent Variable Growth Curve Modeling: Concepts, Issues, and Applications (2nd ed.). T. E. Duncan, S. C. Duncan, and L. A. Strycker. Mahwah, NJ: Lawrence Erlbaum Associates, Inc., 2006, 272 pages, $39.95 (paper).

Reviewed by Kristopher J. Preacher
University of Kansas

Latent growth curve modeling (LGM) is an application of structural equation modeling (SEM) to longitudinal data. LGM is useful for addressing hypotheses relevant to the population of individuals as well as to variability in trajectories among individuals within that population. Although a number of excellent texts on SEM exist (e.g., Bollen, 1989; Kaplan, 2008; Kline, 2004), the popularity of LGM and the particular challenges associated with this technique create a need for self-contained presentations of the topic for applied researchers.

The first edition of *An Introduction to Latent Variable Growth Curve Modeling: Concepts, Issues, and Applications* (Duncan, Duncan, Strycker, Li, & Alpert, 1999) was the first book to address this need. However, LGM has become so popular, and statistical advances have been achieved so rapidly (e.g., categorical variable methods, missing data methods, mixture modeling) that a second edition has become necessary. This second edition provides much-needed discussion of some of these new advances. Additional strengths include an accessible writing style, numerous applied examples, and many path diagrams. It provides coverage of more computer programs, supplementary reference lists in most chapters, and a CD containing all of the example syntax, output, and data files in multiple formats. The CD also contains most of the book's figures and a convenient navigation aid. Example computer syntax is primarily written for the SEM software package EQS (version 6), supplemented by syntax for AMOS (version 5) and LISREL (version 8). The second edition has added syntax for M*plus* (version 3) and, where appropriate, HLM and SPSS. The syntax will work in more recent versions of these software programs with little or no modification.

At the same time, the book suffers from a few limitations. First, the book's emphasis on model specification comes at the expense of substantive interpretation of results. Second,

Correspondence should be addressed to Kristopher J. Preacher, Department of Psychology, University of Kansas, 1415 Jayhawk Blvd., Rm. 426, Lawrence, KS 66045-7556. E-mail: preacher@ku.edu

various models are presented with inconsistent explanatory depth (e.g., the mixed linear model is written out in equation form, but the LGM is not). Third, the same substance abuse data are used for the majority of the examples. The use of one type of applied example promotes continuity of understanding, but might not speak to a diverse readership from other social science disciplines who also use LGM. Whereas attention to new topics is welcome, the technical and mathematical complexity of some topics (e.g., multilevel LGM, latent variable interactions) risks losing the beginning reader. The cursory treatment of some new topics added in the second edition might disappoint the advanced reader; for example, instead of a chapter on generalized linear LGMs, only binary and ordinal outcomes are discussed in chapter 10. Discussion of nonlinear LGMs (aside from quadratic and unspecified growth models), such as structured latent curve models, is omitted entirely.

The book contains 14 chapters. Chapters retained from the first edition have been reordered, expanded, and brought up to date with recent research and additional references, and three chapters have been added to deal with advanced topics. Chapter 1 contains an introduction to LGM, outlining the benefits of LGM over competing methods, and a section on evaluating model fit.

As in the first edition, Chapter 2 presents introductory material on model specification. A two-occasion linear model is used as a springboard for discussing both the limitations of two-wave longitudinal data sets and the consequences of specifying various values for the fixed loadings. Following this discussion are three examples: a three-occasion quadratic growth model, an unspecified growth model with some free loadings, and a single-factor LGM.

Chapter 3 explores the relationships among analysis of variance models, LGM models, and—new to the second edition—mixed linear (multilevel) regression. Parallel analyses of the same data using all three methods are helpful in illustrating the important relations among these methods. The models feature predictors and sequelae of change in adolescent alcohol use, demonstrating some advantages of LGM over competing methods. Very little syntax is presented beyond this point in the book, but it can be found on the CD.

Chapter 4 presents three models for investigating growth in multiple variables simultaneously. Specifically, the chapter discusses an associative LGM, in which growth is modeled in alcohol, tobacco, and marijuana use while intercepts and slopes are permitted to covary; a factor-of-curves model, in which higher order factors are specified to explain correlations among aspects of change; and a curve-of-factors model, in which growth is modeled for a general substance-abuse factor (McArdle, 1988). The chapter ends with an example in which aspects of growth and higher order factors are predicted by age.

Chapter 5 is dedicated to methods for analyzing growth in multiple populations simultaneously. Such models are important because they permit the researcher to test hypotheses concerning the invariance of corresponding parameters across groups. The authors present a guide containing potential invariance hypotheses that may be tested. Following this is an example of a two-group model of growth in alcohol consumption fit to male and female samples, with all parameters constrained to equality across groups. The chapter also contains discussions of Lagrange multiplier tests and an added-growth model for testing group differences in growth (Muthén & Curran, 1997).

Chapter 6 illustrates models for use in accelerated or cohort-sequential designs. Accelerated designs combine features of cross-sectional and longitudinal designs, permitting the researcher to conduct a longitudinal study in a much shorter span of time than would otherwise be

necessary. Two examples are presented—one a traditional multiple-group LGM for modeling multiple alcohol-use cohorts simultaneously, and the other an unspecified growth model from Chapter 2. The authors discuss the advantages of these designs relative to cross-sectional and true longitudinal designs (e.g., reduced attrition, shorter research timeline), as well as several limitations (e.g., they are only approximations to true longitudinal designs).

Chapter 7 describes a complex and important topic: multilevel LGM. Multilevel LGM combines aspects of LGM with multilevel modeling to permit unbiased parameter estimation when repeated measures are nested within cases (e.g., subjects) that in turn are nested within higher order clusters (e.g., classrooms or workgroups). Full and limited maximum likelihood estimation techniques are applied to models of change in substance use for individuals nested in families. A helpful step-by-step guide is provided so that readers can replicate the analysis using their own data. An interesting addition to the second edition is an example extending multilevel LGM to four levels, where families are nested within geographic regions. The mathematics included in Chapter 7 are highly complicated but might be useful for an advanced reader confronted with multilevel longitudinal data.

Chapters 8, 9, and 10 are new to the second edition. Chapter 8 addresses growth mixture modeling. It is not always the case that a grouping variable is observed; often, heterogeneity in trajectories could arise as a result of latent classes that differ in aspects of change. The chapter begins with a general overview of latent class models and mixture models, and illustrates how to specify the growth mixture model in both equation form and using M*plus.* Four illustrative examples are provided: a single-class LGM for modeling change in alcohol use across three occasions, a two-class LGM, and models including covariates and mixture indicators. The chapter also includes practical tips for choosing the number of classes and choosing starting values. Importantly, the authors give a balanced presentation, emphasizing both the advantages of growth mixture modeling and several disadvantages of this controversial method.

Chapter 9 introduces two interesting applications of LGM to analyze differences between distinct segments in time series data: piecewise LGM and interrupted time series LGM. Piecewise models involve modeling potentially different trends in time series data that involve two distinct periods (or segments) of change separated by a transition point. In the first illustrative example, a piecewise model is applied to summarize linear growth in alcohol use in middle school (Segment 1) and in high school (Segment 2). Interrupted time series models, on the other hand, permit the examination of "added" effects (changes in level or slope) in response to an intervention or other event that occurs at a specific point in time. The second example illustrates an interrupted time series LGM, capturing change in alcohol use intercept and slope after the transition from middle school to high school. A third example presents a simple change model, a reparameterization of the interrupted time series LGM. A good summary is provided, along with pros and cons of the procedures and some interesting directions in which these models can be taken. One emerges from this chapter with a sense of the flexibility of LGM to accommodate many kinds of hypotheses about change over time.

Most methods for analyzing longitudinal data were developed with continuous, normally distributed variables in mind, but these methods are not appropriate for handling binary and ordinal categorical data. Chapter 10 contains a discussion of two methods for properly analyzing binary and ordinal data: using a limited information estimator with polychoric or polyserial

correlation input, and treating the data as continuous and correcting the fit statistics afterward. Three programs are used to analyze a growth model of adolescent alcohol use spanning four years using three response categories. Similarities and differences across software packages are discussed. The authors rightly point out that these methods unfortunately are not in widespread use, and that more work needs to be done to alert researchers to the advantages of analyzing ordinal data properly. Chapter 10 provides a basic overview of the topic and serves as a starting point for further reading on this important emerging topic.

Very few longitudinal studies are characterized by complete data. In response to this common problem, Chapter 11 discusses ways to use LGM with missing data. The chapter opens with useful taxonomies of missing data procedures and missing data types. Illustrations of a multiple-group method of handling missing data (in which each group corresponds to a distinct pattern of missing data) and a full-information maximum likelihood approach from the first edition are enhanced by the inclusion of a section on multiple imputation. This new section includes discussions of expectation-maximization and data augmentation methods. Also included is a table demonstrating close agreement across the three methods in terms of point estimates and standard errors.

In applications of SEM, there are two primary kinds of statistical power: the power to detect individual or multiple parameters and the power to reject a poorly fitting model. Chapter 12 begins with discussions of the power analysis frameworks developed by Satorra and Saris (1985) and MacCallum, Browne, and Sugawara (1996) mainly for overall model fit. Examples of each are provided. A valuable addition to the second edition is a section describing a powerful new Monte Carlo simulation approach to power analysis available in M*plus*.

Several promising methods have been suggested for analyzing interaction effects involving latent variables. Chapter 13 contains a detailed presentation of one such method, building on the work of Kenny and Judd (1984) and Jöreskog and Yang (1996) but applied to a model in which the slope factors associated with two outcome variables are hypothesized to interact in predicting the slope of a third outcome variable. This chapter presents many parameter matrices along with covariance algebra, and is easily the most technical in an otherwise highly accessible text. The example is interesting, but will be of most use to readers specifying a similar model. Only one of the promising new latent variable interaction methods is discussed.

The final chapter provides a summary and synthesis of main points.

To conclude, *An Introduction to Latent Variable Growth Curve Modeling* is a particularly helpful resource for researchers wishing to gain a quick yet accurate understanding of beginning to advanced topics in latent growth curve modeling. The authors have once again written a text that not only provides a unified introduction to LGM fundamentals, but also covers many state-of-the-art topics (e.g., the Monte Carlo power approach, categorical outcomes, multiple imputation, and growth mixture modeling), demonstrating the enormous flexibility of LGM as a general modeling approach for longitudinal data.

The book does, however, require some degree of familiarity with SEM, and the required background knowledge can vary widely across chapters. Some chapters (e.g., 7 and 13) require advanced knowledge of SEM, whereas most others require only basic background knowledge. Nevertheless, the additional examples, current topics, and extensive syntax make this text not only a useful reference work for the applied researcher, but also a potentially useful supplementary textbook in a graduate SEM course or primary text for a longitudinal modeling course, assuming students have had prior experience with SEM.

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