Meeting of the
Working Group Structural Equation Modeling

26-27.02. 2015

Freie Universität Berlin
Habelschwerdter Allee 45
14195 Berlin
(Room J32/102)
### Time schedule

**Thursday, 26.02.2015**

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<td>10:30 - 10:45</td>
<td>Address Prof. Michael Eid</td>
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<tr>
<td>10:45 - 11:15</td>
<td>Old and new approaches for the analysis of categorical data in a SEM framework</td>
<td>Rosseel &amp; Katsikatsou</td>
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<td>11:15 - 11:45</td>
<td>Using the pairwise likelihood method to analyze large datasets with discrete responses</td>
<td>Barendse, Oort, Timmerman, &amp; Rosseel</td>
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<td>11:45 - 12:15</td>
<td>An IRT model with person-specific item difficulties</td>
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<td>12:15 - 12:45</td>
<td>A comparison of WLSMV and Bayesian Methods For Multilevel IRT Models in small samples - A simulation study</td>
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<td>12:45 - 14:00</td>
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<td>14:00 - 14:30</td>
<td>The modeling of heterogeneous growth patterns</td>
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<td>Evaluation of the robustness of a second order cohort data based growth model to detect individual dynamics in growth</td>
<td>Fischer, Klein, &amp; Brandt</td>
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<td>Introducing ctsem - an R package for continuous time structural equation modelling</td>
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<td>Evaluating sensitivity of parameters of interest to measurement invariance in latent variable models</td>
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<td>16:30 - 17:00</td>
<td>Explaining cross-country noninvariance in attitudes toward granting citizenship rights</td>
<td>Dülmer, Davidov, Cieciuch, Seddig, Kuntz, &amp; Schmidt</td>
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<td>17:00 - 17:30</td>
<td>Testing for exact versus approximate measurement invariance of the attitudes toward immigrants scale in the European Social Survey: 2002 - 2012</td>
<td>Cieciuch, Davidov, Schmidt, &amp; Algesheimer</td>
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<td>17:30 - 18:00</td>
<td>Meeting Working Group</td>
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**Friday, 27.02.2015**

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<td>Examining components of face cognition - using structural equation modeling and network analysis techniques</td>
<td>Plötner, Mayer, &amp; Kaufmann</td>
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<td>09:30 - 10:00</td>
<td>Mediation analysis: Misconceptions and problems of representing causal mechanisms</td>
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<td>EffectLiteR: Detailed effect analysis using structural equation modeling (Part 1)</td>
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<td>EffectLiteR: Detailed effect analysis using structural equation modeling (Part 2)</td>
<td>Mayer</td>
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<td>11:30 - 12:00</td>
<td>Introducing nlsem: An R package for estimating nonlinear structural equation mixture model</td>
<td>Umbach, Naumann, Hoppe, Brandt, Kelava, &amp; Schmitz</td>
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<td>12:00 - 12:30</td>
<td>Shortening scales based on automated CFA fitting</td>
<td>Schultze &amp; Eid</td>
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<td>12:30 - 13:00</td>
<td>Comparing maximum-likelihood and Bayesian estimation techniques for the analysis of multitrait-multimethod data with few observations</td>
<td>Bohn, Holtmann, &amp; Koch</td>
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<td>13:00 - 13:30</td>
<td>Farewell</td>
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In traditional software for structural equation modeling (SEM), there are two options to deal with binary and ordinal observed variables. The first option is called the three-stage limited information approach (in the Mplus world, this known as estimator WLSMV). The second option is based on the IRT tradition where full information maximum likelihood estimation is the golden standard. Recently, a new approach called pairwise likelihood (PL) estimation has been introduced in the literature. Pairwise likelihood keeps the computational complexity low regardless of the model size (i.e. the number of observed or latent variables) and at the same time shares some of the desired properties of likelihood methods (i.e. the derived estimator is asymptotically unbiased, consistent and normally distributed). In addition, many familiar inference tools can be extended to the case of PL: Wald test for the parameter estimates, pairwise likelihood ratio test (PLRT) for overall fit, nested models, and equality constraints, and PL versions of AIC and BIC criteria. In this talk, I will briefly discuss the three approaches, and their implementation in SEM software. The PL estimation approach is currently only implemented in the R package lavaan, and serves as an example of how open-source software can foster the development of new statistical ideas.

Using the pair-wise likelihood method to analyze large datasets with discrete responses

M.T. Barendse¹, F.J. Oort³, M.E. Timmerman², & Y. Rosseel¹

¹ Ghent University, ²University of Groningen, ³University of Amsterdam

Factor analysis of discrete data often relies on the assumption that the responses are manifestations of underlying normally distributed continuous scores. For small numbers of variables (e.g., six or less) it is already difficult to maximize the likelihood of multivariate response patterns, as it requires numerical evaluation of high-dimensional integration over all underlying normally distributed continuous scores. Alternatively, the sum of the likelihoods of the bivariate response patterns (i.e., pair-wise) of two-way contingency tables can be maximized. This relatively new pairwise maximum likelihood (PML) method performs satisfactorily in small data sets with small numbers of variables. Little is yet known about how well the PML estimation method works with larger numbers of variables that are often encountered in empirical data.
An IRT model with person-specific item difficulties

Rolf Steyer

Friedrich-Schiller-Universität Jena

In the Rasch model we assume that the item difficulties are identical for all persons. In empirical applications, model tests usually show that the assumptions of this model do not hold. This also applies to the more liberal Birnbaum model. I present a generalization of the Rasch model in which it is assumed that the item difficulties are person-specific, i.e., in which each item has a latent trait and a latent difficulty variable. The price for such a model is that there are several occasions of measurement with time-invariant item-difficulty factors. The model is applied to the life satisfaction scale of the Freiburger Personality Inventory (FPI). Using the good-bad scale of the multidimensional mood state questionnaire (MDBF), it is also investigated if and how the model can be extended to items with more than two answer categories.

A Comparison of WLSMV and Bayesian Methods for Multilevel IRT Models in small samples - A Simulation Study

Jana Holtmann, Tobias Koch, & Michael Eid

Freie Universität Berlin

Multilevel-IRT models become increasingly applied in psychological research using multiple informant reports (i.e. raters nested within targets). With increasing complexity of these models, model estimation becomes computationally extremely demanding and frequently encountered small sample sizes pose further challenges on estimation methods relying on asymptotic theory. As an alternative, Bayesian estimation overcomes many shortcomings of the classical estimation techniques when estimating complex multilevel IRT models in small samples. The present study evaluates the performance of Bayesian estimation with diffuse and informative prior inputs as compared to WLSMV for a two-level ordinal IRT model. The differential influence of between- and within-level sample sizes on estimation accuracy was investigated, with a focus on small sample-size situations (50-200 level-2 and 2-8 level-1 units), comparing two software programs, Mplus and RStan. Bayesian estimation outperformed WLSMV estimation solely when used in combination with strong informative accurate priors, irrespective of sample size. RStan as compared to Mplus yielded better results in terms of parameter estimates, while the accuracy of standard error estimates (posterior SDs) was comparable for the two programs. Results suggest that a minimum of 150 level-2 and 6 level-1 observations should be used for Bayesian estimation with diffuse priors in order to obtain proper parameter estimates, while using lower sample sizes (100 level-2 and 4 level-1 units) can be considered in combination with informative priors or using WLSMV. The use of weakly informative inaccurate priors on loading parameters recovered parameter estimates equally well as or even better than Bayesian estimation with diffuse priors.
The modeling of heterogeneous growth patterns

Holger Brandt¹, Andreas Klein², & Augustin Kelava¹

¹ Eberhard Karls Universität Tübingen, ² Goethe Universität Frankfurt am Main

Heterogeneous growth patterns occur, for example, when subjects who have fairly similar characteristics at an initial stage develop differently over time. If such patterns are ignored, interpretations of the development process may be misleading and predictions based on the information at the initial stage may be incorrect. Different models have been proposed to capture such heterogeneity, for example, the Growth Curve Mixture Model (GMM; Meredith & Tisak, 1990; Muthén, 2001) or the Heterogeneous Growth Curve Model (HGM; Klein & Muthén, 2006). While the GMM models any heterogeneity of growth patterns with a latent class framework, the HGM models a specific heteroscedastic structure of the slope factor. In this talk, the two alternative models are compared from a conceptual viewpoint and with regard to their strengths and weaknesses. Furthermore, a semi-parametric extension of the HGM is introduced that may overcome some of the limitations of the original implementation because it allows for a more flexible and general modeling of the heterogeneity. The application of the model is illustrated by an empirical data set from education sciences.

Evaluation of the Robustness of a Second Order Cohort Data Based Growth Model to Detect Individual Dynamics in Growth

Kevin A. Fischer¹, Andreas G. Klein¹, & Holger Brandt²

¹ Goethe Universität Frankfurt am Main, ² Eberhard Karls Universität Tübingen

The investigation of growth processes for not direct observable variables (latent variables) is an important issue in social sciences. When time is measured discrete latent growth curve models (LGM) has become a widely applied method to evaluate growth processes. Longitudinal data with repeated measures of the same subjects are needed to identify the parameters of the model. Means and (co)-variances of latent variables that represent initial status and slope are then used to describe the growth process. However, growth processes may also be investigated using cohort data, i.e. cross-sectional data from different subjects who are located at different stages of the growth process. When standard model are applied to cohort data (e.g. ANOVA) only information over the average growth can be retrieved from the data. Recently, a cohort data based growth model (CGM) has been introduced (Klein & Fischer, 2014) that allows to identify all parameters of a LGM under a set of assumptions solely based on cohort data. In this presentation we introduce the so-called second order cohort data based growth model (2-CGM) which is an extension of the CGM with less restrictive assumptions for not direct observable variables. In a simulation study we evaluate the robustness of the novel method in respect to the bias of the parameters and accuracy of standard errors. In addition we discuss the underlying assumptions of both the LGM and the CGM and point out their appropriateness and limitations in applied research.
Introducing ctsem - an R package for continuous time structural equation modelling

Charles Drivers¹, Manuel Voelkle¹, & Johan Oud²

¹Max-Planck Institute for Human Development (Berlin), ²Radboud University Nijmegen

We introduce ctsem, an R package for continuous time modelling of panel and time series data, using structural equation models (SEM). Most dynamic models for longitudinal data in the social and behavioural sciences are discrete time models, with applications ranging from annual assessments of life satisfaction, daily mood surveys via smartphone, to multiple brain activation recordings in the course of a single experiment. A core assumption of discrete time models is that time intervals between measurements are equal, and that everyone was assessed at the same time. Violations of this assumption are regularly ignored due to the difficulty of accounting for varying time intervals, as such parameter estimates can be severely biased. By using stochastic differential equations and estimating an underlying continuous process, continuous time models allow for any pattern of measurement occasions. By interfacing to a general purpose SEM package OpenMx, ctsem combines the flexible specification of structural equation models with the enhanced data gathering opportunities and improved estimation of continuous time models. ctsem can estimate relationships over time for multiple latent processes, measured by multiple noisy indicators with varying time intervals between observations. Within and between effects are estimated simultaneously by modelling both observed covariates and unobserved heterogeneity. Exogenous shocks with different shapes, group differences, higher order diffusion effects and oscillating processes can all be simply modelled. We first briefly introduce and define continuous time models, then show how to specify and estimate a range of continuous time models using ctsem.

Evaluating Sensitivity of Parameters of Interest to Measurement Invariance in Latent Variable Models

Daniel Oberski
Tilburg University

Latent variable models can only be compared across groups when these groups exhibit measurement equivalence or “invariance”, since otherwise substantive differences may be confounded with measurement differences. In this talk I suggest examining directly whether measurement differences present could confound substantive analyses, by examining the EPC-interest. The EPC-interest approximates the change in parameters of interest that can be expected when freeing cross-group invariance restrictions. Monte Carlo simulations suggest that the EPC-interest approximates these changes well. Three empirical applications show that the EPC-interest can help avoid two undesirable situations: first, it can prevent unnecessarily concluding that groups are incomparable, and second, it alerts the user when comparisons of interest may still be invalidated even when the invariance model appears to fit the data. Thus, it challenges conventional wisdoms such as ‘if the fit statistics are satisfied, any difference in the latent means is indicative of true mean differences’ and clarifies what constitutes a 'small' or 'large' deviation from measurement invariance.
Explaining cross-country noninvariance in attitudes toward granting citizenship rights

Hermann Dülmer¹, Eldad Davidov², Jan Cieciuch², Daniel Seddig², Anabel Kuntz³, & Peter Schmidt⁴

¹Institut für Soziologie and Sozialpsychologie, ²Universität Zürich, ³Universität zu Köln, ⁴Justus-Liebig-Universität Giessen

In this study we test the cross-country invariance properties of measurements of citizens’ willingness to concede citizenship rights to immigrants. First we test for three levels of measurement invariance: configural, metric and scalar. The analysis suggests considerable differences in the measurement intercepts of the items across countries. Next we use multilevel structural equation modeling (Davidov et al. 2012) to explain variations in item intercepts. We show how variation in a contextual variable which reflects the civic conception of citizenship in a country may explain intercept noninvariance. The contextual variable has three categories reflecting the civic conception in a country: *jus solis*, which stands for countries in which any individual born in a state’s territory becomes its permanent citizen; *jus domicili*, which stands for countries which recognize as a citizen any individual who has established a home or has resided in the state for a long period; and *jus sanguinis*, which stands for countries in which citizenship is transferred through family ties. For the analysis we use data from the International Social Survey Program (ISSP) 2003 with the national identity module.

Testing for exact versus approximate measurement invariance of the attitudes toward immigrants scale in the European Social Survey: 2002 - 2012

Jan Cieciuch¹, Eldad Davidov¹, Peter Schmidt², & René Algesheimer¹

¹ Universität Zürich, ² Justus-Liebig-Universität Giessen

One of the most frequently used procedures for measurement invariance testing is the multigroup confirmatory factor analysis (MGCFA). Muthén and Asparouhov recently proposed a new approach to test for approximate rather than exact measurement invariance using Bayesian MGCFA. Approximate measurement invariance permits small differences between parameters otherwise constrained to be equal in the classical exact approach. This study applies approximate and exact equivalence tests to the anti-immigration attitudes scale that was implemented in the European Social Survey (ESS). Measurement equivalence is tested across 35 ESS countries over six rounds. The results of the exact and the approximate approaches are quite different. The exact approach fails to establish scalar measurement invariance, and leads to the conclusion that the measurement is incomparable across all European countries. However, the approximate scalar measurement equivalence is established across all countries in all ESS rounds, thus allowing researchers to meaningfully compare mean scores of the scale and its relationships with other theoretical constructs of interest. Advantages and disadvantages of both approaches to measurement invariance testing will be summarized and discussed.
Examining Components of Face Cognition - Using Structural Equation Modeling and Network Analysis Techniques

Jan Plötner¹, Axel Mayer², & Jürgen M. Kaufmann¹

¹Friedrich-Schiller-Universität Jena, ²Ghent University

There are vast differences in the general population's abilities to process and recognize faces. To study these individual differences, it is necessary to create a face processing model focused on measurable face cognition components. An attempt by Wilhelm et al. (2010) identified three latent components: face perception, face memory and speed of face cognition. However, it is unclear if these three components are the result of the specific sets of tests they used or if they are truly reflecting the underlying face cognition abilities. This aforementioned issue was investigated using structural equation modeling by trying to replicate the model of Wilhelm et al. (2010) with a series of face cognition tests and compete it against a more specific model measuring a single latent variable for each applied test. The analyses were extended using an approach called community detection from network theory. Results depicted a better model fit for a modified version of the second model consisting of a latent variable for each test or test condition respectively, whereas the results obtained from community detection showed three large communities which reflected an emotional, accuracy and speed component of face cognition. It is therefore proposed that components like face memory and face perception do not exist in the sense of a single measurable component, but rather can be used as overarching terms to describe several related, more specific face cognition components. The three communities found via community detection can be seen as exemplars of such overarching terms.

Mediation Analysis: Misconceptions and Problems of Representing Causal Mechanisms

Andreas Klein

Goethe-Universität Frankfurt am Main

In many scientific contexts, researchers are interested in identifying intermediate variables that stand in the pathway of a biological mechanism that transmits an effective treatment. Causal effects that are indirect (mediated) and go through some intermediate variable that acts as a component in a causal chain have also been described under the title “mediator effects”. In the biostatistical literature, however, serious concerns about the conventional methodology used to represent and quantify these effects have been raised. Following this critique, a causal interpretation of a supposed mediator effect is often not justified. In this paper, we explain where the standard mediator model is conceptually flawed. Directions for future model development and consequences for statistical applications are discussed.
EffectLiteR: Detailed Effect Analysis Using Structural Equation Modeling (Part 1)

Lisa Dietzfelbinger
Friedrich-Schiller-Universität Jena

In the first part, we present a framework for estimating average and conditional effects of a discrete treatment variable on a continuous outcome variable, conditioning on categorical and continuous covariates. Using the new approach, termed EffectLiteR approach, researchers can consider conditional treatment effects given values of all covariates in the analysis and various aggregates of these conditional treatment effects such as average effects or conditional effects given values of a subset of covariates. Building on an extended multigroup structural equation model with stochastic group sizes, the EffectLiteR approach combines the following strengths: (1) it allows for latent covariates and outcome variables, (2) it permits (higher order) interactions between the treatment variable and categorical and (latent) continuous covariates, and (3) covariates can be treated as stochastic rather than fixed. We illustrate the Mplus implementation of the approach using two examples (one with a continuous covariate and one with a categorical covariate).

EffectLiteR: Detailed Effect Analysis Using Structural Equation Modeling (Part 2)

Axel Mayer
Ghent University

A detailed analysis of effects can become cumbersome in models with latent variables, categorical covariates and higher-order interactions.) In the second part, we therefore present the open source software EffectLiteR that makes a detailed analysis of effects conveniently accessible for applied researchers. EffectLiteR includes a graphical user interface and is based on the open source R package lavaan for structural equation modeling. We show how EffectLiteR can be used to analyze different kinds of average and conditional effects using a comprehensive example with an unbalanced 3 (treatment groups) by 2 (values of a categorical covariate) design, a latent outcome variable, and a latent pretest. Finally, we give insights into current developments regarding the EffectLiteR approach and provide a roadmap for further research. In particular, we will present ideas related to constrained statistical inference and to extensions for multilevel designs.
Shortening Scales Based on Automated CFA Fitting

Martin Schultze & Michael Eid
Freie Universität Berlin

In many study settings assessment time is limited and researchers aim to minimize the strain on participants by reducing the length of the questionnaires used. This is especially important in ambulatory assessment studies, because participants are asked to respond to the same questions at multiple occasions each day. However, shortening scales with minimal impact on psychometric properties of the scale can be quite challenging. In this talk an automated CFA-based approach will be presented that makes use of the ant colony optimization meta-heuristic to shorten scales while optimizing the overall fit of the measurement model that is defined a-priori. This approach extends upon the approach proposed by Leite, Huang, and Marcoulides (2008) by incorporating variants of the MMAS algorithms (e.g. Stützle, 2000). This approach is demonstrated on a dataset stemming from an ambulatory assessment study with 319 participants.

Comparing maximum-likelihood and Bayesian estimation techniques for the analysis of Multitrait-Multimethod data with few observations.

Johannes Bohn, Jana, Holtmann, & Tobias Koch
Freie Universität Berlin

Structural equation models of multitrait-multimethod data (MTMM-SEMs) are commonly used for examining the convergent and discriminant validity of social and behavioral measures and for studying method effects. Despite the numerous advantages of MTMM-SEMs, researchers often challenged when fitting such complex MTMM-SEMs including many variables and model parameters to data sets with small sample sizes (e.g., 50-200). In this study the performance of maximum likelihood (ML) and Bayesian estimation techniques are compared across various conditions for a multiple indicator CTC(M-1) model (Eid, Nussbeck, Lischetzke, Trierweiler, 2003). In contrast to previous studies (e.g., Bentler & Cou, 1987, Bollen, 1989, 2002, Lee & Song 2004), our study revealed that ML estimation yield unbiased parameter estimates even in small sample sizes (N=50 or 75), where there are as many observations as freely estimated parameters in the model. In contrast, Bayesian estimation techniques showed worse results than ML, if diffuse and wrong priors were used. Only in the presence of strong informative and accurate priors, Bayesian estimation outperformed ML estimation with regard to parameter estimates. However, Bayesian estimation techniques outperformed ML with regard to the trustworthiness of model fit statistics.
Room J32/102, (groundfloor, entrance via side entrance: J-street)

Main entrance to the building: K-street

Entrance to refectory (next to Restaurant «Galileo»)

Rooms of our department JK27/203-JK27/209 (top-floor)

back entrance to main building: K-street (gatekeeper)

Main entrance to the building: K-street

Entrance to refectory (next to Restaurant «Galileo»)

Rooms of our department JK27/203-JK27/209 (top-floor)

back entrance to main building: K-street (gatekeeper)
25.2.15: get-together at « Louise » [http://www.luise-dahlem.de/]

26.2.15: Diner at « Alter Krug » [http://alter-krug-berlin.de/]

back entrance to main building: K-street from U-station dahlem dorf

Entrance to refectory (next to Restaurant « Galileo »)

Rooms of our department JK27/203-JK27/209 (top-floor)

Main entrance to the building: K-street (gatekeeper)

Side-entrance to main-building: J-street

room J32/102 (groundfloor, entrance via side entrance J-street)