Rezensionen

At the beginning the author writes in his introduction "This book was written for the simple reason, that no other book of its kind had been published before" and he is right. To achieve the goal of a user friendly text he uses four strategies:

1. Every key concept is accompanied by an applied data set and the syntax and output from the mostly used structural equation software packages AMOS, CALIS, EQS, LISREL and MPLUS.

2. Tables are included that recap the procedures or steps of the methods being presented (e. g. how to write up the results of a CFA study for reports or publications).

3. Numerous figures are provided that graphically illustrate some of the more complicated concepts or procedures (e. g. forms of measurement invariance, types of nonpositive definite matrices, identification of formative indicator models).

4. Many chapters contain appendices with user-friendly illustrations of seemingly complex quantitative operations (e. g. data generation in Monte Carlo Simulation, calculation of matrix determinants and their role in model fit and improper solutions, the effect of model identification on standard errors).

The book is structured in two parts. The first five chapters present the fundamental concepts and procedures of CFA including an introduction to Exploratory Factor Analysis. The second half of the book deals with more specialized issues like analysis of multitrait-multimethod (MTMM) data and issues of validation (chapter 6), different types of constraints and analysis of multiple groups including intercepts and latent means (MGCFA) and in addition Multiple Indicator Multiple Causes Models (MIMIC) which combine formative and reflective indicators in one model (chapter 7). Chapters 8 and 9 contain Higher Order Confirmatory Factor Analysis, CFA approaches to scale reliability estimation and CFA with formative indicators, missing values and non-normally distributed continuous indicators and a detailed overview of confirmatory factor analysis with categorical indicators. The final chapter deals with the problem of sample size and power.

Timothy Brown uses only computer syntax examples out of two plausible reasons. Graphical input does not lend itself easily to the written page and he argues that using syntax may be often faster than graphical input and gives more transparency to the underlying model. However to understand all the possible model specifications in CFA and structural equation modelling graphical input facilitates the learning for beginners significantly. Those, who want to get a good introduction to graphical input as a complement are well served by the books of Barbara Byrne (Byrne 1998, 2006, 2010). In the following section I want to review the chapters in more detail.

Chapter 1 contains a gentle introduction to the topic and summarizes the four main goals of Confirmatory Factor Analysis that is the Psychometric Evaluation of Test Instruments, Construct Validation, Analysis of

Method Effects and Evaluation of Measurement invariance.

The common Factor Model and Exploratory Factor Analysis (EFA) are discussed in detail. The concepts, the terminology and the basic equations are well explained and it is outlined very clearly, that both exploratory and confirmatory factor analysis are based on the common factor model. Here as in the other chapters he uses the usual notation by using Greek symbols. For the illustration of the results the author uses here and in all other chapters path diagrams. As main goal for EFA he defines the determination of the dimensionality of a set of multiple indicators by uncovering the smallest number of interpretable factors needed to explain the correlations between them. In more detail he explains the selection of a specific method to estimate the factor model, the selection of the appropriate number of factors, selection of a technique to rotate the initial factor matrix to foster the interpretability of the solution and the selection of a method to compute factor scores. In the end (p. 38) he gives a very informative table summarizing all necessary steps. From my point of view I miss a short discussion of the shortcoming of EFA statistically and methodologically and especially in the past and present research practice in the sense of inductive methodology and ad-hoc interpretation. A fine example of such a criticism was given by Duncan's (1984) critique of factor analysis or Borsboom's (2006) criticism of classical test theory.

The purposes, parameters and fundamental equations of confirmatory factor analysis and the comparison of EFA and CFA are dealt with in chapter three. Brown discusses standardized and unstandardized solutions, indicator cross-loadings, unique variances, correlated indicator errors and their possible explanation by method factors. These method factors can be for example question wording, social desirability, acquiescence and others and cannot be estimated in EFA but only in CFA. Furthermore he explains

as central advantage of confirmatory factor analysis to specify a priori the number of factors, the relationship between indicators and latent variables and the relations between factors and those between errors. All the available information can be transformed in corresponding constraints which are tested. In addition he shows by giving an example that in contrast to the correlation of sum or composite scores or single items the correlation of factors is corrected from measurement error and therefore not biased. Very instructive is also how he explains the reproduction of an input correlation matrix from the parameter estimates of a two factor measurement model as this procedure is often difficult for beginners to understand. CFA model identification and estimation and descriptive Goodness of Fit Indices are explained in detail technically but also in a very clear and non-technical way and illustrated with a substantive example. The appendix to the chapter shows nicely how to obtain a solution for a just-identified factor model and the hand calculation of the Maximum Likelihood Fitting Function for one model treated before. Chapter four gives a very good account of the specification and interpretation of CFA models. Using the SEM programs LISREL, MPLUS, EQS and CALIS a two factor model of personality is evaluated. In detail overall goodness of fit, interpretability of the parameters including standardized and unstandardized solutions are discussed. Very informative for users of CFA is Table 4.6 which summarizes based on different articles on this topic what to report in a CFA study for an article or report. Maybe in the whole chapter Brown should have stressed one of the major criticisms of the use of SEM that users should more explicitly document the underlying substantive theory for their model specifications (McCallum/Austin 2000). This refers also to the issue of the deciding whether indicators are formative or reflective, which has been an issue of increasing importance (e. g. Bollen 2007, Howell et al. 2007). Two useful appendices

dealing with the topics "Goodness of Model Fit does not ensure meaningful parameter estimates" and an example report of the "Two-factor model of neuroticism and extraversion" ends the chapter.

"CFA Model Revision and Comparison" deals with the extremely important issue of model modification. In a systematic way Brown deals with the sources of poor-fitting CFA solutions (number of factors, misspecified relationships between indicators and constructs, correlated errors) and the problem of improper solutions and nonpositive definite matrices. All the topics are illustrated by different data-sets. In addition he discusses the use of EFA for model modification in a CFA framework, which has been recently intensively dealt with by Aspourov and Muthen (2009). The discussion of the often neglected problem of equivalent models is treated by him especially in deciding between a second-order factor model versus first-order factor models with multiple factors. In chapter six he shows how the application of CFA to multitrait-multimethod-matrices allows the estimation of convergent, discriminant and method effects in the evaluation of the construct validity of latent variables. The different possible parametrizations (like Correlated Methods Models vs. Correlated Uniqueness Models) are discussed in detail and the syntax for the correlated method models for the five different programs is given. In addition he discusses shortly other parametrizations like the direct product model by Browne, which allows interactions between method and trait factors. However, I miss a discussion of the true score MTMM models (Scherpenzeel/Saris 1997) and the application to the modelling of autocorrelated errors in panel data, which could be especially useful for a sociological and political science audience (Finkel 1995). Confirmatory Factor Analysis with Equality Constraints, Multiple Groups and Mean Structures are dealt with in chapter 7. After a discussion of congeneric, Tau-equivalent and parallel indicators and their implementation in the five programs he introduces the topic of invariance of measurements over time and groups. Furthermore the estimation of latent means and intercepts of indicators is demonstrated. This is done both for multiple time points and for multiple cross-sectional groups and syntax for both cases is given. In addition the relationship between MIMIC models and Multiple Group Confirmatory Factor Analysis is discussed and the test of differential item functioning using MIMIC models. Special emphasis is given to the issue of partial invariance and the practical guidelines discussed in the literature. Higher order factor analysis, scale reliability evaluation and formative indicators are discussed in chapter 8. For the second order factor analysis he gives an example syntax, discusses the necessary steps for testing and describes in general terms and for a specific example the Schmid-Leiman Transformation to estimate the relationship of the observed measures to the higher-order factors. In the next section he discusses procedures based on CFA, which overcome limitations of classical reliability estimates like Cronbach's Alpha, by no longer assuming equal loadings, equal measurement error, unidimensionality and no error correlations. Finally he deals with the issue of models with formative indicators and addresses the problems of identification, estimation and interpretation. Examples are the model specification for the latent variables Life Stress and Socioeconomic Status (SES). Missing, non-normal and categorical data - often neglected problems in practical applications - are treated in chapter 9. In detail the two recommended procedures for treating missing values that is model based full information maximum likelihood (FIML) and multiple imputation are treated and syntax examples are given. Furthermore alternative estimation procedures for non-normal data (robust ML and weighted least squares) are discussed. Finally he describes the estimators for categorical data like weighted least squares and robust weighted least squares (WLSMV) and their strengths

and weaknesses. Very informative is also the section on the comparison of CFA with item response theory (IRT) models normally perceived as two different worlds. He starts with the well known point that factor analysis with binary outcomes is equivalent to a two-parameter normal ogive item response theory model and then discusses other IRT models. Using MPLUS he demonstrate the procedure to estimate a one factor CFA with binary indicators and factor loadings constrained to equality. In the final chapter another neglected topic that is statistical power and sample size is treated. In his discussion he clearly argues that simple general rules like the relation of subjects to number of indicators are not sufficient. One needs to determine the sample size and as a consequence the power of models in the context of a particular model and data-set. He shows how the Satorra-Saris method in LISREL and the Monte Carlo method in MPLUS can be used to reach the goal of the specific determination of power for a given model and data-set. The only important missing information in this chapter but also relevant for chapter 9 is the meta-analysis of the robustness of SEM models in general by Hoagland and Boomsma (1998). Finally an overview of newly developed procedures like multilevel factor models and factor mixture models is given. The only missing point is the treatment of bayesian estimation procedures, which are at least available in AMOS.

Summarizing the review I think that this is presently the best book for applied researchers on confirmatory factor analysis and can be used as a textbook in M.A. courses or Ph.D. courses for confirmatory factor analysis in the social sciences and psychology as the basic textbook. But it also can serve for researchers in the social sciences and psychology as a very useful reference book in modelling measurement models and building scales with confirmatory factor analysis.

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