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Modern Modeling Methods Conference

May 22nd – 25th, 2017

University of Connecticut

2017 Modern Modeling Methods Conference

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Welcome and thank you for joining us for the 7th annual Modern Modeling Methods Conference at the University of Connecticut. Special thanks to all of the keynote speakers and concurrent presenters for making this wonderful program possible! I look forward to this week all year long. I love seeing all the wonderful modeling work that researchers are doing, and I love getting the chance to interact with people whose work I am reading and citing throughout the year. It's a pleasure and an honor to have Dr. Ken Bollen back at the modeling conference. Dr. Bollen was one of our 5 keynote speakers at the first modeling conference in 2011. I am also extremely excited to welcome Dr. Steven Boker to the Modeling conference for the first time. I have been a great fan of his work ever since I saw him speak at UVA over a decade ago. Thank you to the following people for their contributions to the conference: Lisa Rasicot, Casey Davis, Kasey Neves, Cheryl Lowe, Robbin Haboian-Demircan, and conference services for providing administrative and logistical support for the conference. I couldn't keep this conference going without them!

I hope to see you all again at our eighth annual Modern Modeling Methods Conference May 22nd-23rd, 2018. Confirmed keynote speakers for 2018 include Dr. Peter Molenaar (Penn State) and Tenko Raykov (MSU). Tenko Raykov will be offering a full day Pre-Conference workshop on *IRT from a Latent Variable Modeling Perspective* on May 21st. We are in the process of lining up a third keynote speaker and a post-conference presenter, and we hope to announce those presenters soon. Proposals for concurrent sessions will be due February 1st, 2018, and can be submitted online at our website: www.modeling.uconn.edu

If you have suggestions, please be sure to fill out the conference evaluation, located on our website, www.modeling.uconn.edu . We hope you have a great conference – Happy modeling!

D. Betsy McCoach
Professor, Neag School of Education

Contents

Modern Modeling Models – 2017 Schedule

Monday, May 22:
Preconference workshop

OpenMx XSEM with Applications to Dynamical Systems Analysis
Steven Boker

Continental Breakfast and Registration 7:30 am – 8:30 am
Laurel Hall Atrium

Pre – Conference Workshop
OpenMx XSEM with Applications to Dynamical Systems Analysis
Steven Boker

Laurel Hall 102
8:30 am – 5:00pm

The first half of the workshop will introduce OpenMx and the specification of simple latent variable models within R as well as provide an overview of some of its more advanced features such as full information, definition variables, parallelizing, ordinal thresholds, multiple groups, and mixture distributions. The second half of the workshop will present dynamical systems analysis as a continuous-time generalization of time series models using systems of differential equations.

Lunch is on your own. Several options are available in the Student Union.

Afternoon break: Refreshments in Laurel Hall Atrium from 3:00-4:00

Tuesday – May 23

Continental Breakfast and Registration
7:30 am – 8:30 am
Laurel Hall Atrium

Welcome 8:30 am
Laurel Hall 102

Opening Keynote- Steven Boker 8:30 am – 10:15 am
Laurel Hall 102

Dynamical Systems Analysis in the Context of Statistical Methods and Research Design

Steven Boker
University of Virginia

Over the past three decades, there has been a great deal of work on integrating the ideas and generative models produced in particular by mathematicians, physicists, and chemists into methods and algorithms that can be useful to test models on data from the social, behavioral, and medical sciences. Historically, Hotelling suggested in 1927 that differential equations should be used for models of change, but despaired that the problem was intractable using available tools. Stochastic differential equations and Kalman Filters were introduced in the 1950's and 60's. The field of dynamical systems enjoyed a burst of popularity in the 1970's and 80's with the co-occurring introduction of the notions of chaotic systems, fractal dimensions, and the availability of desktop computers that let one explore these generative models. There followed a period of about two decades where methods for estimating parameters of differential equations began to become better developed, but the intensive multivariate, multi-person time series required to identify such models were not yet available. Finally, in the past 10 years we have seen the emergence of widely available technology such as smart phones that can track intensively measured multivariate time series from many individuals. This talk will provide a brief history of the field dynamical systems and a way of organizing the questions we might ask of intensively time-sampled multivariate multi-person data. Some of the main dynamical systems data analytic methods available will be overviewed and placed into context of the questions for which they are best suited. A short discussion and rationale for models for self-regulating phenomena will be presented. The talk will discuss some of the problems associated with modeling nonstationary systems, why we should care, and a review of some of the methods that are in use for estimating and dealing with non-stationarity. The talk will conclude with a brief introduction to the problem of privacy preserving analytics for data on personal devices and one potential solution to this problem: distributed likelihood estimation.

Concurrent paper session 1 **Tuesday 10:30 am - 12:00 pm**

Session 1A: Symposium - Mixture models are measurement models, too! Measurement invariance and differential item functioning in latent class analysis

Laurel Hall 202

Paper	Authors
Unmodeled Differential Item Functioning (DIF) in Latent Class Analysis: A Monte Carlo Simulation	Veronica Cole Katherine Masyn Dan Bauer
Measurement Invariance in Multiple-Group Latent Class Analysis	Katherine Masyn Veronica Cole Dan Bauer
Regression-based Approaches to DIF Detection in Latent Class Models	Veronica Cole Katherine Masyn Dan Bauer

Session 1B: Modeling Educational Effects

Laurel Hall 205

Paper	Authors
Efficacy of a Scaled-Up First Grade Reading Intervention for English Language Learners	Paulina A. Kulesz
Application of Cross-Classified Multiple Membership Growth Curve Modeling in a Study of the Effect of School Mobility on Students' Academic Performance	Bess. A Rose
A Piecewise Latent Growth Model to Study the Effects of a College Admissions Test Overhaul	Paulina Pérez Mejias Alberto F. Caberera

Session 1C: Survey Research Models

Laurel Hall 206

Paper	Authors
Footballs, Eigenvectors, and Psychometrics: An Outlier Detection Proposal for Likert-Type Survey Data	Allen G. Harbaugh
Item Response Theory and Ranking of Congressional Voting Behavior	Holmes Finch Gregory Marchant Alicia Hazelwood
The Use of Topic Modeling to Analyze Open-Ended Survey Items	Holmes Finch Maria Hernandez Finch Constance McIntosh Claire Braun

Concurrent paper session 1 **Tuesday 10:30 am - 12:00 pm**

Session 1D: Measurement and Psychometrics
Laurel Hall 305

Paper	Authors
The α and the ω of Congeneric Test Theory: An Extension of Reliability and Internal Consistency to Heterogeneous Tests	Joseph F. Lucke
Using the Nominal IRT Model for Recency of Drug Use Items	A.R. Georgeson
Exploring Measurement Invariance Using CTT and IRT Techniques	Noela Haughton Priti Signh

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Lunch **Tuesday 12:00 pm – 1:15 pm**

Student Union Ballroom
3rd floor, Student Union

Concurrent paper session 2 **Tuesday 1:15 pm – 2:15 pm**

Session 2A: IRT Methods and Applications

Laurel Hall 202

Paper	Authors
A Conditional Joint Modeling Approach for Compensatory Multidimensional Item Response Model and Response Times	Kaiwen Man Hong Jiao Peida Zhan Chi-Yu Huang
Detection of Differential Item Functioning in the Context of Clustered Data: A Comparison Study	Graham G. Rifenbark H. Jane Rogers

Session 2B: Mediation Models

Laurel Hall 205

Paper	Authors
Multimethod Moderated Mediation Analysis using a Categorical Multigroup Design	Kaylee Litson Christian Geiser G. Leonard Burns
Tools for Computationally Efficient Power and Sample Size Determination for Mediation Models	Alexander M. Shoemann Aaron J. Boulton Stephen D. Short

Session 2C: Intra and Inter-individual Variation Modeling

Laurel Hall 206

Paper	Authors
Bayesian/Mixed-Effects Nonstationary Latent Differential Equation Models	Mauricio Garnier-Villarreal Pascal R. Deboeck Davis K. Johnson Amber Watts

Session 2D: Modeling Composite – Based Populations

Laurel Hall 305

Paper	Authors
Modeling Composite-Based Populations Using Composite-Based Methods	Jan-Michael Becker Edward E. Rigdon Arun Rai

2:15-2:30 Break- Refreshments in the Laurel Hall Atrium

Concurrent paper session 3 **Tuesday 2:30 pm – 3:30 pm**

Session 3A: Casual Inference
Laurel Hall 202

Paper	Authors
The Mechanics of Omitted Variable Bias: Bias Amplification and Cancellation of Offsetting Biases	Yongnam Kim Peter M. Steiner
Marginal Structural Models for Estimating the Effects of Chronic Community Violence Exposure on Youth Aggression and Depression	Traci M. Kennedy Edward H. Kennedy

Session 3B: Probability Index Models
Laurel Hall 205

Paper	Authors
Probability Index Models	Jan De Neve

Session 3C: Bayesian Single Case Models
Laurel Hall 206

Paper	Authors
Bayesian Testing in Single-Case Research: A Forward Paradigm Shift	Tyler Hicks Jason Travers Leslie Bross
Design-comparable Effect Sizes for Single-Case Research: A Bayesian Approach	Tyler Hicks Eun Sook Kim Seang Hwane Joo Jeong Hoon Choi John Ferron Jeff Kromrey

Session 3D: Modeling Change and Context
Laurel Hal 305

Paper	Authors
Variance Estimation of Health Disparity Measures in Complex Survey Settings	Meng Qui
Affective Red Zones: An Examination of Bivariate Change in Context	Joel Steele David Sbarra Emilio Ferrer

3:30-3:45 Break- Refreshments in the Laurel Hall Atrium

Concurrent paper session 4 **Tuesday 3:45 pm – 4:45 pm**

Session 4A: Symposium – Applications of Multilevel Models with Latent Variables to K-12 Education

Laurel Hall 202

Symposium	Authors
Different Levels of Leadership for Learning: Investigating Differences Between Teachers Individually and Collectively Using Multilevel Factor Analysis of the 2011-12 Schools and Staffing Survey	Jared Boyce Alex J. Bowers
Site Section in School District Research: A Measure of Effectiveness Using Hierarchical Longitudinal Growth Models of Performance	Alex J. Bowers
Feasibility of Increasing Access: How Does Instructional Leadership Influence Opportunity to Learn in U.S. and Belgium?	Angela Urick Allison Wilson Timothy G. Ford

Session 4B: Longitudinal and Multilevel SEM

Laurel Hall 205

Paper	Authors
Estimating Latent trends in Multivariate Longitudinal Data via Parafac2 with Functional and Structural Constraints	Nathaniel E. Helwig
Toward Multilevel SEM with Latent Quadratic Effects	Joshua Pritikin

Session 4C: Power and Program Evaluation

Laurel Hall 206

Paper	Authors
The Illusion of Intended Statistical Power: Avoiding Underpowered Replication Studies via Effective Sample Size Planning	Samantha Anderson Scott Maxwell Ken Kelley
Using Aggregate Unit Pre/Post Assessment Results Across Classrooms: A Monte Carlo Study Proof of Concept in Program Evaluation	Matthew Lavery

Session 4D: Suppression / Non-Monotonic Effects

Laurel Hall 305

Paper	Authors
Suppression Effects in Regression: The Case of Learning Strategies and Academic Achievement	Eric Loken Xiaowen Liu
A New Model for Non-Monotonic Effects	David Weakliem

Poster session and Reception
Student Union Ballroom
5:00 pm – 6:30 pm
Tuesday, May 23
Third Floor, Student Union

Please join us for appetizers, an open bar, and 51 fascinating posters on a wide variety of modeling topics. Poster abstracts and presenters are listed in the back of the program, starting on page 46.

Wednesday – May 24

Continental breakfast
7:30 am – 8:30 am
Laurel Hall Atrium

Concurrent paper session 5 **Wednesday 8:00 am – 9:00 am**

Session 5A: Symposium – Considerations When Utilizing Indicators to Evaluate Latent-level Differences across Time and Groups

Laurel Hall 301

Symposium	**Authors**
Longitudinal Factorial Invariance: Measuring and Modeling the Same Construct Over Time	Marilu Isiodia
Implications of Establishing Internal Consistency but Not Factorial Invariance on Growth Model Parameter	Marilu Isiodia

Session 5B: Papers – Dealing with Non-normality

Laurel Hall 305

Paper	**Authors**
Effects of Non-normality of Residuals in Hierarchical Linear Modeling	Kaiwen Man Yating Zheng Laura Stapleton
Evaluation of Supplemental Samples in Longitudinal Research with Non-normal Missing Date	Jessica Mazen

Session 5C: Evaluating Balance for Causal Inference

Laurel Hall 306

Paper	**Authors**
Evaluating Balance for Causal Inference: An Illustration of the Cobalt Package in R	Noah Greifer

Concurrent paper session 6 **Wednesday 9:15 am – 10:45 am**

Session 6A: Workshop by Craig Enders: *Multiple Imputation for Multilevel Data*
Laurel Hall 301 (**Please note: this is a double session which runs 9:15-12:30.)**

Special Workshop	**Presenter**
Multiple Imputation for Multilevel Data (Part I)	Craig Enders

Session 6B: Graphical Methods for Understanding SEM Models
Laurel Hall 305

Paper	**Authors**
Graphical Methods for Understanding SEM Models	Keke Lai Samuel Green Roy Levy

Session 6C: What the Dutch can do with prior information (and you can too)
Laurel Hall 306

Symposium	**Authors**
Bayesian Structural Equation Models with Small Samples	Sanne Smid Dan McNeish Rens van de Schoot
Using the Data Agreement Criterion to Rank Experts' Beliefs	Duco Veen Diedrick Stoel Rens van de Schoot
Testing ANOVA Replications by Means of the Prior Predictive p-value	Mariëlle Zondervan-Zwijnenburg Rens van de Schoot Herbert Hoijtink

Session 6D: Dyadic, Social Network, and Social Relations Models
Laurel Hall 106

Paper	**Authors**
Applying Modern Methods for Missing Data Analysis to the Social Relations Model	Terrence Jorgensen
Modeling Parent's Reports of Children's Gender-Type Behavior Over Time with an Indistinguishable Dyads Common Fate Growth Model	Randi Garcia Abbie Goldberg
Teacher Social Network Change over Time: How do Longitudinal Modeling Approaches Compare?	Elizabeth Dietrich Nathan Abe Elizabeth Sanders Jessica Thompson

Concurrent paper session 7 **Wednesday 11:00 am – 12:30 pm**

Session 7A: Symposium - Recent Advances in Regression Modeling with Complex Real-World Data

Laurel Hall 305

Paper	Authors
Robust Finite Mixture Modeling of Censored Data Using the Multivariate Student t-Distribution	Victor Lachos
Leveraging Mixed and Incomplete Outcomes via a Mixed-Response Reduced Rank Regression	Kun Chen
Efficient Stagewise Regression for Correlated Data with Interaction Selection	Gregory Vaughan

Session 7B: Symposium - Dynamic Methods for Multivariate Data Analyses

Laurel 306

Paper	Authors
Individual as Dynamic Networks: Merging of Intraindividual variability, Network Analysis and Experience Sampling	Xiao Yang, Nilam Ram, Scott Gest, David Lydon-Staley, David Conroy, Aaron Pincus, Peter Molenaar
Capturing Developmental Change in Regulation Processes using Dynamic Systems Model: Borrowing Differential Equations from Ecology	Lizbeth Benson, Nilam Ram, Jonathan Helm, Cynthia Stifer
A Dynamic Model of Heart Rate Synchrony of Mother-Child Dyads in the Strange Situation	Gustav Sjobeck Steven Boker
Windowed Recurrence Quantification for the Analysis of Dynamical Systems	Allison Gray Timothy Brick
Windowed Spectral Coherence: A Method of Evaluating Cross-Spectral Coherence Between Nonstationary Time Series at Multiple Time-Lags	Robert G. Moulder

Concurrent paper session 7 **Wednesday 11:00 am – 12:30 pm**

Session 7C: Educational & Developmental Applications

Laurel Hall 106

Paper	Authors
Self-Regulatory Climate Measures	Mwarumba Mwavita Kathy Curry
Confirming the Factor Structure of the Critical Thinking Assessment Test: A Bayesian CFA Approach	Chi Hang Bryan Au Allison Ames
Longitudinal Studies on Night Sleep Trajectories throughout Infancy	Shaun Goh, Daniel Goh, Teoh Oon Hoe, Seang Mei Saw, Fabian Yap, Yap Seng Chong, Anqi Qiu, Birit Brokeman

Session 7D: Workshop- Craig Enders- Multiple Imputation for Multilevel Data

Laurel Hall 301

Special Workshop	Presenter
Multiple Imputation for Multilevel Data (Part II)	Craig Enders

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Lunch **Wednesday 12:30 pm – 1:30 pm**

Student Union Food Court

The card in your packet has $13.00 that can be used at any of the Student Union eateries EXCEPT Subway.

Keynote- Kenneth Bollen **Wednesday 1:30-3:00pm**

Model Implied Instrumental Variables: A New Orientation to Structural Equation Models

Kenneth Bollen

Laurel Hall 102

1:30 pm – 3:00 pm

It is hardly controversial to say that our models are approximations to reality. Yet when it comes to estimating structural equation models (SEMs), we use estimators that assume true models (e.g., ML) and that can spread bias through estimated parameters when the model is approximate. This talk presents the Model Implied Instrumental Variable (MIIV) approach to SEMs originally proposed in Bollen (1996). It has greater robustness to structural misspecifications and the conditions for robustness are well understood. In addition, the MIIV-2SLS estimator is asymptotically distribution free. Furthermore, MIIV-2SLS has equation based overidentification tests that can help pinpoint errors in specification. Beyond these features, the MIIV approach has other desirable qualities (e.g., a new test of dimensionality). MIIV methods apply to higher order factor analyses, categorical measures, growth curve models, and nonlinear latent variables. Finally, it permits researchers to estimate and test only the latent variable model or any other subset of equations. Despite these promising features, research is needed to better understand its performance under a variety of conditions that represent real world empirical examples. This presentation will provide an overview of this new orientation to SEMs and illustrate MIIVsem, an R package that implements it.

Refreshment Break- 3:00-3:15
Laurel Hall Atrium

Concurrent paper sessions 8 **Wednesday 3:15 pm – 4:45 pm**

Session 8A: Advances in Mixture Modeling

Laurel Hall 301

Paper	Authors
A Framework of R-squared Measures for Single-level and Multilevel Regression Mixture Models	Jason Rights Sonya Sterba
Methods of Covariate Inclusion in Latent Transition Analysis: A Monte Carlo Simulation Study	Ai Ye Jeffery Harring Luke Rinne
Statistical Modeling of EEG Brain Mapping Data: Challenges and Opportunities	Jay Magidson

Session 8B: Modeling Health Disparities

Laurel Hall 305

Paper	Authors
Assessing Health Disparities in Intensive Longitudinal Data: Gender Differences in Granger Causality Between Primary Care Provider and Emergency Room Usage, Assessed with Medicaid Insurance Claims	Emil Coman Yinghui Duan Daren Anderson
How to Peel Oranges into Apples: Finding Causes and Effects of Health Disparities with Difference Scores Built by 1-on-1 Matching	Emil Coman Helen Wu
A Review of Modern Methods of Estimating the Size of Health Disparities	Emil Coman Helen Wu

Session 8C: Symposium – Advances in multivariate multilevel models for cross-sectional, longitudinal, and repeated cross-sectional data

Laurel Hall 306

Symposium	Authors
Estimating a Piecewise Growth Model with Longitudinal Data that Contains Individual Mobility across Clusters	Audrey Leroux
A Cluster-level Latent Transition Model for Multivariate Multilevel Repeated Cross Sectional Data	Katherine Masyn Rashelle Musci Amie Bettencourt Albert Farrell

Thursday, May 25
Post-conference workshop
8:30 am-12:00
Laurel Hall 102

Model Implied instrumental variables using MIIVsem
Kenneth Bollen and Zachary Fisher

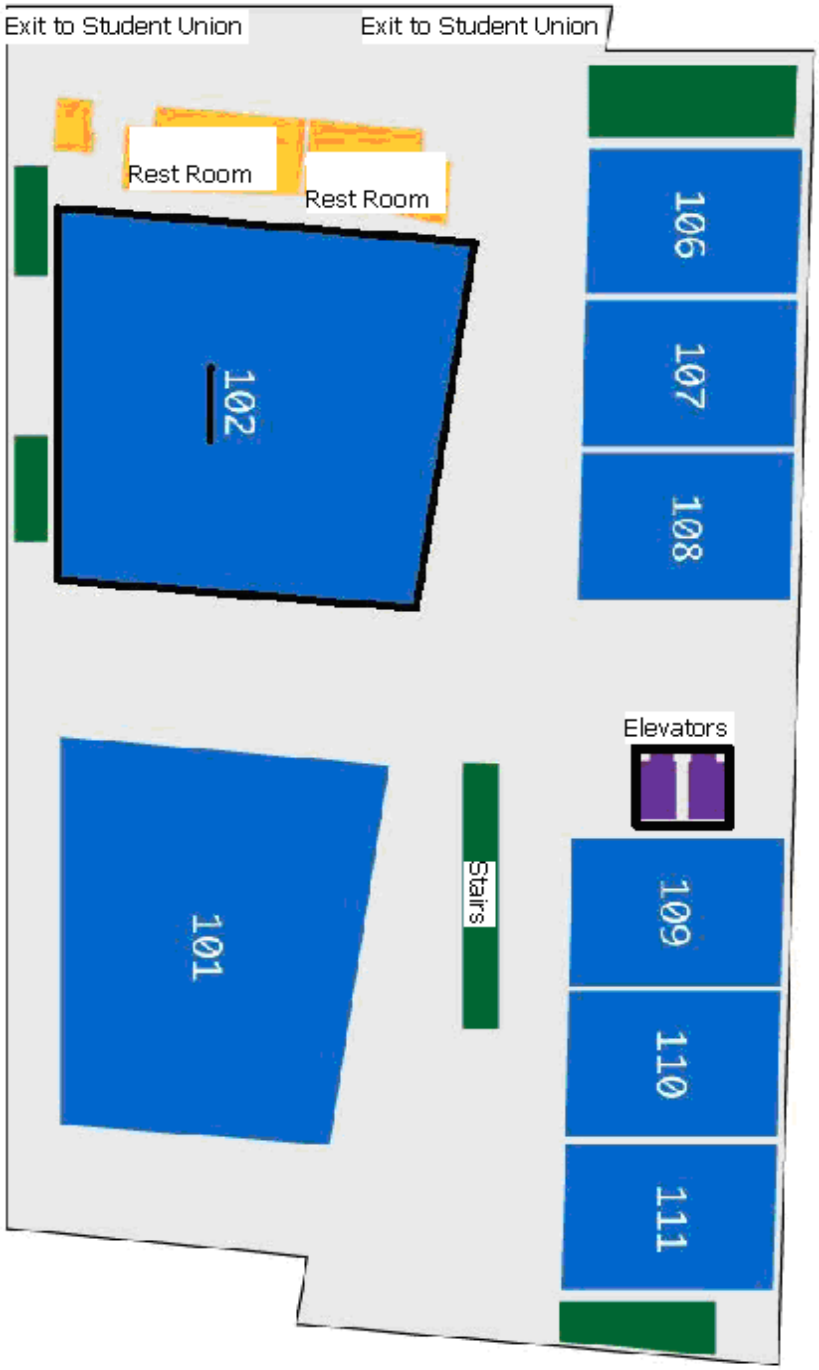
Continental Breakfast
8:00 am – 8:30 am
Laurel Hall Atrium

Post – Conference Workshop
Model Implied instrumental variables using MIIVsem
Kenneth Bollen and Zachary Fisher

This workshop will discuss more robust estimators that better represent real world conditions. Model Implied Instrumental Variable (MIIV) estimators are more robust to the approximate nature of our models and are asymptotically distribution free. In addition, they can test equation level fit so as to better localize model misspecification. The workshop will give an overview of the free R package MIIVsem. We will introduce the key ideas behind MIIV estimation; we will show how MIIVsem automates the selection of MIIVs, the estimation of coefficients and standard errors, and provides over identification tests for equations. These and other features will be introduced and illustrated with a variety of empirical examples.

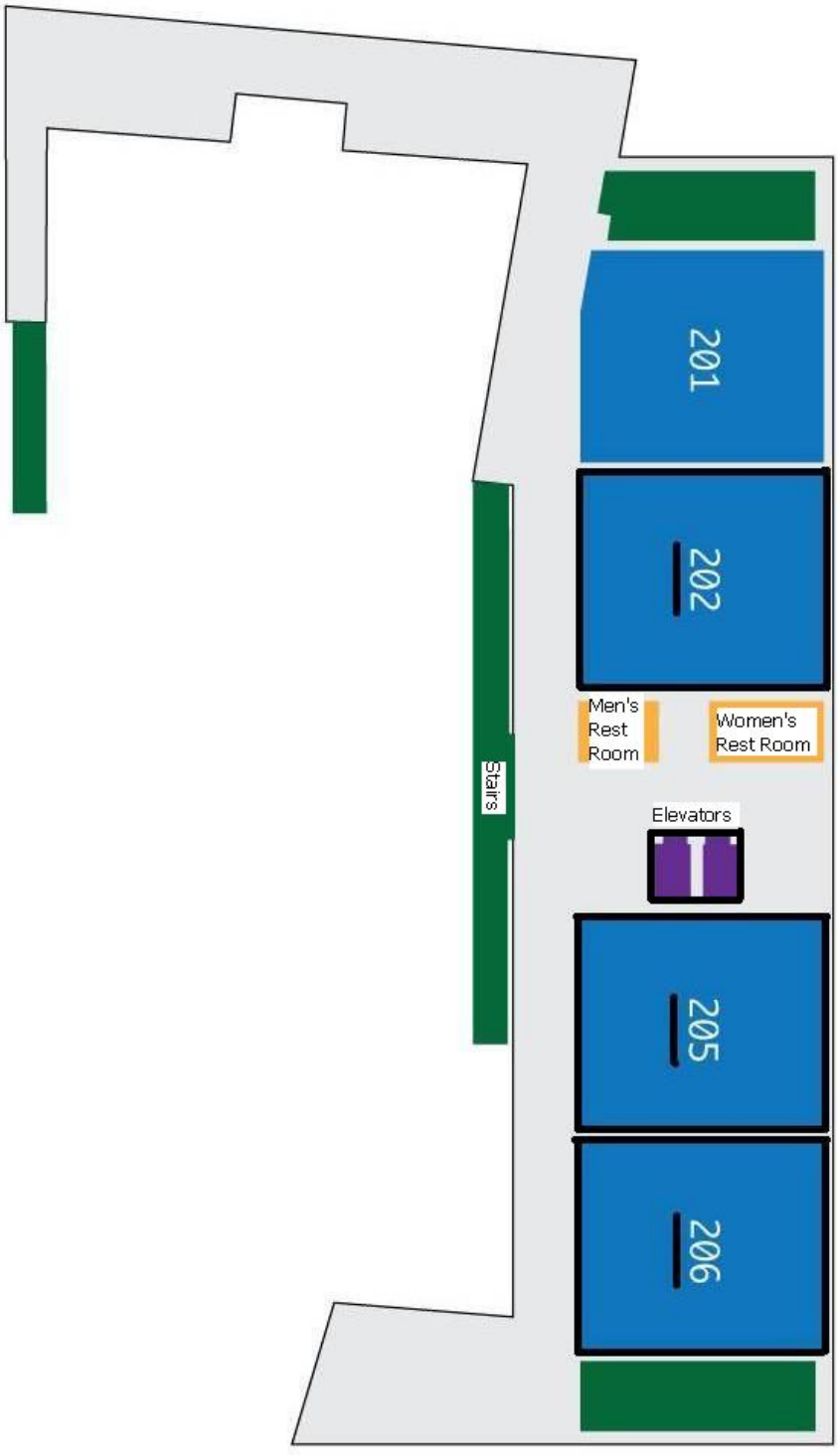
Maps

Laurel Hall (Classroom Building) Floor Plans:
First Floor:



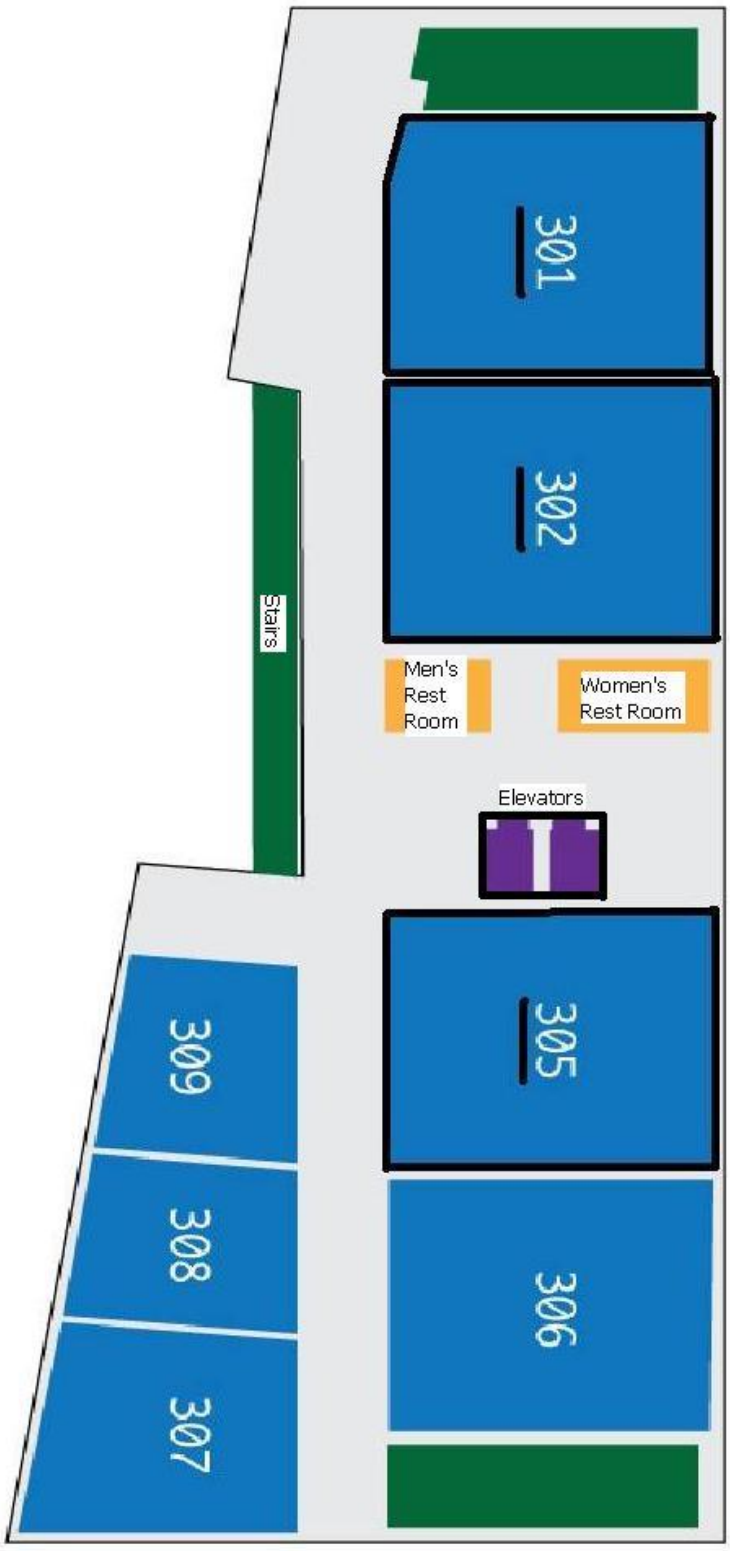
Laurel Hall (Classroom Building) Floor Plans:

Second Floor:



Laurel Hall (Classroom Building) Floor Plans:

Third Floor:



Paper Abstracts

Concurrent paper session 1 — Tuesday 10:30 am – 12:00 pm

Session 1A: Mixture models are measurement models, too! Measurement invariance and differential item functioning in latent class analysis

Chair: Katherine Masyn

Compared to the vast and ever-growing psychometric research corpus regarding measurement invariance (MI) and differential item functioning (DIF) in the SEM and IRT spheres, there is a relative scarcity of work addressing these issues in finite mixture modeling. To be fair, a great deal of attention has been paid to the inclusion of covariates in latent class analysis (LCA), but without a focus on measurement bias. To address this insufficiency in the mixture modeling literature, our symposium brings together three papers that collectively provide a methodological framework for conceptualizing, parameterizing, and testing for measurement invariance in latent class models. The first paper lays the critical simulation groundwork, exploring the consequences of not accounting for DIF in latent class models, which to-date are undocumented, un-explicated, and unquantified. The second paper presents a multiple-group approach to parameterizing and testing for MI in latent class models. The third and final paper presents and compares a set of sequential, regression-based procedures for DIF detection in latent class analysis for multiple covariates on different scales.

Paper 1. Unmodeled differential item functioning (DIF) in latent class analysis: A Monte Carlo simulation.
Veronica Cole, Katherine Masyn, and Dan Bauer

Paper 2. Measurement invariance in multiple-group latent class analysis
Katherine Masyn, Veronica Cole, and Dan Bauer

Paper 3. Regression-based approaches to DIF detection in latent class models
Veronica Cole, Katherine Masyn, and Dan Bauer

Session 1B: Modeling Educational Effects

Efficacy of a Scaled-Up First Grade Reading Intervention for English Language Learners
Paulina A. Kulesz
The project examined the effectiveness (IES Goal 4 Study) of a fully developed first grade literacy intervention in Spanish and English, with proven efficacy, when implemented directly by school personnel across various settings and populations, and assessed the factors at the student and school levels that moderate intervention effectiveness. Schools across four general settings (border-Texas; suburban-Texas, suburban-Colorado; urban-California) were randomized to treatment or a business-as-usual control. Treatment schools were given access to the researcher-developed intervention in both English and in Spanish, but delivered the treatment themselves to the students they identified as ‘at-risk’ and in the language chosen by the school. In many educational studies, interventions are

administered at the classroom, school, or district level. Yet in some educational studies, interventions are administered using more complex designs such as a partially nested design. In the partially nested design, students who are assigned to a treatment condition are nested in a higher-level unit, for instance a tutoring group. Students who are assigned to a control condition are not nested within this unit as a part of the design. The aforementioned design introduces a new set of challenges that need to be appropriately addressed in the analyses.

Application of Cross-Classified Multiple Membership Growth Curve Modeling in a Study of the Effect of School Mobility on Students' Academic Performance
Bess A. Rose
Frequently in multilevel growth curve modeling, we encounter situations where individuals belong to multiple clusters (e.g., schools or classrooms) over the course of study. Student mobility between schools is a salient example, as in the U.S. about one-fourth of students transfer schools during their school career, not including normal moves between elementary and middle, or middle and high school (Rumberger, 2002; U.S. General Accounting Office, 2010). Usually when facing this situation, researchers either delete such cases or assign mobile individuals to only a single cluster. Both of these approaches are problematic. This paper presents methods and results from a completed study of the effect of mobility on academic performance, focusing on the use of cross-classification and multiple membership in growth curve modeling.

A Piecewise Latent Growth Model to Study the Effects of a College Admissions Test Overhaul
Paulina Pérez Mejias & Alberto F. Cabrera
For more than six decades, Chile has relied on admissions tests to select students entering to public and private colleges. In 2004, the assessment focus of admissions tests changed from aptitude to knowledge of the national curriculum, hoping that this change will reduce the gap between high school graduates of publicly funded and private schools. Using a latent growth modeling approach, the purpose of the study was to determine whether the score gaps reduced after the test revamp. Our findings show that the test change marginally reduced the score gap.

Session 1C: Survey Research Methods

Footballs, Eigenvectors, and Psychometrics: An Outlier Detection Proposal for Likert-Type Survey Data
Allen G. Harbaugh
This paper proposes a protocol to detect "outliers" and other disingenuous responses in Likert-type survey data. After a brief review of the psychometric motivation for the use of factor analysis, a variety of mathematical interpretations of the eigenvectors obtained from principle components analysis will be discussed. The proposed protocol builds on the theoretical assumption that the first eigenvector should practically be the 45°-line thru n-dimensional space (after appropriate transformations). The next step of the protocol utilizes the result that the principle eigenvector would span the most variance, and the remaining (smaller) variance is treated as a distance measure. This report explains the mathematics of the protocol (including both limitations and benefits of working with meta-volumes in higher dimensional spaces), examines the protocol applied to simulated data, and assesses the viability via application to authentic data sets.

Item Response Theory and Ranking of Congressional Voting Behavior
Holmes Finch, Gregory Marchant, & Alicia Hazelwood
This study explored the use of Item Response Theory for investigating U.S. congressional voting patterns, and compared IRT estimates of political conservatism to conservatism scores and rankings of Congress persons provided by a political action committee, Freedom Works. It was hypothesized that IRT would yield more informative results about voting patterns, beyond the scores established by the group. In particular, the statistically driven methodology provides less subjective relative congressional rankings, and yields additional information for understanding voting behavior. There were four goals of this study: 1) To characterize congressional voting patterns using IRT, 2) To investigate differential item functioning (DIF) by political party to identify votes that were relatively more party based, 3) To use IRT person fit statistics to identify legislators who voted anomalously, and 4) To compare IRT legislator rankings with those of FW. This study demonstrated how IRT based tools, such as DIF detection, estimation of latent traits, and person fit indices, can be used to identify ranking variables that do not behave consistently and unusual ranked elements. With respect to this study, 3 of the 15 votes were found to exhibit high levels of DIF between the two parties, with an additional 4 exhibiting moderate DIF. In each case where DIF was present, the bills were easier for Republicans to endorse than for Democrats.

The use of Topic Modeling to Analyze Open-Ended Survey Items
Holmes Finch, Maria Hernandez Finch, Constance McIntosh, & Claire Braun
Social scientists frequently use questionnaires and surveys in their research, most often consisting of Likert items consisting of a series of statements each followed by a discrete set of ordered response options. Other item formats are available, including those for which respondents generate their own text in response to a question or statement. Such open-ended items can be difficult to code, but also allow for a deeper exploration of respondent attitudes than is possible with Likert items. Two issues with using open-ended items involve challenges in quantifying responses, and difficulties connecting open-ended responses with responses to other items on the instrument. The goal of this study is to demonstrate the use of topic modeling (TM; Blei & Lafferty, 2009) in the analysis of open-ended questionnaire items. Results demonstrated the utility of TM to identify substantively meaningful topics, which could then be included in analyses involving other items, allowing for deeper insights into respondents' attitudes and opinions.

Session 1D: Measurement and Psychometrics

The α and the ω of Congeneric Test Theory: An Extension of Reliability and Internal Consistency to Heterogeneous Tests
Joseph F. Lucke
A decade or so ago, several authors independently proposed model-based definitions of Cronbach's alpha and McDonald's omega as derived from the congeneric psychometric model and its extensions. Unfortunately, these versions of alpha and omega have not gained much traction in the psychometric literature. The goal of this presentation is to present the model-base versions and show how the work in applications. Using a single data set, the presentation covers these parameters in a single factor model, a two factor model, a four factor model, a hierarchical factor model, and a bifactor model. In each case, the presentation shows how alpha and omega can be decomposed into single factor components, cross-factor components, and factor path components. The presentation also reveals where alpha differs from omega.

Using the Nominal IRT Model for Recency of Drug Use Items

A.R.Georgeson

The present study uses the nominal item response theory model to examine items asking about recent drug use. Such items often include separate response options for never having used a substance and not using the substance in the time period specified in the item. As these options are qualitatively different, the nominal model was used to determine whether these response options were different. In modeling these data, we are also examining polysubstance use and determining whether there is unidimensionality in use across substances. Many substance abuse measures have a two-part structure sometimes referred to as presence-severity (Liu & Verkuilen 2013; Olsen & Schafer, 2001). Because a number of aspects of drug use are integrated into the determination of severity, the idea is that a question evaluating the presence of substance use will act as a filter for other items. A presence item would ask whether or not an individual had used a particular substance within a certain time period. Thus, if the individual endorses recent use of a particular substance, they will receive questions pertaining to the severity of the substance use. If the individual did not endorse recent use of the substance, they are effectively opting out of receiving additional questions related to that item. A unique problem that applies to these presence/absence of use items is that an individual who has not recently used a substance is essentially treated as being the same as an individual who has never used that substance. This problem created the initial motivation for the investigation described in this paper. What does it mean to treat individuals who have not recently used a substance in the same way as individuals who have never used a substance? When the construct of interest is severity of use of a particular substance, this equivocation is probably permissible. However, we were interested in taking a more holistic look at substance use and considering whether there is a unidimensional latent variable underlying lifetime use of any substance compared to lifetime abstinence from every substance. Stated differently, do individuals only use a single substance and are fully abstinent from any other substance? This notion seems possible, but unlikely. In this project, we modeled items asking about recent substance use using the nominal IRT model. This model allows the researcher to have uncertainty about the order of response categories beforehand. It may also be used in cases where the response categories might have some quantitative as well as qualitative attributes (Thissen, Cai, and Bock, 2010).

Exploring measurement invariance using CTT and IRT techniques

Noela Haughton & Priti Singh

Surveys offer a relatively easy and flexible approach to data collection. A key concept that is too often overlooked is measurement invariance, i.e., the consistency of the constructs being measures across sub groups and longitudinal situations. The purpose of this study is to explore and propose framework for using IRT and CTT modeling techniques for validation purposes in survey research. Survey responses were collected from college freshman (n=441) who attended a six-week university summer bridge program. The survey's initial design was based on a priori hypothesis of a ten factor, second-order model of academic and social engagement. SEM and Rasch modeling techniques were carried out using AMOS and WINSTEPS software respectively.

Concurrent paper session 2 1:15 pm – 2:15 pm

Session 2A: IRT Methods and Applications

A Conditional Joint Modeling Approach for Compensatory Multidimensional Item Response Model and Response Times

Kaiwen Man, Hong Jiao, Peida Zhan, & Chi-Yu Huang

Many previous studies focused on the investigating the speed and accuracy within a uni-dimensional IRT framework (Meyer, 2010; Thissen, 1983; van der Linden, 2008; Wang & Hanson, 2005). In this study, a conditional joint modeling approach for exploring the compensatory multidimensional IRT and RTs was proposed. Such an approach describes the relationship between the speediness and accuracy of a person in a multidimensional structure. In this way, the relationship between speediness and latent construct relationship would be further investigated. The new hierarchical model was estimated by Bayesian approach using Markov chain Monte Carlo (MCMC). The model parameter recovery is assessed via simulation studies to investigate the improvements of the parameter recovery for both item and latent traits parameters by joint modelling the MIRT with RTs.

Detection of Differential Item Functioning in the Context of Clustered Data: A Comparison Study

Graham G. Rifenbark & H. Jane Rogers

Investigations of differential item functioning (DIF) continue to be of interest and importance to measurement practitioners. Item response theory (IRT) provides a strong theoretical framework for DIF detection procedures; however, the multilevel linear modeling (MLM) framework provides an alternative that has several advantages. Kamata's (2001) multi-level formulation of IRT models (i.e., HGLM) provides an optimal solution for not only detecting DIF items, but also for explaining DIF via contextual effects (Williams & Beretvas, 2006). Vaughn (2006) extended the HGLM approach for DIF detection to polytomous items and clustered response data. One of the most widely used methods for DIF detection in practice is the Mantel-Haenszel statistic (MH; Holland & Thayer, 1988). French and Finch (2013) investigated a multilevel extension of the MH statistic for clustered response data. They investigated adjustments include matching with respect to a MLM predicted matching score (Pommerich, 1995) and an augmented MH statistic that takes into account clustering (Begg, 1999). Both of these procedures can be extended to the polytomous case (French & Finch, 2013). The purpose of this study is to compare Type I error rates and power for the adjusted MH statistics and the HGLM approach, estimated using a Hamiltonian Monte Carlo routine available in the program STAN (STAN Development, 2016), in the context of polytomous response data.

Session 2B: Mediation Models

Multimethod Moderated Mediation Analysis using a Categorical Multigroup Design

Kaylee Litson, Christian Geiser, & G. Leonard Burns

Moderated mediation analysis is a statistical tool used to examine whether the mediated effect varies as a function of some moderating factor. Commonly, moderated mediation analyses are used to answer questions researchers have about how and when a variable influences another variable. Recently, researchers have begun creating statistical models to account for the measurement structure of factors in moderated mediation analyses; specifically, researchers have created models to control for measurement error (Cheung & Lau, 2015; Fritz et al., 2016). However, measurement

error is only a single aspect of a variable's measurement structure. Another common aspect of measurement that is common in psychological research is the method of measurement (e.g., self-report versus other-report). The method of measurement is well-known to influence results of statistical analyses (Podsakoff, MacKenzie, & Podsakoff, 2012), and researchers attempt to control for such influences by measuring data using multiple methods (e.g., self-report and other-report). However, with regards to moderated mediation analyses, no method has previously been created which combines multimethod measurement designs with moderated mediation analyses. As such, researchers cannot integrate all data from a multimethod design into current moderated mediation approaches. We propose a new multimethod moderated mediation model by combining 1) a confirmatory factor analysis multitrait-multimethod (CFA-MTMM) approach (Eid et al., 2003) with 2) a multigroup approach to moderated mediation using latent variables (Lau & Cheung, 2010). We present an application of the new method in which child inattention was predicted to mediate the relationship between child hyperactivity and academic impairment. Further, the mediated path was expected to differ across the child's biological sex, the grouping (moderating) variable. In this application, N = 798 children were evaluated by mother and father reports across three waves. We discuss the results and implications of the new model in more detail.

Tools for computationally efficient power and sample size determination for mediation models
Alexander M. Schoemann, Aaron J. Boulton, & Stephen D. Short
Mediation analysis has been one of the most popular statistical methods utilized by social and behavioral researchers for decades. Current best practice recommendations for assessing power and sample size in mediation models are to use a Monte Carlo power analysis and, preferably, to test the indirect effect with a bootstrapped confidence interval (e.g., Zhang, 2014). Unfortunately, these methods have rarely been adopted by researchers due to limited software options and long computational times. We propose a new method and convenient tools for determining sample size and power in mediation models. The method uses a randomly varying N approach to sample size determination (Schoemann, Miller, Pornprasermanit, & Wu, 2014). In addition, our method uses Monte Carlo confidence intervals to test the indirect effect. Monte Carlo confidence intervals (Preacher & Selig, 2012). Combing the varying parameters approach to Monte Carlo power simulations with Monte Carlo confidence intervals for indirect effects allows researchers to quickly produce estimates of power and sample size that are as accurate as traditional approaches using fixed sample sizes and bootstrap confidence intervals. We will demonstrate the accuracy of our new method through Monte Carlo simulations and an easy-to-use Shiny application (located at http://marlab.org/power_mediation) that implements our method for several different mediation models. These developments will allow researchers to quickly and easily determine power and sample size for simple and complex mediation models.

Session 2C: Intra and Interindividual Variation Modeling

Intra and Interindividual Variation Modeling: Bayesian/Mixed-Effects Nonstationary Latent Differential Equation Model
Mauricio Garnier-Villarreal, Pascal R. Deboeck, Davis K. Johnson, & Amber Watts
Longitudinal analysis are powerful methods to estimate change over time. The combination of nomothetic and idiographic approaches within longitudinal analysis would allow to answer questions related to intra and interindividual variability in one integrated method. Differential equations modeling is a method that studies intraindividual variability as a form of continuous-time modeling, which can be implemented as fixed-effects or mixed-effects. This research tend to extend the Latent Differential Equation (LDE) by adding the mixed-effects, estimating subject and sample

parameters, including interindividual variability on parameters of interest. This model estimates non-stationary LDE, by allowing an the model to have a linear slope; the present research estimates the non-stationary LDE model in a mixed-effects framework, including both individual and sample parameters, combining nomothetic and idiographic information. The inclusion of the non-stationary slope means that the model includes short term dynamics (DE) and long term dynamics (slope). The proposed model was tested with a simulation.

Session 2D: Modelling Composite-Based Populations Using Composite-Based Methods
Jan-Michael Becker, Edward E. Rigdon, & Arun Rai
In structural equation modeling (SEM), the method most commonly used is common factor-based: unobserved variables like psychological attributes are represented by common factors extracted from multiple indicators. However, soon after the birth of factor-based SEM, the first composite-based approach, known as partial least squares (PLS) path modeling, arose. Today, the assortment of composite-based methods includes generalized structured component analysis (GSCA) and regularized generalized canonical correlation analysis (RGCCA). Collectively, though, composite-based methods have a reputation for producing biased estimates of model parameters. Yet the research behind this general conclusion has almost universally involved simulations with data drawn from factor-based populations, where these composite-based populations are misspecified. This research demonstrates a procedure for specifying composite-based populations and then examines the performance of composite-based approaches to SEM in simulations based on composite-based populations. Jöreskog (e.g., 1969) launched modern structural equation modeling with the development of an inferential approach to structured factor modeling using maximum likelihood (ML) estimation. In response, Jöreskog's mentor, Wold (e.g., Jöreskog & Wold 1982) developed a composite-based partial least squares (PLS) method for approximating factor model results while reducing the computing and distributional assumption demands. Yet parameter estimates tended to be biased in certain ways, as demonstrated by extensive simulation research. Unfortunately, all of this research involved sampling for populations defined by factor models. PLS path modeling is a composite-based method, so for simulation models to be correctly specified, they must draw data from composite-based populations (Rigdon 2012). Moreover, in forming expectations about the behavior of composite-based methods, researchers need to look to work on the behavior of regression methods. Dana and Dawes (2004), for example, showed that in terms of out-of-sample R^2 (using sample based parameter estimates to predict population cases not used to compute the estimates), ordinary least squares (OLS) regression weights only provide best performance when sample size and true population R^2 are both high. Rigdon (2012) asserted that PLS path modeling includes one estimation approach which amounts to using OLS regression weights while another amounts to using correlation weights, so it seems likely that the performance of composite-based methods may vary on the same basis. Other composite-based approaches to SEM have emerged, including Hwang and Takane's (2004) generalized structured component analysis (GSCA) and Tenenhaus and Tenenhaus' (2011) regularized generalized canonical correlation analysis (RGCCA). Critics of PLS path modeling have periodically suggested other alternatives, including simple path analysis using unweighted composites and path analysis using principal components. Any reassessment of composite-based methods, using correctly specified composite-based populations, ought to include these alternatives, as well. Becker et al. (2013) demonstrated a technique for deriving an observed variable covariance matrix consistent with a composite-based population, though their model was a very simple one. We expand the Becker et al. (2013) approach to specify a somewhat more complex model as a basis for our simulations.

Concurrent paper session 3 Tuesday 2:30 pm – 3:30 pm

Session 3A: Casual Inference

The mechanics of omitted variable bias: Bias amplification and cancellation of offsetting biases

Yongnam Kim. & Peter M. Steiner

Causal inference using observational studies frequently requires researchers to estimate treatment effects conditional on a set of observed covariates. The hope is that such conditioning eliminates or at least reduces the confounding bias. The resulting bias has been referred to as the omitted variable bias (OVB), that is, a bias left after conditioning on other covariates. Though OVB is well known and has been extensively discussed in the methodological literature, its exact mechanics have not yet been fully formalized, especially with respect to causal inference. Applied researchers frequently believe that including more covariates in a regression model (or matching on more covariates) will always reduce the confounding bias. However, recently researchers have found that this rationale does not hold in general, that is, it is possible that conditioning on a covariate can increase the overall bias instead of reduces it. In this paper, we formally characterize the mechanics of omitted variable bias and investigate the conditions under which conditioning on confounders actually increases the overall bias. We also explore how measurement error and correlation affect OVB.

Marginal Structural Models for Estimating the Effects of Chronic Community Violence Exposure on Youth Aggression and Depression

Traci M. Kennedy, & Edward H. Kennedy

A major limitation to modeling observational data is that causal inferences can rarely be made confidently. Because treatments (or "exposures") occur naturalistically and are not randomly assigned in observational studies, it is difficult to determine the extent to which an observed or predicted association between exposure and outcome is causal, the direction of causality, and whether confounders play a role. Although longitudinal data are helpful to establish a sequential ordering of phenomena, they introduce their own threats to valid causal inferences – notably, the issue of time-dependent confounding. Such is the case when a time-varying covariate confounds the association between a predictor and outcome, but is also a critical element of the causal pathway. In longitudinal data, this may occur when an outcome of interest (e.g., aggression) is both a potential consequence and cause of an exposure (e.g., community violence exposure). For instance, numerous studies have suggested that community violence exposure (CVE) among youth is associated with increased aggression over time (Fowler et al., 2009). However, it is well-documented that youth aggression, in turn, can place them at risk for involvement in community violence – via gang involvement, for example (Lynch & Cicchetti, 1998). "Desensitization" theories postulate that as aggression increases linearly with increasing CVE, emotional symptoms, such as depression, may follow a quadratric trend, which levels off and may decrease at the highest exposure levels, suggesting an emotional desensitization effect (Mrug et al., 2008; Ng-Mak et al., 2004). Standard regression techniques that adjust for the autoregressive effects of the outcomes may over-control the effects of the exposure itself, thereby leading to biased estimates of its effect on the outcomes. Thus, advanced modeling techniques are critically needed that permit valid causal inferences for longitudinal, observational data. Marginal structural models (MSM; Robins et al., 2000; Robins & Hernan, 2009) are a useful set of tools within the potential outcomes framework that help isolate causal effects in longitudinal, observational data (Coffman & Zhong, 2012). Although this method has been increasingly applied in medical treatment settings, it has scarcely been used to model

observational data in the social sciences (Bacak & Kennedy, 2015; VanderWeele et al., 2016). MSMs model the potential outcome of an exposure that varies over time, which provides an estimate of the exposure's causal effect on the outcome as if individuals were randomized to receive different levels of the exposure over time instead of selecting into exposure groups naturalistically. The first step of an MSM application is to model the likelihood of exposure across time points, conditioning on past data at each time point (analogous to a time-varying propensity score). Individuals are then weighted based on their likelihood of exposure, and a simple weighted regression model then predicts the outcome from the exposure. Essentially, a "pseudopopulation" is created that eliminates any association between exposure and confounding covariates. Thus, a pure causal effect can be estimated equal to what would be observed had individuals been randomly assigned to exposure levels.

Session 3B: Probability Index Models

Probability Index Models

Jan De Neve

Latent variables are not necessarily linearly related to the observed outcome. Diffusion models, for example, typically assume a complex non-linear but monotone relationship between the observed reaction time and the latent drift rate (Wagenmakers et al, 2012). Questionnaire data form another example: if participants are reluctant to express extreme feelings for social desirability reasons and report more moderate feelings than they actually have, the relationship between the observed and latent variable can be curvilinear instead of linear (Garcia-Marques et al., 2014). Since the exact relationship is typically unknown but assumed to be monotone, it is desirable to have effect sizes that are invariant under monotone transformations. One example of a monotone-invariant effect size is the Probabilisitic Index (PI): it is the probability that one outcome exceeds another, i.e.P(Y < Y') for two outcomes Y and Y'. The PI as an effect size has several desirable properties: 1) it is robust to outliers and relevant for skewed distributions, 2) it is a meaningful effect size for ordinal outcomes, 3) tests based on the PI typically have good power properties and 4) the monotone-invariance property implies that interactions do no disappear under monotone transformations - a problem conventional models (e.g. ANOVA) suffer from (Wagenmakers et al, 2012). The PI is sometimes referred to as the Mann--Whitney functional since it is the parameter associated with the nonparametric Wilcoxon--Mann--Whitney test. Recently, a new flexible class of semiparametric regression models, called Probabilistic Index Models (PIMs, Thas et al., 2012, De Neve and Thas, 2015), has been developed to model the PI as a function of covariates in a regression context. In this presentation we introduce the PIM by examples and summarize the most important aspects of the estimation theory. We illustrate the similarities and differences with the conventional linear regression model and the Cox proportional hazards model. We further demonstrate how well known rank tests, such as the Wilcoxon-Mann-Whitney and Kruskal-Wallis test can be embedded in a PIM. In addition to hypotheses testing, the method allows for the estimation of meaningful effect sizes, resulting in a better understanding of the data. We illustrate the methodology using the R package pim. This talk is largely based on Thas et al. (2012) and De Neve & Thas (2015).

Session 3C: Bayesian Single Case Models

Bayesian Testing in Single-Case Research: A Forward Paradigm Shift

Tyler Hicks, Jason Travers, & Leslie Bross

This paper offers a rationale for a Bayesian approach to model selection in single-case research. We argue that Bayesian testing has a special relevance for single-case research because the logic of a

Bayesian model selection pivots on Bayes' rule rather than asymptotic considerations (e.g., error control in the limits). As the main tool of Bayesian analysis, the rule shows how rational agents modify beliefs given evidence. One major obstacle to the adoption of Bayesian testing in single-case research is a lack of direction and software. We provide a SAS program and practical guidance through examples that illustrate the proposed methods.

Design-comparable effect sizes for Single-Case Research: A Bayesian Approach
Tyler Hicks, Eun Sook Kim, Seang-Hwane Joo, Jeong Hoon Choi, John Ferron, & Jeff Kromrey
Ambiguity remains about how to proceed when a search of literature returns both single-case and group research. Pustejovsky, Hedges, and Shadish (2014) have articulated a general modeling framework to compute an effect size comparable across designs. Yet, recovering the parameters needed to construct this effect size can be challenging with traditional estimation procedures. We offer a tutorial on estimating these parameters using a Bayesian approach. We then perform a simulation study to compare traditional frequentist and Bayesian estimation approaches.

Session 3D: Modeling Change

Variance Estimation of Health Disparity Measures in Complex Survey Settings
Meng Qui
Health disparities (HD) refer to differences in the health status across different racial, ethnic, and socioeconomic groups (Keppel K, Pamuk E, Lynch J, et al., 2005). Great effort has been made to identify and address the factors that lead to health disparities and many summary indices (e.g., Concentration Index) have been developed to measure the extent of health disparities. Early methodological work assumed that data were obtained through simple random sampling (SRS), with each individual having an equal probability of being included in the sample (Chen & Roy, 2009). For large, nationally representative health surveys, however, complex sampling designs are often employed to select the sample, involving stratification, multistage clustering, or both. Research on methods of incorporating design features is burgeoning, but the scale is still sporadic and ad-hoc. This study proposed a variance estimation method, focusing on the widely used Relative Concentration Index (RCI) (Kakwani, Wagstaff, and Doorslaer, 1997), by calculating the Taylor deviates which incorporate the complex sample design features. This approach can be easily applied on other similar HD summary measures. Simulation studies demonstrate the impact of design features on estimating the point and variance of RCI.

Affective Red Zones: An Examination of Bivariate Change in Content
Joel Steele, David Sbarra, Emilio Ferrer
This work focuses on individual behaviors that are dependent on a context that is ephemeral yet recurrent. The focus is on ratings of affect from individuals in romantic relationships over time. By temporally identifying ostensible markers of poor relationship functioning, this work aims to understand the correlates and eventual impacts of interindividual differences in affective change that are related to these episodes. The term Red Zone is used to indicate these episodes and three geometrically based measures are introduced to quantify bivariate changes in affect related to a Red Zone traversal. Variance in these measures are used to model two distal indicators of relationship functioning, relationship satisfaction and potential dissolution.

Concurrent paper session 4 — Tuesday 3:45 pm – 4:45 pm

Session 4A: Applications of Multilevel models with Latent Variables to K-12 Educational Leadership and Policy Research

In this symposium the authors will present three research studies that apply multilevel analysis with latent variables to current issues within K-12 educational leadership and policy. The session will first open with a brief overview of research concerns within leadership and policy of K-12 schools that are addressed through the application of multilevel models: factor analysis, growth, and structural equation models. The session includes three studies as an application for each: 1) to investigate different levels of leadership for learning between teachers individually and collectively using multilevel factor analysis; 2) to identify school districts as research sites based on effectiveness using hierarchical longitudinal growth models; 3) and to test the relationships between school leadership, school supports and instruction on a student's opportunity to learn math using a multilevel structural equation model. The session will then end with a participatory discussion between the authors and the audience on novel applications of multilevel models with latent variables to current issues in K-12 education practice and policy.

Paper 1. Different levels of leadership for learning: Investigating differences between teachers individually and collectively using multilevel factor analysis of the 2011-12 Schools and Staffing Survey
Jared Boyce & Alex J. Bowers
Paper 2. Site section in school district research: A measure of effectiveness using hierarchical longitudinal growth models of performance
Alex J. Bowers
Paper 3. Feasibility of increasing access: How does instructional leadership influence opportunity to learn in U.S. and Belgium?
Angela Urick, Alison Wilson, & Timothy G. Ford

Session 4B: Longitudinal and Multilevel SEM

Estimating latent trends in multivariate longitudinal data via Parafac2 with functional and structural constraints
Nathaniel E. Helwig
Longitudinal data are inherently multimode in the sense that such data are often collected across multiple modes of variation, e.g., time x variables x subjects. In many longitudinal studies, multiple variables are collected to measure some latent construct(s) of interest. In such cases, the goal is to understand temporal trends in the latent variables, as well as individual differences in the trends. Multimode component analysis models provide a powerful framework for discovering latent trends in longitudinal data. However, classic implementations of multimode models do not take into consideration functional information (i.e., the temporal sequence of the collected data) or structural information (i.e., which variables load onto which latent factors) about the study design. In this paper, we reveal how functional and structural constraints can be imposed in multimode models (Parafac and Parafac2) in order to elucidate trends in longitudinal data. As a motivating example, we consider a longitudinal study on per capita alcohol consumption trends conducted from 1970-2013 by the U.S. National Institute on Alcohol Abuse and Alcoholism. We demonstrate how functional and structural information about the study design can be incorporated into the Parafac and Parafac2 alternating least squares algorithms to understand temporal and regional trends in

three latent constructs: beer consumption, spirits consumption, and wine consumption. Our results reveal that Americans consume more than the recommended amount of alcohol, and total alcohol consumption trends show no signs of decreasing in the last decade.

Toward multilevel structural equation modeling with latent quadratic effects
Joshua Pritikin
Rampart can efficiently model data gathered at many different levels. For example, a single data set may contain measurements by time (lowest level), by student, by teacher, by school, and by district (highest level). An extension that permits latent quadratic terms (i.e. interactions or random slopes) is described.

Session 4C: Power, GI, & Effect Sizes

The illusion of intended statistical power: Avoiding underpowered replication studies via effective sample size planning
Samantha Anderson, Scott Maxwell, Ken Kelley
Planning an appropriate sample size for an adequately powered study often requires specifying a population value of the effect size, which is, by definition, unknown. A common sample size planning approach circumvents this unknown parameter by using the observed effect size estimate from a previously published study as an approximation of the likely effect size for the planned study. Although this strategy is intuitively appealing, observed effect size estimates at face value are typically not accurate estimates of the population effect size, due to publication bias and uncertainty. We first show sample size planning that takes a sample effect size at face value often results in underpowered studies, sometimes to a startling degree. We then present an alternative approach that corrects sample effect size estimates for bias and uncertainty, and we demonstrate its effectiveness for several experimental designs. Finally, we provide an R package and show how this approach can be applied in practice.

Using Aggregate Unit Pre/Post Assessment Results Across Classrooms: A Monte Carlo Study Proof of Concept in Program Evaluation
Matthew Lavery
Teachers often use assessment instruments in their classrooms from various sources, including teacher-made tests, with unknown psychometric properties. While an individual teacher may use such assessments in a pre/post design to measure student learning gains, reflect on teaching, and evaluate the quality of an instructional unit, it is uncertain whether or how these data could be used to inform program improvement or evaluation across classrooms or across schools. The present study uses a multilevel Monte Carlo simulation study to evaluate the use of unit pre/post assessment data aggregated across classrooms to investigate the impact of programs designed to improve teachers' instructional effectiveness with specific subgroups of students. Based on simulation findings, guidelines are presented for a priori power analyses for level-1 and level-2 effects as well as for cross level interaction effects. This analytical approach is then demonstrated by analyzing a non-simulated data set of N = 6812 K-12 students taught by N = 244 teacher candidates during student teaching in order to evaluate a differentiated ESOL teacher preparation program.

Session 4D: Suppression / Non-Monotonic Effects

Suppression Effects in Regression: The Case of Learning Strategies and Academic Achievement

Eric Loken, & Xiaowen Liu

Suppressor effects in regression occur when coefficients behave inconsistently as more predictors are added to the model. In a typical regression model, as new predictors are added to the model the unique contribution of the predictors tends to diminish and the slopes attenuate towards zero. However, in some cases the slopes increase or switch sign in the presence of new predictors, and it is even possible for the multiple R-square for a model to be greater than the sum of the bivariate squared correlations. A common reaction when this occurs is to cast doubt on the model, sometimes dismissing the result as "just a suppressor effect". There is a history in statistics and social science of trying to understand more about the conditions that give rise to suppressor effects. The first part of our paper will further explore suppression using the eigenvector decomposition of the predictor matrix. For example, the eigenvector structure that leads to suppression is common in longitudinal research. Often measures at two time points correlated highly, as might be the case for two repeated measures of academic achievement or weight status or other measures with high stability. But if an outcome is predicted to be associated with change from time 1 to time 2, then it will be correlated with a contrast that reflects the second eigenvector of the predictor correlations. We will explore the consequences of this for unbiased estimates of correlates with change. We will also use this framework to explore whether suppression effects might contribute to false-positives and biased effect size estimates in models with two and more predictors. The second part of our paper focuses on one specific example that is emerging in educational psychology.

A New Model for Non-Monotonic Effects

David Weakliem

Non-monotonic effects are often of interest in the social sciences. The standard way to model such effects is with a model including x and its square as independent variables, but this model imposes some important restrictions: the implied relationship between x and y is symmetrical, and changes in predicted values are proportional to the square of the distance from the maximum/minimum value of x. The usual way to extend the quadratic model is with polynomials of a higher degree, but the parameters are difficult to interpret. This research proposes an alternative model which extends the quadratic regression model by including two additional parameters that can be interpreted as representing skewness and "peakedness." The model also suggests a simple specification test for the adequacy of quadratic model. The extended model can be fitted by non-linear regression--macros in several popular statistics programs will be shown. The paper will give several examples of fitting and interpreting this model, and conclude by suggesting several possible extensions.

Concurrent paper session 5 — Wednesday 8:00 am – 9:00 am

Session 5A: Symposium: Consideration When Utilizing Indicators to Evaluate Latent – Level Differences across Time and Groups

The issue of measurement invariance is important to any research where the same measurement model is used across time or groups. When the goal is to make latent level comparisons, the assumption of measurement invariance must hold. The main objective of this symposium is to demonstrate the consequences of violating the assumptions of measurement invariance when

making cross-group and occasion comparisons. First, we present a review and application of how to evaluate different levels of factorial invariance (i.e., configural, weak, strong, and strict) using empirical longitudinal data and illustrate how a construct's latent trajectory can be assessed from multiple indicators at each time point using a second-order latent growth model—i.e., the Curve of Factors model. Second, we examine the convention of using a "sufficiently high" internal consistency estimate to justify creating composite variables to model change over time, but not establishing factorial invariance. Specifically, using simulated longitudinal, multivariate data, we demonstrate how failure to achieve factorial invariance can result in parameter estimate discrepancies of mean change over time when using latent growth models. Finally, via simulation study, we demonstrate how misspecification of the referent indicator affects the estimation of model parameters, as well as the detection of measurement invariance.

Paper 1. Longitudinal Factorial Invariance: Measuring and Modeling the Same Construct Over Time *Marilu Isiordia*

Paper 2. Implications of Establishing Internal Consistency but Not Factorial Invariance on Growth Model Parameters *Marilu Isiordia*

Session 5B: Dealing with Non- Normality

Effects of Non-normality of Residuals in Hierarchical Linear Modeling
Kaiwen Man, Yating Zheng, Laura Stapleton
Multilevel modeling (MLM) has become more and more popular in social science research. However, most of the data in reality do not perfectly satisfy all the assumptions that are required when implementing multilevel models. One major assumption of the multi-level model is that of normality of the error distributions, at both the individual level and group level. Previous research has explored the effects of the violation of the normality assumption at the higher level(s) and has found that the estimates of the standard errors of the parameters are downward biased (van der Leeden & Busing, 1994; Verbeke & Lesaffre, 1997; Mass & Hox, 2003). Few studies, however, have explored the effects of the violation of this assumption at the lowest level of the model. In this study, the effects of the breach of the normality assumption at both individual and group levels were explored with both normal (e.g. number of clusters is 50) and small number of clusters (e.g. number of clusters is 30). Specifically, the following research questions are addressed:1.What effects does the violation of the normality assumption, at both individual and group levels, have on the estimates of the fixed effects and random effects?) 2. Is any effect of a violation of the normality assumption moderated by the number of clusters, especially with a small number of clusters?

Evaluation of Supplemental Samples in Longitudinal Research with Non-normal Missing Date
Jessica Mazen
Although methodological articles provide advice on ways to handle missing data at the analysis stage, there is less guidance for researchers who wish to use supplemental samples (i.e., the addition of participants after the first measurement occasion) to handle attrition. Despite the lack of research investigating the effects of using this approach on parameter estimates, supplemental samples have been used in numerous studies in the field of psychology and beyond including multiple large-scale studies. The purpose of this study is to explore the benefits and limitations of supplemental samples in evaluating longitudinal data that is non-normally distributed. We distinguish between two supplemental approaches: a refreshment approach where researchers select additional participants

using the same criteria as the initial participants (i.e., random selection from the population of interest) and a replacement approach where researchers first identify auxiliary variables that explain missingness and then select new participants based on those attributes. We compare the two types of supplemental approaches in analyzing missing completely at random and missing at random data in longitudinal research. By focusing on a linear growth curve model with a covariate, nine possible influential factors are studied: distribution of the population, missing data mechanism, supplemental sample type, missing data rate, sample size, number of measurement occasions, correlation between the latent slope and auxiliary variable, variance of measurement errors, and the size and timing of the supplemental samples. Overall, 7152 conditions of simulations are considered. For each condition, a total of 500 data sets are generated and analyzed using a two-stage procedure for robust structural equation modeling with missing data (Yuan & Zhang, 2012). The estimate of interest is the population mean slope parameter and the impact of adding refreshment and replacement samples is assessed using the degree of bias, mean square error, confidence interval width, and power. Results show that, in general, patterns of bias were similar for different distributions. As expected, the listwise deletion method yielded high rates of bias in the MAR conditions, but in MCAR conditions this method resulted in bias comparable to complete data. Indeed, bias was low for all MCAR conditions including all supplemental sample conditions. However, when the missing data mechanism was MAR, the pattern of bias was strongly influenced by the supplemental sample approach. When a refreshment approach was used, bias was low across conditions, whereas when a replacement approach was used, bias was high across all conditions. As with bias, the results for power were comparable across the various distributions. In general, power was high (at or above .8) across most conditions. However, some patterns did emerge. For instance, when the missing rate was low, power was similar across conditions, whereas when the missing rate was high (e.g., .15) power differed depending on how the missing data was handled. Overall, results suggest that the addition of refreshment samples, but not replacement samples, is an effective way to respond to attrition in longitudinal research.

Session 5C: Evaluating Balance for Casual Inference

Evaluating Balance for Causal Inference: An Illustration of the cobalt Package in R
Noah Griefer
Covariate balance is the sine qua non of counterfactual causal inference research using preprocessing methods such as propensity scores. Although many simulations and theoretical proofs exist to demonstrate the unbiasedness of various preprocessing methods, in practice a researcher must evaluate the results of their applied preprocessing implementation to determine whether to proceed with a given method or to try again. For example, generalized boosted modeling has empirically been shown to be very effective at generating propensity score weights in the face of outcome model uncertainty, but for any given data set, a variety of other methods, including weighting with propensity scores estimated from simple logistic regression, may be more effective at reducing dependence between treatment and potential confounders. Because, ideally, the outcome data has not been included in preprocessing analysis, the researcher can re-specify their conditioning model and assess balance to guarantee the assumption of conditional independence on observed confounders has been met. In addition, demonstrating covariate balance to consumers of causal research is key to developing confidence that the obtained results are not a result of the researcher's manipulation of the model to attain a desired result, but rather valid results meeting the required assumption of conditional independence. To satisfy the dual requirements of balance assessment—to assess a preprocessing method and to demonstrate to readers that assumptions have been met—a variety of tools should be used to assure balance is attained. Historically, these have included quantitative

measures of dependence such as mean differences, hypothesis tests, and correlations, as well as qualitative measures such as Q-Q plots, probability density graphs, and histograms. Though assessing balance is essentially assessing the adequacy of a preprocessing model, balance itself must be modeled. Approaches to modeling balance have been the subject of a fair amount of research in recent years, but have received far less attention than estimation and conditioning methods in the methodological literature, despite the importance of balance assessment to making and defending causal claims. For causal research with preprocessing analysis, R is the preferred tool because of its flexibility, transparency, and support for rapid innovation and dissemination of new methods. Some of the most popular R packages for preprocessing include the Matching, MatchIt, and twang packages, which collectively implement various methods of matching, sub-classification, and weighting for causal inference. Recently, the CBPS and ebal packages, which implement covariate balancing propensity scores and entropy balancing, respectively, are growing in popularity. All of these packages contain either estimation or conditioning methods and (with the exception of ebal) methods for balance assessment. Across packages, there is much variation in how balance is modeled and reported; no two packages present exactly the same statistics or graphics, and there is no consensus on how balance statistics are calculated. Because of this, it is difficult to compare conditioning methods across packages or even to be confident that the results from one package are valid with respect to others. In addition, packages are rarely if ever updated with balance diagnostic measures that align with current research on balance assessment. To solve these issues (and others), we present the cobalt package, a tool that integrates with all the above packages to provide a unified balance assessment that responds to contemporary research on methodological innovations and best practices. Cobalt is both flexible and intuitive, with many user options for customizable output and intelligent defaults for quick assessment. Users can control which balance statistics and data summaries are displayed and how specific calculations are performed. Included are both quantitative and qualitative methods for balance assessment and tools for visualization, such as the popular Love plot displaying covariate balance, which is not included in any of the conditioning packages named above. In addition to assessing the balance of output from the packages mentioned above, cobalt can assess balance on data processed outside any of these packages, allowing researchers who manually match, stratify, or generate weights to assess balance on their data. As preprocessing methods mature and expand to solve different problems in data analysis, they demand more sophisticated tools to remain accessible to researchers. cobalt has capabilities to assess balance in clustered data (e.g., students within schools), moderated data (e.g., moderated by race), and multiply imputed data, making it the first package to do so despite the burgeoning ubiquity of these data scenarios. Here, we introduce cobalt's capabilities in a variety of data scenarios, comparing and contrasting them with those of the balance assessment tools of popular preprocessing packages. We provide a demonstration of the current best practices in balance assessment and how cobalt accomplishes them with minimal effort on the part of the analyst. Finally, we demonstrate an applied use of cobalt to evaluate balance.

Concurrent paper session 6 **Wednesday 9:15 am – 10:45 am**

Session 6A: Workshop: Multiple Imputation for Multilevel Data (Part I)

Craig Enders

(Please note: this is a double session which runs 9:15-12:30.)

Multiple imputation has been widely available for many years, but classic imputation routines are inappropriate for multilevel data because they ignore clustering and generate imputations from a model that assumes zero intraclass correlations. Joint modeling (JM) and fully conditional

specification (FCS) are the principal imputation frameworks for single-level data, and both have multilevel counterparts. The multilevel versions of JM and FCS apply different underlying models, and software packages offer different functionality. The JM and FCS tools that researchers currently have at their disposal work well for very specific tasks, but these methods are generally not equipped to handle a wide range of complexities that are typical of behavioral science data. The Blimp application for Mac OS and Windows was developed to address a range of scenarios that are difficult or impossible to handle with existing software. In particular, the FCS machinery implemented in Blimp can accommodate random slopes, nominal and ordinal variables, unique within- and between-cluster covariance structures, heterogeneous within-cluster variance structures, and models with up to three levels, with missing data at any level of the data hierarchy. An imputation model that implements any combination of these features can be specified with a simple command language or through the graphical user interface. The session will provide attendees with a broad overview of multilevel imputation, followed by a specific discussion of the FCS methodologies implemented in Blimp. The presentation will include a mixture of theoretical and applied topics and will include a software demonstration that illustrates the use of Blimp with popular analysis programs such as Mplus, R, SAS, and SPSS. The Blimp software, documentation, and various analysis scripts are available for download at www.appliedmissingdata.com/multilevel-imputation.html .

Session 6B: Graphical Methods for Understanding SEM Model

Graphical Methods for Understanding SEM Model

Keke Lai, Samuel Green, Roy Levy

When structural equation models are not equivalent or nested, they may still have similar fit across a wide range of data. In this paper we propose a framework to study the similarity between SEM models. This framework can help researchers (a) identify the characteristics in data or model parameters that lead to similarity in fit; (b) explain specifically how those key elements affect model similarity. The first part of the framework is a new method to span the data space (i.e., generate covariance matrices) where two given models tend to exhibit a certain pattern of fit difference (e.g., similar fit, similarly well fit, etc.). The two models and the pattern of fit difference are specified by the researcher. The second part of the framework involves using graphical methods to study the similarity between the two models with respect to the data space of interest. The graphical approaches allow researchers not only to describe the relationship between models, but also why and how they are similar or dissimilar.

Session 6C: What the Dutch can do with prior information (and you too)

Bayes is growing in all disciplines! This is one of the results found by van de Schoot, Winter, Ryan, Zondervan-Zwijnenburg and Depaoli (in press) in an extensive systematic review. There are many different reasons why one might choose to use Bayes (e.g., the use of priors, estimating otherwise intractable models, modeling uncertainty, etc.). They found in this review that the use of Bayes has increased and broadened in the sense that this methodology can be used in a flexible manner to tackle many different forms of questions. In this symposium we will show a broad range topics that can be tackled by using prior information. We start off with an evaluation of Bayesian estimation for small sample problems, when is it a solution and what are some pitfalls? Thereafter we discuss a new method to judge experts based on their elicited prior beliefs. To provide proof of concept an application is presented ranking regional directors in a large financial institution. To conclude, an

innovative way of testing replication of hypothesis using prior predictive p-values is presented and illustrated. Online tools are made available so that you too can start using this method.

Paper 1. Bayesian Structural Equation Models with Small Samples
Sanne Smid, Dan McNeish, Rens van de Schoot

Paper 2. Using the Data Agreement Criterion to Rank Experts' Beliefs
Duco Veen, Diedrick Stoel, Rens van de Schoot

Paper 3. Testing ANOVA replications by means of the prior predictive p-value
Mariëlle Zondervan-Zwijnenburg, Rens van de Schoot, Herbert Hoijtink

Session 6D: Dyadic, Social Network, and Social Relations Models

Applying Modern Methods for Missing Data Analysis to the Social Relations Model
Terrence Jorgensen
To account for missing person-level or dyad-level data in the Social Relations Model (SRM), I illustrate how to incorporate partially observed covariates as either auxiliary variables or substantive predictors. I apply the method to network data about peer perceptions of body preoccupation among 162 sorority members, only 90 of whom provided self-reports of body preoccupation to use as covariates. I use Bayesian estimation to fit the SRM as a cross-classified multilevel model (dyads nested within perceivers and targets), in which the cross-classified effects are correlated (i.e., perceivers and targets were the same group of women), treating random effects and missing data as parameters (i.e., data augmentation). I conclude with simulation results to verify the validity of the method.

Modeling Parent's Reports of Children's Gender-Types Behavior over Time with an Indistinguishable Dyads Common Fate Growth Model
Randi Garcia, Abbie Goldberg
The current longitudinal study examined patterns and predictors of parent-reported gender-typed play behavior in adopted boys and girls in lesbian, gay, and heterosexual two-parent families, across early childhood (Mage = 2.82 to 6.06 years). Specifically, using a sample of 181 couples (56 lesbian couples, 48 gay male couples, and 77 heterosexual couples), we examined parent reports of children's gender-typed play behavior on the Pre-School Activities Inventory (PSAI; Golombok & Rust, 1993) at three time points (mean age = 2.82 years at T1, 3.93 years at T2, and 6.06 years at T3). Family structure variables (i.e., parents' gender and sexual orientation; children's gender and sibling status) were included as predictors. At T1, according to parent reports, children in lesbian-parent families had less gender-differentiated behavior (boys were less masculine, girls were less feminine) than children in heterosexual- and gay-parent families, whereas the degree of gender differentiation did not differ between heterosexual- versus gay-parent families. Findings from a Common Fate Growth Model (Ledermann & Macho, 2014) revealed that, regardless of family type, the parent-reported gender-typed behavior of boys, but not girls, significantly changed over time (i.e., boys' behavior became more masculine). Our findings have implications for researchers who study gender development in children and adolescents, particularly those who are being raised by two mothers or two fathers.

Teacher Social Network Change over Time: How do Longitudinal Modeling Approaches Compare?

Elizabeth Dietrich, Nathan Abe, Elizabeth Sanders, Jessica Thompson

Social network analyses appearing in educational research is often limited to descriptive, rather than model-based methods. Further, when model-based methods are employed for educational data, they are usually limited to single timepoint models. The present study fills this gap by applying and comparing major modeling techniques for estimating social network change over time within the context of educational research. We use real data from a three-year study of a science teacher network of N = 55 teachers located in a diverse public school district in which 68% of its students receive free or reduced lunch. Our applied research interest is whether network characteristics change (for the better) over time, and whether there were teacher characteristics that predicted change. Our methodological research question is focused on comparing approaches to estimating network change over time. Modeling approaches include the temporal random exponential graph model (TERGM), the stochastic actor-oriented model (SAOM), as well as a 2-step approach using ERGM estimates + multilevel modeling. Estimates of parameters, goodness-of-fit, and out-of-sample fit, as well as practical considerations will be compared across approaches.

Concurrent paper session 7 — Wednesday 11:00 am – 12:30 pm

Session 7A: Recent Advances in Regression Modeling with Complex Real-World Data

In many fields of science and technology, the amount of data being collected is growing at an exponential rate, and so too is the complexity of the data. As data driven techniques are becoming more popular, new and interesting data structures are being discovered that present new and unique problems. In this ever expanding world of Big Data, we are faced with the challenge of trading off the efficiency/scalability in computation and the accuracy/stability in modeling, which has been reshaping statistical thinking and pushing a genuine refinement and expansion of the classical statistical toolbox. Especially with the different forms data can take and the intrinsic multivariate nature of these problems, how to achieve stable and scalable computation has been extremely challenging. This symposia thus focuses on the state-of-art developments in multivariable regression modeling with complex data structures. Some specific topics include finite mixture modeling with censored and heavy tailed data, reduced rank estimation for mixed-responses with incomplete data, and stagewise regression with interaction terms for correlated data. Without a doubt, these cutting-edge works will be of great interest to our community and help make complex data a little simpler.

Paper 1. Robust Finite Mixture Modeling of Censored Data Using the Multivariate Student-t Distribution
Victor Lachos

Paper 2. Leveraging Mixed and Incomplete Outcomes via a Mixed-Response Reduced Rank Regression
Kun Chen

Paper 3. Efficient Stagewise Regression for Correlated Data with Interaction Selection
Gregory Vaughan

Session 7B: Dynamic Methods for Multivariate Data Analyses

Guided by advances in dynamical systems theories and longitudinal modeling, this symposium features five papers that illustrate how dynamic, multivariate approaches are being used to advance theoretical conceptions of and analytic possibilities for the study of social, emotional, and developmental processes. The first paper utilizes unified structural equation modeling to construct a multivariate EMA time-series as person-specific network, and then use network statistics to link to person-level characteristics. Highlighting a hybrid method that aims to inform meta-theory that human development as a product of dynamic processes across multiple domain and on multiple time-scales. The second paper demonstrates the utility of a differential equation modeling approach for studying how the dynamics of co-regulation change with age. Fishery management is used as an analogy for examining mothers' management of infants' crying (i.e. fish harvesting). The analysis illustrates how changes in infants' self-regulation and mothers' efficiency of soothing (co-regulation) can be captured using a "harvesting" model. The third paper models longitudinal heart rate variability measures from mother-infant dyads in the Strange Situation paradigm using windowed-cross correlations and peak-picking algorithms to produce a graphical representation of synchrony between mother and infant. The dynamic relations between mother and infant are dissected for each episode of the Strange Situation. The fourth paper compares and contrasts two measures of synchrony via Recurrence Quantification Analysis (RQA) and Windowed Cross Correlation (WCC). Applying the windowing method from WCC to the metrics calculated by RQA, Windowed Recurrence Quantification Analysis highlights changes in within-person/dyad processes and provides a more refined examination of change over time. Fifth, spectral coherence is a method of assessing similarity between frequencies of two time-series but it is inadequate when time series are nonstationary. We propose a windowed spectral coherence method for assessing nonstationary time series. We describe this method using behavioral data, and physiological models. Overall, this symposium highlights how study designs and analytic methods facilitate the articulation, testing, and refinement of theory, the limitations embedded in the designs and procedures, and promising future extensions.

Paper 1. Individual as Dynamic Networks: Merging of Intraindividual variability, Network Analysis and Experience Sampling
Xiao Yang, Nilam Ram, Scott Gest, David Lydon-Staley, David Conroy, Aaron Pincus, Peter Molenaar

Paper 2. Capturing Developmental Change in Regulation Processes using Dynamic Systems Models: Borrowing Differential Equations from Ecology
Lizbeth Benson, Nilam Ram, Jonathan Helm, Cynthia Stifter

Paper 3. A Dynamic Model of Heart Rate Synchrony of Mother-Child Dyads in the Strange Situation
Gustav Sjobeck, Steven Boker

Paper 4. Windowed Recurrence Quantification for the Analysis of Dynamical Systems
Allison Gray, Timothy Brick

Paper 5. Windowed Spectral Coherence: A Method of Cross-Spectral Coherence Between Nonstationary Time Series at Multiple Time-Lags
Robert G. Moulder

Session 7C: Educational & Developmental Applications

Self-Regulatory Climate Measures

Mwarumba Mwavita, Kathy Curry

Schools face a multitude of challenges that affect student performance. Social conditions such as poverty, violence, limited teaching capacity, and limited parent-school interactions (Boykin & Noguera, 2011; Darling-Hammond, 2010; Diamond & Spillaine, 2004; Guin, 2004), conditions often prevalent in high poverty environments, inhibit student ability to fulfill their educational potential (Adams, Forsyth, Dollarhide, Miskell, & Ware, 2009; Bevel & Mitchell, 2012; Diamond & Spillane, 2004). The effects of these conditions are often highlighted in research centered on the urban school setting (Diamond & Spillane, 2004; Guin, 2004) painting a bleak picture for the future of urban students. Therefore, attention is needed to understand school conditions that can mitigate negative effects of urban conditions and enhance student performance. In order to gain an understanding of the relationship between student perceptions of school conditions (i.e., self-regulatory climate) that can mitigate barriers to learning, we examined the relationship between self-regulatory climate and student grit. We used multilevel modeling to explore the relationship.

Confirming the Factor Structure of the Critical Thinking Assessment Test: A Bayesian Confirmatory Factor Analytic Approach

Chi Hang Bryan Au, Allison Ames

This study seeks to empirically confirm a critical thinking instrument's purported factor structure in a confirmatory factor analysis (CFA) framework. Conventional Maximum Likelihood (ML) estimation encountered difficulties in estimation due to several features of the instrument (e.g., multidimensionality of the items and an inconsistent scoring scheme leading to adoption of the Bayesian Structural Equation Modeling (BSEM) approach.

Longitudinal Studies on Night Sleep Trajectories throughout Infancy

Shaun Goh, Daniel Goh, Teoh Oon Hoe, Seang Mei Saw, Fabian Yap, Yap Seng Chong, Anqi Qiu, Birit Brokeman

Longitudinal studies on night sleep trajectories throughout infancy are sparse. Moreover, most studies examined Caucasian samples, while cultural differences in sleep habits have been described. To expand on the current literature, here we aim to determine night sleep trajectories in an Asian population from age 3-24 months. Latent growth curve analyses were run in Mplus version 7.3, using night sleep data from each infant (n = 893) at each time point to estimate the trajectory which represents the change in level of night sleep across 3 to 24 months. We established a trajectory of night sleep that was valid by modelling different latent growth curves and assessing them on a series of fit indices from simpler, more parsimonious models to more complex, less parsimonious ones. A piecewise latent growth curve model with two freely estimated/basis curves was retained as the best fitting model. This model was not a precise fit of the data (Chi-square test of model fit = 18.01, df = 9, $p<.05$) but nonetheless was of close fit as shown by low RMSEA, CFI, TLI and SMRM values (0.03, 90% CI 0.01 to 0.06; 0.97, 0.95, 0.04). The first curvilinear curve was estimated across 3 to 12 months, with an average increase of 0.12 hours of sleep per month. The second curvilinear curve was estimated across 12 to 24 months, with an average increase of 0.02 hours of sleep per month. There is an overall increase in the night sleep trajectory in this South-East Asian sample, which is indeed different from existing Western samples (Zurich, Quebec). This difference in sleep trajectory after the first year may be due to societal differences in bedtime routines, parental sleep-settling behaviors and parental perception of sleep problems that have been attributed to influencing night sleep

duration, while sleep duration during the first year is more driven by biological factors such as brain maturation of circadian networks or genetic factors. Data from this study may be helpful in informing sleep medicine guidelines in Singapore and possibly other predominantly Asian countries on the average sleep trajectory within infants from 3 to 24 months. It is especially useful for clinicians and health professionals to understand that "one-size-does-not-fit-all", hence Western-based sleep-related guidelines and interventions may not always be applicable to infants of predominantly-Asian countries, especially after the first year of age, where cross-cultural differences in sleep trajectories are more likely to be present.

Session 7D: Workshop: Multiple Imputation for Multilevel Data (Part II)

Craig Enders

(This is a double session which runs 9:15-12:30. Session 7D is a continuation of session 6A.)

Concurrent paper session 8 Wednesday 3:15 pm – 4:45 pm

Session 8A: Advances in Mixture Modeling

A framework of R-squared measures for single-level and multilevel regression mixture models

Jason Rights, Sonya Sterba

Psychologists commonly apply regression mixture models in single-level (i.e., unclustered) and multilevel (i.e., clustered) data analysis contexts. Though researchers applying non-mixture regression models typically report R-squared measures of explained variance, there has been no general treatment of R-squared measures for single-level and multilevel regression mixtures. Consequently, it is common for researchers to summarize results of a fitted regression mixture by simply reporting class-specific regression coefficients and their associated p-values, rather than considering measures of effect size. In this talk, we discuss recent developments that fill this gap by providing an integrative framework of R-squared measures for single-level regression mixture models and multilevel regression mixture models (with classes at level-2 or both levels). Specifically, we describe 11 R-squared measures that are distinguished based on what the researcher chooses to consider as outcome variance and what sources the researcher chooses to contribute to predicted variance. We relate these measures analytically and through simulated graphical illustrations. Further, we demonstrate how these R-squared measures can be decomposed in novel ways into substantively meaningful sources of explained variance. We describe and demonstrate new software tools to allow researchers to compute these R-squared measures and decompositions in practice. Using two empirical examples, we show how researchers can answer distinct substantive questions with each measure and can gain insights by interpreting the set of measures in juxtaposition to each other.

Methods of Covariate Inclusion in Latent Transition Analysis: A Monte Carlo Simulation Study

Ai Ye, Jeffery Harring, Luke Rinne

Latent transition analysis (LTA) is a longitudinal variant of latent class analysis that allows researchers to analyze how individuals change between latent classes over time. In LTA models, one is often interested in relating latent class membership to auxiliary variables. However, in contrast with recent investigations focused on evaluating the accuracy of covariate inclusion procedures within the contexts of latent class analysis (LCA) or growth mixture modeling (GMM), where one latent variable is estimated, investigations with multiple latent categorical variables, like latent transition analysis (LTA), are scant. In the present study, we conducted a Monto Carlo simulation to evaluate several recent bias-corrected three-step approaches with the traditional three-step and one-step methods for incorporating covariates into LTA under various conditions, including class separation, covariate

effect size, type of parameters estimated, and sample size. Preliminary results suggest that the newer three-step approaches yield consistently less biased parameter estimates and more accurate standard errors than the uncorrected three-step method. Part of the inspiration for the study comes from a presentation at the 2016 MMM conference regarding the work of investigating the method under the context of LCA. Our purpose in this proposal is to extend the method to its longitudinal form.

Statistical Modeling of EEG Brain Mapping Data: Challenges and Opportunities
Jay Magidson
Mixture latent Markov (MLM) modeling often provides new insights from longitudinal data where the goal is to track changes in latent states over time. Recently, there has been increased interest in the use of EEG data to identify latent brain state patterns in need of improvement and to design a therapy protocol to provide such improvement. For example, an individual with low alpha and high beta waves, relative to a normal reference group, may suffer from anxiety. We propose a methodology where MLM can be used to analyze EEG data to benefit an individual suffering from some psychological condition. Despite the fact that data is obtained from only a single case, a massive amount of data can be attained over a 2-3 minute period. In this paper we propose a new methodology where MLM can be used to analyze EEG data and illustrate its application using pre and post neuro-feedback brain map data. The resulting latent states are intriguing and suggest that MLM may provide new insights in the area of neuro-feedback and other areas involving the analysis of EEG data.

Session 8B. Modeling Health Disparities

Assessing health disparities in intensive longitudinal data: gender differences in Granger causality between primary care provider and emergency room usage, assessed with Medicaid insurance claims
Emil Coman, Yinghui Duan, Daren Anderson
This presentation introduces the concept of Granger causality for intensive longitudinal (panel) data, and demonstrates simple Stata and R code for implementing it. We illustrate how one can contrast direction of causality in two populations of interest (like race/ethnicity e.g.), when health disparities (HD) questions arise. We test which is the predominant direction of causality between primary care provider (PCP) use and emergency room (ER) use, using the Granger causality/noncausality approach, and compare male vs. female results, using a subset of a large Medicaid CT dataset (N = 14,358) for adults (n = 12,381, 18 and older, 33.2% males, 66.8 % females), of claims spanning three years (April 2013-Sept. 2016). We describe common challenges of modeling intensive panel data (some cases having as much as 5,300 repeated observations), and then delve into the details of processing and analyzing such claims data, focusing on either actual utilization (number of times patients see PCPs or go to ER) within specific time intervals, or on the actual cost of paid claims. The mutual causation of two key outcomes questions are explained in the context of known panel analytical econometric approaches. We use Stata's recent pvargranger and R's grangertest. These 'chicken and egg' questions have been asked before, even literally with chicken and eggs data, but not with claims data to our knowledge. We interpret the results in terms of their implications for practice, regarding how the use of PCP services drive (or not) lower/higher ER use. We expect that PCP use to reduce ER use; similarly, more ER use should drive up PCP use, as patients are referred back to their PCP by ER physicians, yet patients follow up more/less with such recommendations. We examine HD questions as gender differences in the strength of Granger causality findings regarding PCP-ER usage and costs over time, and conclude with HD implications of these modeling options.

How to peel oranges into apples: Finding causes and effects of health disparities with difference scores built by 1-on-1 matching

Emil Coman, Helen Wu

Understanding the causes of health disparities (HD) is a major public health objective in the US, because it promises to uncover efficient solutions to achieve health equity, and ultimately better health for all individuals. HD models however commonly focus on detecting population differences, between a racial/ethnic (R/E) or gender group (e.g. Black patients), and a reference group (e.g. white patients). Such differences are tested for significance using a variety of statistical models, primarily tests of differences between some averages in the comparison groups, controlled for some proper covariates. Judging the size of HDs in health outcomes is but the first step in understanding the causal mechanisms that led to such HDs, and hence recommending changes that could reverse and hopefully erase disparities. Causal analyses of the emergence of HDs however are not straightforward. Revealing causes of HD requires modeling directly the difference in health outcomes, in other words the actual differences in health outcomes between comparable cases need to become the (variable) outcome, and potential predictors of it tested for impact, in size and significance. We propose an approach that borrows strengths from the Latent Change Score (LCS) tool, here more properly labeled Latent Difference Score (LDS). A LDS score is simply an (latent) difference score between two commensurable variables, like post-pre scores of a same variable, or in our case the scores of half of the sample (e.g. white patients) and the other matched half (Black patients). We will detail an approach to match one-on-one patients, so that the data literally then becomes dyadic in structure.

A review of modern methods of estimating the size of health disparities

Emil Coman, Helen Wu

We review the current advanced/modern statistical methods of comparing racial/ethnic groups in search of true health disparities (HD) estimates, and provides an applied 'how to' using Stata commands. Currently, modern HD methods fall short of making sound causal claims, because 'assignment' to a racial/ethnic (R/E) group is not random at birth (like gender is), or R/E is not itself an exogenous predictor, when it comes to health outcomes. It is well known for instance that education and income act as 'precursors' or one's R/E, or that R/E differences in outcomes of interest are partially 'due to' education and income, and only partially 'due to' R/E membership. If a researchers is interested in comparing health outcomes Y, like stress, a key mechanisms involved in health processes, s/he would either: 1. Compare the two means using an independent samples student's t test; 2. Test for the significance of the Black/white dummy predictor in a regression of HIL on the grouping variable (with adequate controls, like SES); 3. Compare the Y intercepts in two-group regression/path models, with SES indicators as predictors; other more advanced methods. We provide a comprehensive review of modern methods, accompanied by simple software code (Stata, then Mplus) for obtaining HD estimates with education and income as controls/covariates, using: 1. Multiple regression with covariates/controls (regress commands) 2. Clustered regression for clusters defined by controls/covariates; (vce(cluster) options) 3. Propensity score matching approaches, based on block matching algorithms, like 1. using Stata's psmatch2; 2. atnd; 3. teffects. 4. Structural Equation Modeling methods, including 2-group models allowing for differential effects within R/E groups (sem command) 5. Instrumental variable estimation, in the econometric tradition, using Stata's ivregress. 6. A new approach, based on 1-on-1 matching of cases, and latent difference scores (sem command, implementing latent difference scores; Mplus will be used for contrasts). While results differ little, some methods provide wider estimates with smaller standard errors (IV in particular), which require further investigations, we will illustrate and contrast them visually and analytically.

Session 8C: Advances in multivariate multilevel models for cross-sectional, longitudinal, and repeated cross-sectional data

Chair: Katherine Masyn

This symposium brings together three papers that broaden the horizons of multivariate multilevel modeling. Collectively, the papers represent innovation in the specification, estimation, performance, and application of multivariate multilevel models for a variety of particularly challenging data structure scenarios. The first paper considers the situation of multiple-membership multilevel longitudinal data wherein some individuals followed over time change cluster membership during the period of data collection. In her novel approach, the author presents the model specification and estimation for a multilevel piecewise growth model that allows for the possibility that some individuals may change cluster membership within and/or across different segments of the growth process, comparing her model performance to a model that only used cluster membership at the first measurement occasion and another that ignored individual mobility across clusters. The second paper considers the situation of multivariate multilevel longitudinal models based on multilevel repeated cross-sectional data wherein clusters are followed over time but independent samples of individuals within clusters are measured at each time point and the time-specific, individual-level measures are a set of indicators for a latent class variable. The authors propose a multilevel latent transition analysis (LTA) with between-cluster random intercepts of the individual-level indicators at each time point functioning as indicators for a time-specific, cluster-level latent class variable and cluster changes in latent class membership over time captured by a cluster-level LTA.

Paper 1. Estimating a piecewise growth model with longitudinal data that contains individual mobility across clusters
Audrey Leroux

Paper 2. A cluster-level latent transition model for multivariate multilevel repeated cross-sectional data
Katherine Masyn, Rashelle Musci, Amie Bettencourt, Albert Farrell

Poster Abstracts

1. **A method for identifying low variance**

Cara Arizmendi & Kathleen Gates

Whether to include variables with low variance in analyses is a common predicament for researchers. Despite the frequency of obtaining data with one or more variables with low variance, a method for successfully identifying these variables for removal has yet to be developed. Simply identifying problematic variables based on the value of their variance alone does not account for the interdependencies among the variables as a whole. By failing to account for these interdependencies, researchers may be removing innocuous variables from their data or may be including variables that will over-inflate standard errors, resulting in unstable estimates in the partial correlation matrix. Here, we present a method for identifying low variance using an adaptation of the Haitovsky test, a test for detecting very high multicollinearity in correlation matrices. Simulations demonstrate the test statistic's ability to identify when the variance of one or more variables in a covariance matrix is too low for stable partial correlation estimates and determine how to differentiate between detecting multicollinearity versus detecting low variance. An empirical example is provided using data on community attitudes toward law enforcement from the Police Foundation's Public Safety Open Data Portal.

2. **Predicting Positive Youth Development: The role of intentional self-regulation and relationships**

Caitlin Aymong, Jacqueline Lerner, Sara Johnson, & Michelle Weiner

Past research has demonstrated that having a role model and having intentional self-regulation (ISR) have been linked with positive developmental outcomes. We used data from 413 6th-11th graders from eleven New England schools who participated in the Connecting Adolescents Beliefs and Behaviors study to examine the relations between ISR, role model relationship quality, and positive youth development (PYD). A structural regression model was used to examine these relationships. Standardized fit statistics for the full model were mixed (chi-square=1893.79, $p<.001$; RMSEA=0.04; CFI=0.82; SRMR=0.08), with the chi-square statistic and CFI indicating poor fit, but the RMSEA and SRMR indicating adequate fit. Similar to previous work, this model provides evidence that ISR and relationships predict PYD. Interestingly, this model demonstrates that the five factors (i.e., caring, connection, confidence, competence, and character) of PYD are differentially predicted by relationship quality in this sample. Specifically, relationship quality significantly predicted three aspects of PYD whereas ISR significantly predicted all five. ISR and relationship quality together predicted 13-34% of the variance for each of the five factors of PYD.

3. **Measurement Implications: Assessment of Invariance in the Everyday Discrimination Scale across Transgender and Sexual Minority Identities**

Loren Bauerband, Leslie A. Brick, & Wayne F. Velicer

The Everyday Discrimination Scale (EDS) is a brief measure of perceived experiences of discrimination first designed for African Americans in a medical setting as a 9-item, single factor measure. The EDS has been used in research with various racial and ethnic identities, LGBT identities, and health conditions. Several studies have found the structure of the EDS to be invariant across race, but no research has assessed structure across transgender and sexual orientation identities. The current research used a nonprobability sample of 553 cisgender sexual minorities and

484 transgender individuals to assess invariance across LGBT identities. Structural invariance was evaluated across configural, metric and scalar levels between cisgender and transgender groups, and across gender identities among cisgender and transgender separately. Results supported the same factor structure as previous research, but only partial metric invariance between cisgender and transgender individuals. One item was noninvariant between transgender and cisgender groups, but when invariance was assessed across genders within the transgender group, the same item was noninvariant. This suggests one item was differentially related to experiences of discrimination for only transgender women. Additional analyses may support the removal of this item from the scale, but distinguishes a discrimination experience specific to transgender women.

4. **Intervention effects on stage transitions for adolescent smoking and alcohol use acquisition**

Leslie A. Brick, Wayne F. Velicer, Colleen Redding, & Andrea Paiva

The health impacts of smoking and alcohol abuse have been long established with smoking representing one of the most preventable causes of disease and alcohol use the most popular psychoactive substance among adolescents. The current study evaluated stage of change progression in a large (N=4,158), longitudinal school-based, computer delivered, Transtheoretical model-tailored multiple behavior intervention focused on preventing acquisition of smoking and alcohol use in adolescents. Assessments began in sixth grade and continued yearly until eighth grade, with a follow-up in ninth grade. Longitudinal Markov modeling with an absorbing class (e.g., a class that represented students who became smokers/drinkers and could not transition into any other class) was used to explore behavior acquisition stage transitions over the course of the intervention. Nested models were employed to determine the best pattern of stage movement, whether the pattern was consistent over time, and whether intervention condition affected stage transitions. Major findings supported positive intervention effects for both the intervention and comparison condition, which focused on energy balance behaviors and provided no direct intervention on substance use behaviors. Substantial differences in stage membership and transitions across intervention conditions highlighted the process of smoking and alcohol use acquisition in middle school students across each intervention condition.

5. **Fit for a Bayesian: An Evaluation of PPP and DIC**

Meghan Cain & Zhiyong Zhang

This poster introduces Bayesian SEM and its fit indices: posterior predictive p-value (PPP) and deviance information criteria (DIC). Both fit indices rely on frequentist ideas of model fit, but can be calculated directly from the MCMC methods used in Bayesian analysis. As of yet, no criteria have been established for their use in practical analysis, severely limiting the utility of Bayesian SEM. This project aims to establish such criteria. Three simulations studies were conducted on popular models in psychology and other social sciences. A wide variety of type and severity of misspecifcation were covered, and the effects of sample size, model size, prior specification, and data nonnormality were evaluated. Some recommendations for evaluating model fit in Bayesian SEM using PPP and DIC are proposed.

6. **AIC and BIC for Simple Models of Severely Complex Data**

Ian Campbell

Different information criteria are often used to compare non-nested models in Structural Equation Modeling (SEM), with the Bayesian Information Criterion (BIC) and the Akaike Information Criterion (AIC) being the most common. Many previous simulations have recommended BIC as the better method for model selection. However, these simulations have often focused on scenarios

where the true Data Generating Process (DGP) is relatively simple, often less complex than some of the models under consideration in the candidate set. This does not reflect reality in psychology, where complex human behaviors are thought to result from many interacting factors. To understand how information criterion perform when the true DGP is substantially more complex than any of the potential models, the current simulations used a severely complex DGP and examined the ability of AIC and BIC to select the optimal model from among different sets of non-nested, relatively simple candidate models—none of which contained the true model—across a wide range of misspecified parameter values and sample sizes. The results indicate that BIC requires surprisingly large sample sizes to select the best model with high consistency and that AIC may be a better option at certain commonly seen sample sizes.

7. Accounting for Test Score Measurement Errors in Student Growth Models

Pei-Hsuan Chiu, H. Jane Rogers, & Hariharan Swaminathan

Student growth models based on test scores can provide important information about student's progress over time and allow prediction of future performance. These models can be constructed under regression-based or latent variable frameworks. In either case, it is critical to take into account test score measurement errors that come from either classical test theory (CTT) or item response theory (IRT) models. As Fuller (1987) and other studies have indicated, ignoring or misspecifying measurement errors can result in attenuation bias in parameter estimates and reduced power for testing hypotheses . In the present study, three methods for accounting for test score measurement errors are compared: 1) correction of parameter estimates using test score reliabilities in a linear regression model; 2) specification of individual test score measurement error in the level 1 error variance structure of a linear growth model; and 3) incorporation of an IRT model as the measurement model in a structural equation model (SEM) where the IRT model describes the relationship among items and latent variables and a linear regression model (the structural model) describe the relationship among latent variables. A simulation study compared the prediction accuracy of the models.

8. Effects of Measurement Error on Autoregressive Parameters in Time Series Analysis

Kristine Christianson, Siwei Liu, & Emilio Ferrer

In the field of psychology, interest in investigating intraindividual processes through individual time series analysis has grown in the last two decades. However, despite the fact that research has shown that failure to take measurement error into account leads to biased estimates of autoregressive (AR) coefficients (e.g., Schenker & Gentleman, 2001; Schuurman, Houtveen, & Hamaker, 2015), the majority of these analyses do not explicitly incorporate measurement error. The purpose of this project is to further investigate the effects of measurement error in individual time series data by comparing the dynamic factor analysis (DFA) model to an AR model using composites of observed indicators. We conducted a Monte Carlo study in which we generated data under a DFA(1,1) model varying the factor loading/error variance ratios while holding all other parameters constant. We generated 500 replications for each condition and then fit DFA(1,1) and AR(1) models to the simulated data. Our findings suggest that, as expected, the DFA model successfully recovered the AR parameter, but the AR(1) model using composites yielded attenuated estimates that worsened with increasing error variance. These findings add support to previous work suggesting measurement error in time series analysis leads to biased estimates of the AR parameter.

9. **Evidence of Age-Varying Associations in Risk and Protective Factors for Obesity and Overweight from the National Survey of Children's Health**

Darce Costello

Background: According to the Centers for Disease Control and Prevention, the proportion of U.S. children classified as obese more than tripled since the early 1970s. Recent estimates indicate that around 17% of U.S. children are obese and 16% are overweight. Obesity is associated with a variety of chronic health problems in childhood and adulthood. In addition, overweight and obese children experience negative social and mental health consequences, such as being bullied or socially isolated and suffering from depression, anxiety, and low self-esteem. Obesity also disproportionately affects children from low income households and racial and ethnic minorities. Despite the wealth of research on childhood obesity and overweight in the U.S., there have been few studies examining how the associations between risk and protective factors for being obese or overweight may change during childhood. This secondary analysis uses data from the 2011-2012 National Survey of Children's Health (NSCH) to examine how the associations between physical activity, sedentary activity, and the risk for being overweight or obese vary between ages 10 to 17 years in order to shed light on developmental periods when the associations are strongest and when intervention may be most effective. A secondary aim was to examine whether household income moderated these age-varying associations. Method: The 2011-2012 NSCH was designed to be representative of the U.S. population of non-institutionalized children in the U.S. ages 0-17. The study outcome was a dichotomous indicator of overweight or obesity derived from age- and gender-specific BMI based on parental report of the child's height and weight.

10. **Applying Equivalence Testing to Measurement Invariance**

Alyssa Counsell & Robert A. Cribbie

Measurement invariance (MI) is an important concept for scale developers and researchers who would like to compare data from multiple populations on some trait or construct. It is the idea that differences between populations are a function of group membership rather than bias in how a scale measures the target trait. A common practice to test levels of MI is through comparison of nested confirmatory factor analysis models after adding equality constraints on parameters across the groups. Statistically nonsignificant results from a chi square difference test are typically used as an indication of MI since the additional constraints do not statistically worsen the model fit. Yuan and Chan (2016) proposed to use equivalence testing approaches instead of this method to avoid the logical and statistical issues with "accepting" the null hypothesis. This work introduces and evaluates Yuan and Chan's equivalence testing approach to MI, and demonstrates the use of the method with data from males and females on the Generic Conspiracist Beliefs Scale, and discusses statistical and theoretical differences between equivalence testing and traditional approaches.

11. **A More Powerful Familywise Error Controlling Procedure for Evaluating Mean Equivalence**

Heather Davidson & Robert A. Cribbie

When one wishes to show that there are no meaningful differences between two or more groups, equivalence tests should be used; a nonsignificant test of mean difference does not tell us that the groups are all equivalent. The current research proposed a modified-Holm based procedure for controlling the familywise Type I error rate when we fail to reject the null hypothesis in a one-way equivalence test (i.e., when not all groups are equivalent, but some might be equivalent). Caffo, Lauzon and Rohmel (2013) suggested dividing the alpha level by a correction of K squared divided by 4, where K is the number of levels, however more statistical power is possible if a stepwise

approach is adopted. In this presentation we outline the new method and use a simulation study to demonstrate the power advantage of the proposed method.

12. **Beyond Two Dimensions of Effectiveness: A Three-Step Latent Profile Analysis of New York City Schools**

Megan Duff & Alex J. Bowers

The purpose of this study is to identify a typology of school effectiveness in New York City. The city's new Framework for Great Schools suggests there are six key factors that lead to school effectiveness, including: rigorous instruction, supportive environment, collaborative teachers, effective school leadership, strong family-community ties, and trust. Although previous research has supported these factors' inclusion in models of school effectiveness; no one has attempted to identify different subgroups of effective schools using these indicators. Employing a sample of all New York City public schools serving students in grades 3-12 that participated in the New York City School Survey in 2016 (N=1,853), we perform a 3-step latent profile analysis (LPA). First, we estimate the subgroups of effective schools. Then we introduce a number of covariates to characterize schools belonging to each group, using school-level descriptive data. Finally, we examine the extent to which schools' subgroup classifications explain academic outcomes. This study contributes to the literature by applying recent developments in LPA to all but the 10 New York City schools that did not participate in the 2016 survey.

13. **An Evaluation of MIIV Estimation for Multilevel Structural Equation Modeling**

Michael Giordano & Ken Bollen

This monte carlo simulation study evaluates properties of Model Implied Instrumental Variable (MIIV) estimation for multilevel latent variable structural equation models (SEMs). Multilevel SEMs are commonly estimated through full Maximum Likelihood as implemented in GLLAMM (Stata) or MPLUS. Maximum likelihood estimators have ideal properties when their structural and distributional assumptions are met; however we know in practice these assumptions are often violated (e.g. incorrect model specification and nonnormality). Prior work has shown MIIV estimators are more robust to structural and distributional assumptions for single level latent variable SEMs. The current study builds upon previous findings extending the application of MIIVs for multilevel SEMs. We estimate two-level confirmatory factor analysis models with MIIVs and full ML. We look at the bias and variance of each estimator under correct and incorrect specifications. We vary the number of indicators per latent variable, the sample size, and generate data from normal and nonnormal distributions.

14. **Analysis of item-level bias in the Bayley-III language subscales : The validity and utility of standardized language assessment in a multilingual setting**

Shaun Goh, Elaine KH Tham, Iliana Magiati, Sim Lit Wee, Shamini Sanmugam, Anqui Qui, L. Mary Daniel, Birit Brokeman, & Anne Rifkin-Graboi

Purpose: To improve standardized language assessments among bilingual toddlers by identifying and removing items that show differential functioning (DIF). Background: It remains unclear if standardized language assessments can fairly assess the construct of language among bilinguals due to possible unfamiliarity with cultural norms or a distributed language system. This paper operationalizes and empirically estimates possible item level biases among a standardized language assessment adapted for bilinguals. Methods: DIF was applied to Bayley's-III expressive language scales administered to two-year-olds (n = 459) with typical language development from the Growing Up in Singapore Towards healthy Outcomes (GUSTO) cohort study. Confirmatory factor analyses for binary items were run in Mplus version 7 with Weighted Least Squares Means and

Variances adjusted (WLSMV) estimator with probit link, a limited information estimator designed to handle categorical type data. Then, each item was sequentially tested for the presence of DIF. This was done by regressing a factor item onto the covariate of interest while simultaneously adjusting for any true group difference by regression of the latent factor onto the covariate.

15. **Evaluating UNC's Chancellor's Science Scholars Program: A Propensity Score Analysis**

Noah Greifer, Abigail Panter, & Viji Sathy

We evaluated the Chancellor's Science Scholars (CSS) program, an academic enrichment program aimed at increasing underrepresented minority achievement and participation in science, technology, engineering, and mathematics (STEM) PhD programs. To adjust for confounding, we employed propensity score weighting to create a control group of non-participating student similar on background covariates to CSS participants. Multiple imputation with chained equations was used to handle missingness, and propensity scores were generating using the Covariate Balancing Propensity Scores method. We estimated the effect of CSS participation on cumulative hours completed, cumulative science hours completed, D/F/W rate, and science D/F/W rate after the first year for the first three CSS cohorts. Results indicate that, assuming no unobserved confounding, CSS participation causes improvements in these outcomes, especially science outcomes, for CSS participants, consistent with the program's mission.

16. **Temperamental Exuberance Moderates the Relation Between Effortful Control and 1st Grade Reading Achievement: a Latent Growth Curve Modeling Approach**

Rachel A. Gross & Anne Dopkins Stright

Theory suggests that reactive and regulatory temperament dimensions may interact to predict children's academic achievement, but no studies have examined the interaction of exuberance and effortful control in relation to children's achievement. Low effortful control is usually associated with poorer achievement, but can be moderated by external factors (e.g., teacher support). Data were drawn from the NICHD Study of Early Child Care and Youth Development to explore whether the relation between effortful control at 54-months and reading achievement across 1st, 3rd, and 5th grades can be moderated by a resource internal to the child: exuberance. Free-loading latent growth curve models were estimated to account for the nonlinearity of individual growth trajectories in children's achievement scores. The interaction of exuberance and effortful control predicted the intercept, such that when 54-month effortful control was high, children demonstrated high levels of achievement in 1st grade regardless of 54-month exuberance, but when 54-month effortful control was low, higher 54-month exuberance predicted higher 1st grade achievement. Results suggest that higher exuberance may help children with poor effortful control obtain greater reading achievement in 1st grade but that their exuberance may no longer compensate for their poor effortful control in 3rd and 5th grades.

17. **Examining multiple approaches to evaluating measurement invariance with multilevel data and a level-1 grouping variable**

Heather Gunn & Kevin Grimm

To make valid group comparisons on a latent construct, the indicators that define the construct need to have an equivalent factor structure across the groups being compared. Occasionally, participants are clustered in higher-level units, which can create dependency in the data. When testing for measurement invariance with multilevel data, the dependency needs to be taken into consideration. In this study, we compared the statistical conclusions of five approaches that evaluate measurement invariance in regards to gender in multilevel data with a level-1 grouping variable. The five

methods we used were a multilevel factor mixture model for known classes approach, a MIMIC approach, a definition variable approach, a design-based approach, and a Muthén's maximum likelihood approach. To evaluate measurement invariance, we used a subset of children (N = 2,617, 49.45% female) from the publicly available Early Childhood Longitudinal Study-Kindergarten Cohort dataset. The boys and girls from this sample were nested within 150 schools. For this illustrative example, the conclusions of the five approaches were the same (e.g., the same parameters exhibited bias across approaches). Further work should explore the differences in power and type I error rates between the approaches and how the assumptions of each approach affect the results.

18. Nonlinear relationships between Traits and methods in MTMM models

Fred Hintz, Christian Geiser, & G. Leonard Burns

The examination of construct validity is of vital importance to psychological research, and the multitrait-multimethod (MTMM) design is one of the most frequently employed methods to examine construct validity. While most contemporary confirmatory factor analysis (CFA-MTMM) methods do not allow correlations between trait and method latent variables, the latent difference and latent means models of CFA-MTMM allow for the examination of linear relationships between traits and methods (Browne, 1985; Eid, 2000; Geiser, Eid, West, Lischetzke, & Nussbeck, 2012; Kenny, 1976; Marsh & Hocevar, 1983; Pohl, Steyer, & Kraus, 2008; Widaman, 1985). Theoretical conceptualizations of method effects have suggested that in addition to linear relationships, nonlinear relationships between traits and methods may exist in practical applications and be relevant to the interpretation of the trait-method relationship (Schmitt, 2006). In the present paper, two methods for examining nonlinear relations between traits and methods are proposed and described in detail. An application to a multi-rater study of children with attention deficit and hyperactivity disorder is described (N=725). A Monte Carlo study is presented that tested the performance of the methods under different levels of convergent validity (variance of method factor), reliability of indicators, and sample size.

19. **Comparing Different Planned Missingness Designs in Longitudinal Studies**

Nicholas Illenberger & Ofer Harel

Planned Missingness (PM) designs, in which researchers deliberately collect only partial data, have enjoyed a recent growth in popularity. Among other benefits these designs have been proven capable of reducing the study costs and alleviating participant burden. Past research has shown that Split Form PM designs can be effective in simplifying complex surveys while Wave Missingness PM designs act similarly for Longitudinal studies. However, less work has been done to inform how to implement PM structures into studies which incorporate elements of both survey and longitudinal designs. Specifically, in studies where a questionnaire is given to participants at multiple measurement occasions the best way to design missingness is still unclear. To address this deficiency, data in this hybrid format was simulated under both Split Form and Wave Missingness PM structures. Multiple Imputation techniques were applied to estimate a multilevel logistic model in each of the simulations. Estimated parameters were compared to the true values to see which PM design allowed us to best capture the true model. The results of this study indicate that, compared to the Split Form Design, the Wave Missingness design consistently performed less effectively in capturing the multilevel model. Thus, in the context of longitudinal surveys this study recommends the use of Split Form missingness designs, which performs well under a number of different conditions.

20. **Evaluating the Factor of Curves Model's Capability to Capture Change Across Psychometric Conditions**

Marilu Isiordia

It is well-established that factorial invariance is a necessary condition for comparing latent means over time. However, the literature has yet to support any analytical techniques to researchers who wish to conduct latent mean analysis across repeated measurements when factorial invariance is not tenable in the data. The Factor of Curves (FOCUS) model might be a practical solution to this challenge. The FOCUS model evaluates whether a higher-order factor structure is responsible for the covariation among univariate latent growth models. An advantage of the FOCUS model is that it does not require factorial invariance constraints to assess common growth among lower-order developmental functions. This study examined the FOCUS model's capability to capture the underlying growth process among a set of indicators across different levels of invariance. To accomplish this, multivariate, longitudinal data was simulated under the following indicator-construct relations: level of invariance, factor loading size, and number of indicators. Results showed that across conditions, the FOCUS model recovered the population latent trajectory only when factorial invariance was tenable. Overall, findings indicate that although the FOCUS model does not require longitudinal factorial invariance constraints, factorial invariance still needs to hold to make valid inferences about a construct's latent trajectory over time.

21. **Modeling the Longitudinal Effects of Executive Functioning on Theory of Mind in Preschool Children using Structural Equation Modeling**

Minji Kang & Randi L. Garcia

Although studies have found that there is an effect of executive functioning on acquisition of theory of mind in children (Carlson, Claxton, & Moses, 2015), the most modern longitudinal modeling techniques, using Structural Equation Modeling (SEM), have yet to be fully utilized in this field. Theory of mind is measured with the false belief task which tests whether children can understand that others may have diverging beliefs from their own. Emergence theory (Moses & Carlson, 2004) states that executive functioning enables the weighing of different perspectives, a consequence of which is the ability to consider the contents of others' mental states. Using two waves (N = 326) from a multi-year NIH language study, we estimated a model where executive functioning at T1 predicts change in theory of mind from T1 to T2. The model results indicate that there is a positive relationship between executive functioning and change in theory of mind. Various indirect effects of language acquisition on theory of mind through executive functioning were also estimated. Future directions include using data from the full 4-wave longitudinal study to fit a Latent Growth Curve Model predicting change in theory of mind from change in executive functioning.

22. **Gain Scores Revisited: A Graphical Models Perspective**

Yongnam Kim & Peter M. Steiner

The use of gain scores (i.e., the difference between posttest and pretest) for estimating the effect of an intervention from observational data has been frequently avoided in education and psychology. Recent advances in causal inference, in particular the graphical models approach (Pearl, 2009), shed new light on the misunderstandings about gain scores. Using simple graphical models, we visualize the conditions under which gain scores allow us to identify causal effects. Our graphs show that gain scores remove bias in effect estimates by offsetting non-causal associations instead of directly blocking them by conditioning on the pretest. The offsetting mechanics rely on the common trend assumption and do not require a reliably measured pretest. Also, because gain score analyses do not need to condition on other variables, they are neither prone to bias amplification—bias increases after conditioning on covariates—nor to collider bias—bias induced by conditioning on a common

outcome. In addition to giving insight into the famous Lord's paradox, our gain score graphs give an idea how more complex identification strategies, such as difference-in-differences, fixed effects models and comparative interrupted time series designs can be graphically represented.

23. Multiple imputation for incomplete categorical variables in multilevel data structure

Helani D. Kottage, Carole L. Birrell, & Marijka J. Batterham

Multiple imputation is considered a prominent method of handling missing data and has been researched widely in recent years. Studies addressing its behavior in multilevel data structure are lacking, especially when there are incomplete categorical variables. We attempt to fill such a gap in literature by comparing three popular imputation methods available for handling incomplete data in a multilevel data structure. A simulation study will compare the approaches of: (a) joint modelling, (b) fully conditional specification, (c) fixed effects imputation specifically focusing on where missingness is found in categorical predictor variables. Methods (a) and (b) assume underlying continuous latent variables for categorical variables in a multilevel structure whereas the common approach of (c) involves a single level imputation model. Further, the performance of these methods will be investigated with varying cluster sizes and intra class correlations while missing rates (level-1 variables), number of clusters and number of imputations are kept fixed. The substantive analysis is to fit a two-level random intercept model to a continuous outcome variable (such as reading score) with categorical predictors in both level-1 (e.g. students) and level-2 (e.g. schools).

24. An effect size measure for moderated mediation models

Mark Lachowicz

Mediation analysis has become an increasingly popular statistical method in education research. However, currently available effect size measures for mediation have limitations that restrict their use to specific mediation models. In particular, complex mediation models with moderators and latent variables have no established effect size measures for indirect effects. In this study, I develop a measure of effect size that addresses these limitations. This work has several components: 1) derivation of an expression mathematically for an effect size for moderated mediation models with manifest and latent variables, 2) evaluation of the measure in terms of established criteria for good effect sizes, 3) derivation of an expression for the finite sample bias of the new measure and a bias-corrected estimator, 4) evaluate the finite sample properties of the estimators using Monte Carlo simulation, and 5) demonstrate the utility of the measure using empirical data. The example will be a moderated mediation model with multiple mediators using the National Longitudinal Study of Adolescent Health (AddHealth) that will examine the processes through which childhood maltreatment affects educational attainment. The developments here extend the existing literature on both effect size and mediation by developing a method of communicating the magnitude of indirect effects in complex mediation models.

25. Statistical power analysis for logistic models with multiple covariates and interaction terms: a Monte Carlo based approach

Haiyan Liu & Zhiyong Zhang

Power analysis and sample size planning are of particular interest in experimental design. In existing approaches, the analysis is conducted based on either the likelihood ratio test, the score test, or the Wald test, which works well for models with one predictor. However, it is not easy to extend these tests to more complex models, for instance, models with confounders and interaction terms. This study proposes to compute the power through Monte Carlo simulation, a general framework that works for models with multiple predictors, interactions, and other situations. Simulation studies are conducted to evaluate its performance. A demonstration of the method is provided.

26. Performance of the Weighted Root Mean Square Residual (WRMR) in Structural Equation Modeling

Jin Liu, Ginger Jiang & Christine DiStefano

In structural equation modeling, the tenability of a model is evaluated by examining ad hoc fit indices, which illustrate the fit of the tested model to the data. Overall model fit is typically assessed by examining a variety of fit indices, such as the Chi-squared ratio test, Root Mean Squared Error of Approximation, and the Comparative Fit Index. The Weighted Root Mean Square Residual (WRMR) available in Mplus is an index that has been included to evaluate model fit by many applied researchers; however, limited study has been conducted on the WRMR. One study (Yu, 2002) recommended that the WRMR may indicate acceptable fit when values are under 1. Alternatively, the developers of Mplus (Muthen & Muthen, 2014) recommended that this index is only an experimental fit index. Yet, applied researchers are currently using the WRMR for model support (e.g., Wiesner & Schanding 2013). This study will investigate the performance of the WRMR for categorical data to provide additional information about the performance of the index at evaluating model fit. A variety of correctly and misspecified models will be tested and the WRMR are compared with other well-known indices to examine fit under typically encountered conditions.

27. The impact of Likert point scale, number of items, theoretical reliability on reliability estimates

Qimin Liu & A.R. Georgeson

The literature suggests that Cronbach's alpha underestimates the theoretical reliability when used with Likert point response scales. The current simulation study examines the reliability estimates of Likert point scales under a variety of conditions and assesses the degree to which the reliability estimate underestimates the theoretical reliability. Within each condition, the number of Likert points, number of items, and theoretical reliability values were manipulated. Thus, the simulation had 120 conditions: 6 Likert scale point levels (2, 3, 4, 5, 6, 7), 5 item number levels (8, 12, 16, 20, 40), and 4 theoretical reliability levels (.4, .6, .8, .9). We obtained 500 replications with n=350 for each condition. Results show that the reliability estimates (as assessed with Cronbach's alpha) underestimate the theoretical reliability in Likert point scales for all conditions. However, the reliability estimates improve as more points are added to the Likert scale. Increasing item numbers also improves the reliability estimates. Theoretical reliability also seems to have effects on the reliability estimate with Likert point scales. Recommendations for researchers are discussed.

28. Addressing Test Difficulty Variance In College Computer Based Testing

Xiaowen Liu & Eric Loken

Random item selection from an item bank is widely used in the measurement of learning management systems, including those used in college classes. Unfortunately, random item selection introduces the problem of large variance in test difficulties among students. We describe the problem and look at three potential resolutions: stratifying the item pool by content and item difficulty, estimating ability by item response theory (IRT), and equating test scores by adjusting for test difficulty. We can demonstrate the problem by simulating a large item bank and randomly sampling tests for examinees. By tracking the difficulty level of the items a student encounters, we can calculate overall test difficulties and see the distribution across the population of students. We will show that a substantial degree of variability exists, which means that students may be having very different testing experiences. Stratifying the item pool by difficulty level, even coarsely, can reduce the testing variance. It is also possible to do post-test adjustment based on the test difficulty

after gathering evidence for the whole student sample. Finally, IRT estimates of student ability adjust for the pattern of items and are less biased than the standard practice currently in place.

29. Evaluation of Multi-Parameter Test Statistics for Multiple Imputation

Yu Liu & Craig K. Enders

In Ordinary Least Square regression researchers often are interested in whether a set of parameters is different from zero. With complete data, this could be achieved using gain in prediction test, hierarchical multiple regression, or an omnibus F test. However, in substantive research scenarios missing data often exist. In the context of multiple imputation, one of the current state-of-art missing data strategies, there are several different analogous multi-parameter tests of the joint significance of a set of parameters, and these multi-parameter test statistics can be referenced to various distributions to make statistical inferences. However, little is known about the performance of these tests, especially in scenarios that are typical of behavioral science data (e.g., small to moderate samples, etc.). We use Monte Carlo simulation techniques to examine the performance of these multi-parameter test statistics for multiple imputation under a variety of realistic conditions. We also provide a number of practical recommendations for substantive researchers.

30. Examination of Large Models with Ordinal Data

Heather L. McDaniel, Liyun Zhang, & Christine Distefano

Within the covariance structural modeling framework, robust estimators have been gaining in popularity. Such estimation methods assist with estimation by correcting standard errors of parameter estimates for attenuation and also adjusting fit indices when data are suboptimal, such as non-normally distributed (e.g., Savalei, 2014). When categorical data are analyzed, robust methods (often termed Diagonal Weighted Least Squares -DWLS) have advantages over more traditional Weighted Least Squares/Categorical Variable Modeling methods, including the ability to analyze larger models and the ability to use smaller sample sizes than were previously able (e.g., Bandalos, 2008, 2014; DiStefano & Morgan, 2014; Flora & Curran, 2004). While previous studies have investigated the ability of DWLS methods to accommodate smaller sample sizes (e.g., Bandalos, 2008, 2014; DiStefano & Morgan, 2014), fewer studies have investigated the ability of DWLS to accommodate larger models. This study performed a simulation to investigate the ability of the Weighted Least Squares Mean- and Variance-Adjusted estimator available in Mplus. Models included p = 16, p=36, and p=60 items with 2- and 5-category item level data and various levels of model misspecification. Recovery of true item parameter values and accuracy of standard error of parameter estimates, chi-square fit indices, robust versions of the comparative fit index, root mean square error of approximation were evaluated.

31. Using Hierarchical Linear Growth Modeling to Identify Longitudinally Outperforming School Districts from the United States District Population, 2009-2013

Elizabeth Monroe & Alex J. Bowers

School district effectiveness research is a growing field in education research, but it lacks a method for identifying districts that significantly and longitudinally outperform peer districts from similar community and local contexts. In this study, we analyze the US population of public school districts over the five years 2009-2013. We built a two-level hierarchical linear growth model that nests time in districts and has parameters on both the intercept, in 2009, and change in slope over time, as well as including an AR1 autocorrelation specification. Using this model, we identify school districts that significantly outperform or underperform their predicted longitudinal student performance, given demographic and community covariates. The model's covariates are variables district administrators cannot control, such as student demographics and state funding. Therefore,

districts that outperform the model based on the residual analysis are significantly outperforming their peers, after controlling for such characteristics. The aim of this study is to present a method for selecting the most effective school districts in the United States, so that leaders of these districts may share how they have led their school districts to success. Several outperforming school districts are identified as potential sites for qualitative studies of district effectiveness.

32. Improvements to missing data treatment in presence of skipping fields: A new possibility using Multiple Imputation

Esteban Montenegro, Youngha Oh, Kyle Lang, & Todd Little

Missing data is a common problem that can cause serious issues in human and social sciences (Little & Schenker, 1995). Surveys and especially national surveys are often a big challenge due to the different missing data patterns. One of the most common patterns and the problem of analyzing data in large-scale surveys is when the skip pattern is present. For example, when a participant answers no to a gate question (e.g., have you had surgery for your cancer?), then the next question (e.g., how many surgeries have you had for your cancer) would be skipped. To impute missing data and utilize the information of the gated variable, He et al. (2010) utilized what they called a "deterministic imputation approach", where a number zero was imposed in a question gated by a previous question, to impute the skipped questions. The authors proposed that this approach took into account the relation between the missing patterns and the questions gated by another question. They even claimed that it is possible to use this kind of approach assuming MAR assumption. The present study conducts a Monte Carlo simulation in R (R Core Team, 2015) to test the approach proposed by He et al. (2010). Missing data are treated by multiple imputation (MI). The study includes three different variables: binary, normal distributed and Poisson. Conditions compare MI without imposing zeros vs. MI imposing zeros.

33. Analyzing the Effects of the Absence of Levels in Multilevel Modeling using TIMSS Data

Breanna Morrison, Xinya Liang, & Wen-Juo Lo

Multilevel models are popular for handling data nested within multiple higher-level clusters. It provides substantial power and accuracy if the levels of data are properly specified. However, leaving out higher levels of nested data may result in biased standard errors and inaccurate variance estimates for lower levels (Gilbert et. al., 2016). The current study investigates how reduced models (ignoring a level of the nested structure) affects various outcomes in estimating students' math achievement from a variety of potential predictors. The analysis sample comes from TIMSS data at the student, teacher, and school level. Complementing with literature, an exploratory analysis is first conducted to identify predictors to be used in the three-level full model. Then two reduced two-level models, one with students nested within schools, and the other one with students nested within teachers, are compared to the full model. The evaluation criteria include model fit, parameter estimates, standard errors, and variances explained at each level. The consequences of leaving out levels in multilevel models will be discussed. This study is important due to the increased use of multilevel modeling without fully understanding the consequences of leaving higher levels out of these models.

34. **Overcoming the Boundary Problem in Bayesian Growth Curve Modeling: A Data Permutation Method for Testing Random Slopes**

Robert Moulder & Xin Tong

Growth curve modeling is a common tool for measuring intraindividual change and interindividual differences in intraindividual change over time. More and more researchers fit growth curve models to their data using Bayesian methods, because Bayesian methods allow for both a high degree of modeling flexibility and the use of prior information to impact parameter estimation. Within a Bayesian framework, the random effects of a growth curve model are often assumed to have gamma distributed priors, and thus usually result in gamma distributed posteriors. This creates a problem during model selection as gamma distributions have a lower bound of zero. Thus, a Bayesian Highest Posterior Density (HPD) interval will never cross zero, making determining significance of a random slope parameter difficult. The existing methods for solving this boundary problem are time consuming and may be technically difficult to implement. Therefore, in this study, we demonstrate a way of using data permutations to efficiently determine the significance of a random slope parameter. Simulations show that this method is adequate for determining the existence of a random slope parameter at noise-to-random slope ratios of 2:1 and shows a strong ability to select random slopes at noise-to-random slope ratios of 1:1 and lower.

35. **The mediating effect of pre-medical school education attainment on undergraduate medical school performance in the UK: A multilevel structural equation modelling cohort study**

Lazaro Mwakesi Mwandigha, Paul A. Tiffin, Adetayo S. Kasim, & Jan Boehnke

Several studies have demonstrated that both the United Kingdom Clinical Aptitude Test (UKCAT) and medical school entrants' Previous Education Attainment (PEA) are predictive of undergraduate medical performance in the UK. This present study seeks to assess whether the predictive validity of the UKCAT for medical school theory and skills based exam outcomes throughout the five years of undergraduate medical school is mediated by an entrant's PEA. Selection data (UKCAT and PEA scores) and medical school outcomes were available for 2,107 medical school entrants enrolled in 19 UK medical schools in 2008 and followed up until 2013. Since the outcomes utilized were local measures derived from participating universities, mediation effects were investigated using multilevel structural equation modelling with university taken as high level variable. The results revealed statistically significant mediation effects of PEA in the first two years of pre-clinical training (years one and two) and first year of clinical training (year four) for theory based exams. No mediation effects were detected in any year of training for skills based exams. The results suggest that, for the most part, the UKCAT adds value when used as a selection tool over and above previous educational achievement.

36. **Forecasting Potential School District Effectiveness Trends in Ohio State: Using Bayesian Hierarchical Longitudinal Model to Inform Policy Decision-Making**

Xinyu Ni, Alex J. Bowers & Yilin Pan

The purpose of this study is to apply a Bayesian statistical approach to a hierarchical growth modeling framework to predict longitudinal U.S. school district effectiveness trajectories as a means to inform cross-district improvement and evidence-based policymaking. Previous district effectiveness research has successfully incorporated the use of time-nested hierarchical growth models to identify significantly outperforming school districts from entire population in a state, however, no research to date has attempted to build forecasting models to accurately predict future school district performance. Providing reliable performance forecasting for local education agencies could provide a new means to help inform decision-making by local and state-level policymakers.

In the present study we trained a time-nested Bayesian hierarchical growth model on the first three years of test-score data from a seven-year longitudinal dataset of all school districts in Ohio (n=610), and then predicted future four-year district effectiveness with Markov Chain Monte Carlo (MCMC) techniques in the Rstan program. This model incorporated appropriate individual prior distributions controlling for district demographic characteristics and specified an AR1 autocorrelation. Our results indicate that the majority of district trajectories can be forecasted with acceptable accuracies, predicting individual local district performance trends for each district in Ohio for the first time.

37. Comparison of Approaches to Examining Moderators of Change in Latent Change Score Models

Holly O'Rourke & Kevin J. Grimm

When using latent change score (LCS) models, researchers often are interested in examining moderators of longitudinal change, which traditionally have been investigated using a multiple group approach (McArdle & Grimm, 2010). In this study, we proposed a new method for examining moderators of longitudinal change in LCS models using definition variables, and compared the definition variable approach to the multiple group approach. One benefit of using the definition variable approach is the easy examination of moderators with more than two levels, or continuous moderators. To this end, we conducted a simulation that used both approaches to examine moderators of change in bivariate LCS models. Conditions included group differences in fixed and random parameters, and number of levels and scale in moderating variables. For each data set generated, we fit a LCS model to the data using a definition variable approach and a multiple group approach. Results indicated that the multiple group and definition variable approaches produced comparable and unbiased results fitting bivariate LCS models with categorical predictors, although the definition variable approach models took more time to converge. The efficient investigation of continuous moderators of change was the main benefit of using the definition variable approach for bivariate LCS models.

38. Planned Missing Data Design with Larger Multi-Form Designs

Youngha Oh, Rong Chang, & Jaehoon Lee

Planned missing data (PMD) designs are becoming popular because of their extreme advantages. Data collection is the most time-consuming and high cost part of conducting research. PMD can make research cost effective, and it permits researchers a great deal of control over their studies efficiently (Little & Rhemtulla, 2013). Especially, multi-form planned missing data designs allow fewer questions for participants without causing fatigue and practice effects. They also have the benefit of improving data quality (e.g., reliability and validity; Little & Rhemtulla, 2013). There are several simulation studies for three-form planned missing data designs, yet no simulation study has been conducted with the larger multi-form designs such as 6-form and 10-form. The advantage of these larger designs (> 3-forms, e.g., 6-form, 10-form) is that researchers can address more questions (Graham et al., 2006). Although previous research proved the 3-form design is manageable for a small sample size, dealing with larger multiple forms has a disadvantage. The fundamental disadvantage of larger designs is that it requires a very large sample size. Otherwise, these designs are not appropriate. This study explores this question by using simulated 6-form and 10-form PMD. The purpose of this study is to identify how large sample size is required for the larger multi-form designs. The simulation design involved three latent models; a one-time-point and a two-time-point confirmatory factor analysis (CFA) model. Both full information maximum likelihood (FIML) and multiple imputation (MI) were used to handle the missing data. This study will focus on model convergence, parameter estimate bias, standard error bias, mean squared error

(MSE), and relative efficiency (RE) in order to evaluate the models. Results showed the larger form reduced the convergence rates for the small sample size, as well as increased the parameter bias.

39. Using the Integrative Data Analysis Framework to Study Child Development

Fan Pan, Jin Liu, & Christine Distefano

The Behavioral and Emotional Screening System (BESS; Kamphaus & Reynolds, 2015) was designed to be a reliable and accurate predictor of a variety of behavioral and emotional problems of children is widely used by many schools in the United States and worldwide. However, the forms include different items for different age groups (e.g., preschool, child, adolescent), making examination of behavioral and emotional problems over time difficult. Typically, longitudinal investigations require the same assessment at each time point. To combat this, the methodological framework termed Integrative Data Analysis (IDA; Hussong & Curran, 2007) may allow for examination of change over time when items differ, but construct definitions remain constant. This study will pooled data across preschool and child forms to investigate the transition from preschool to first grade. Using IDA, and a focus on internalizing problem behaviors, a mixture growth modeling framework was used to examine patterns of development as children transitioned to the school environment. The results uncovered different classes of development and growth, which may be used to design interventions to assist young children.

40. A further exploration of the Principal-Component-Auxiliary approach for Missing Data Imputation

Pavel Panko, Kyle Lang, & Todd Little

There are several strategies for including auxiliary variables for informing missing data handling procedures, each with its own drawbacks. However, the recently established Principal-Component-Auxiliary (PC-Aux) method maximizes the utility of the all-inclusive method while minimizing its weaknesses. Through the use of principal components, the information-dense portion of the auxiliary variables is used to inform missing data handling with a leaner set of predictors of missingness. The current study examines the PC-Aux implementation for multiple imputation using the R package paveR and compares paveR to other multiple imputation packages using Markov Chain Monte Carlo methods.

41. Examining parametric bootstrap confidence intervals for indirect effects: Simulation, application, and software implementation

Ivan Jacob Pesigan, Iris Sun Rongwei, & Shu Fai Cheung

The parametric bootstrap (PB) method, sometimes called parametric simulation, is a useful procedure for constructing confidence intervals for indirect effects. It is a re-sampling procedure where a parametric model is fitted to the data. Afterwards, samples of random numbers are drawn from this fitted data. Even though parametric assumptions are invoked for ˆa and ˆb, no parametric assumptions are made about the distribution of ˆab.Similar to the non-parametric confidence intervals, PB confidence intervals can be asymmetric and thus are useful in situations where the sampling distribution of a parameter estimate is not necessarily normal. The parametric bootstrap method, differs from the more commonly used non-parametric bootstrapping procedure wherein cases are re-sampled. Because PB is not limited to using cases from the empirically obtained sample,the sampling distribution produced is smoother than the non-parametric counterpart making PB more accurate in higher confidence levels, smaller sample size, and when the sampling distribution is highly skewed. Furthermore, since PB only requires summary data, it is useful for examining indirect effects in other analytic methods such as meta-analysis. We summarize the results of a simulation study comparing PB with other competing methods both in primary studies

and meta-analysis, particularly meta-analytic structural equation modeling; demonstrate the use of the procedure in an applied setting; and discuss implementation of the procedure in R.

42. Consideration on validity and consistency of Value-Added school performance measures

Yoon Ah Song & Brandon C. LeBeau

Linear mixed models (LMMs), also known as one kind of value added models (VAMs) (Lockwood et al 2003) have been used to measure individual student growth and relative school performance in education field. However, there are a few studies that explore whether the school performance measure obtained from VAMs are valid or reliable measure of school performance (Rubin et al, 2004). This simulation study, therefore, will focus on exploring possible evidence to support the use of VAMs by looking into how various model specifications and different random school distributions affect school variance estimate and the consistency of school performance measures.

43. Comparing methods for adding control variables in Structural Equation Modeling

Suppanut Sriutaisuk & Sunthud Pornprasertmanit

Control variables or covariates are widely used since including them can provide more accurate estimates and rule out alternative explanations. A Monte Carlo simulation was conducted to examine the performance of four analysis models representing different covariate effect specifications in Structural Equation Modeling. In addition to the analysis models, the design conditions include the sizes of factor loadings, structural coefficients, coefficients from covariates to latent variables (covariate effects), coefficients from covariates to manifest variables (DIF) and sample size. As expected, the results indicated that the omission of the covariate led to biased estimates in every condition, while the specification in which the covariate effects were included, but no DIF, yielded biased estimates when DIF was nonzero. Further, whereas the analysis model which included all possible paths from the covariate to manifest variables yielded a perfect fit and unbiased unstandardized estimates across all conditions, the standardized structural coefficients were misleading because the specification altered the meaning of the constructs through the change of the latent variances. We further discuss how and when each method is appropriate. In general, our recommendation is that researchers should specify covariates at the latent-level, and may free more paths from covariates to manifest variables when necessary.

44. Evaluating intervention programs across multiple outcomes: Multivariate latent growth modeling approaches

Congying Sun

Most intervention studies include multiple measures, but use the univariate approaches to evaluate the intervention programs. It is unknown how the general literacy ability is influenced by the intervention, and it is also unknown the extent to which the intervention effects might be general versus specific. The current study evaluated five reading programs for adolescent struggling readers (ASRs) using the multivariate latent growth modelling approaches. 665 6th – 8th students were randomly assigned to one condition and received one year intensive reading instruction. They were tested three times per semester on AimsWeb Reading Fluency as well as Word Attack, Letter-Word Identification, Passage Comprehension, Reading Fluency and Spelling. The results suggested that ASRs had an integrated literacy system measured by these six tests. The curve of factor model showed significant growth in the literacy ability, but little variability in the amount of change across students (autoregression R-square > .95). The factor of curve model failed to fit a common slope factor due to the little variation in slopes and the low correlations among slopes. Based on these two

models, we found three programs showing significant treatment effects on the literacy ability, but their treatment effects varied across measures.

45. Surfacing classifications of student interest in a multi-user virtual environment

Shane Tutwiler & Jason A. Chen

Latent growth modeling allows for changes in continuous constructs to be modeled over time. Post-hoc analyses of such models often hint at the potential existence of latent profiles based on the intercept and slope in the construct being measured. The authors (2016) previously measured the decay in student interest in a science-based educational video game over time, and used the latent intercept and slope variables as predictors of gains in auxiliary constructs such as science self-efficacy. Post-hoc analyses hinted at the existence of two unique classes, with uniformly high (or low) intercepts and slopes. Using the BCH method in MPlus (Asparouhov & Muthén, 2014), we test the existence of these latent classes and their relationship to distal variables of interest.

46. A web-based effect-size calculator for t-tests, ANOVA, multiple regression, and multilevel modeling

James Uanhoro

I present a web-based effect-size calculator for the computation of effect sizes in the context of t-tests, analysis of variance (ANOVA), multiple regression, and multilevel modeling. The inputs for the calculator are values which can be obtained from commonplace statistical software. Within the context of t-tests, ANOVA, and multiple regression, non-central distributions are used to construct confidence intervals, which are returned alongside point estimates of the different effect size measures. This web-based calculator accomplishes this using the MBESS R package via the OpenCPU API. Within the multilevel modeling context, point estimates for the different reduction in variance estimates (pseudo R^2) are computed.

47. Best Practices for Conducting Multiple Imputation in Latent Class Analysis When the MAR Assumption Requires Covariates

Marcus Waldman & Katherine Masyn

Despite the burgeoning popularity of person-centered analyses using latent class models, there exists very little guidance for applied researchers to appropriately treat missing data in the contexts that researchers would most likely encounter. For example, consider the situation when the missing-at-random (MAR) assumption is only tenable conditional on a set of auxiliary covariates and these covariates themselves contain missing values. The lack of guidance to deal with missingness when fitting latent class models is especially problematic given that multiple imputation (MI) for multivariate data procedures assume that the missing values are drawn from a single-class population. Consequently, the class enumeration process using the imputed data is likely to result in an under-extraction of latent classes relative to the true number in the population (Enders, 2010; Enders & Gottschall, 2011; Sterba, 2016). We propose a multiple imputation procedure that does not assume the data are drawn from a single-class population. Instead, we draw multiple imputations by sampling from the posterior distribution of a latent class model that includes auxiliary covariates as indicators of class membership. We conduct a simulation study comparing the proposed method to traditional, single-class approaches in high- vs. low- separation settings and at varying rates of missingness. We discuss recommendations for specifying the number of classes in the imputation model.

48. A pseudo-reliability coefficient for latent class models

Shuangshuang Xu, Yunxiao Chen, Yang Liu, & Shuangshuang Xu

The current study investigates a Mutual Information Index (MII) measure for latent class models (LCMs), where the latent variables being measured are categorical. LCMs, including cognitive diagnosis models (CDMs), are typically used when classifying individuals into subgroups based on their item responses. The need for this study was highlighted by the fact that reliability is an important measure of the quality of psychological tests, and that there lacks a consensus on the definition of reliability measures for LCMs nevertheless. The proposed MII has desirable theoretical properties and can be applied to both fixed and computerized adaptive testing designs. In our study, we demonstrate that the MII increases as more items are added to the test, whereas the mean classification error decreases. When 100 items are entered, the maximum overall MII will achieve 0.95. When more than 35 items are entered, the overall MII exceeds 0.8 and the corresponding mean classification error is no more than 0.15. We also demonstrated with simulated data that the model-data fit of calibrated CDMs/LCMs should be established prior to the calculation of any measures of reliability and classification quality. Furthermore, we illustrate the use of the proposed reliability measure with several empirical data.

49. Investigating Measurement Invariance across Ethnicity Groups on Students' Perception of Math

Lihua Yang, Xinya Liang, & Wen-juo Lo

In confirmatory factor analysis (CFA), measurement invariance (MI) is essential for comparison of latent factor scores across multiple groups. The traditional MI analysis typically starts with a fully non-invariant model, and tests for configural, metric, and scalar invariance models using exact invariance constraints. Alternatively, the Bayesian approach uses an informative prior on the differences between group parameters to allow approximate measurement invariance. This study empirically compares the two approaches using the scale with six items measuring "how people important to you view mathematics" in PISA. Understanding potential influences on students' perceptions of math from parents and peers can provide valuable information for facilitating the educational process. Measurement invariance was tested for multiple ethnicity subpopulations. An exploratory factor analysis has identified a two-factor structure, and items potentially crossly loaded on the untargeted factors. Bayesian CFA is used for detecting the cross-loadings and determining the final factor structure. We then compare the Bayesian approach to the traditional method for multiple-group MI analyses. The sensitivity of outcomes to different Bayesian priors is also examined. This study offers insight for different MI applications, and provides evidence for the utility of the PISA scale for group-level analysis.

50. Deciding on Number of Classes in Latent Class Analysis Using Bayesian Non-parametric Methods

Yuzhu Yang & Sarah Depaoli

Latent class analysis (LCA) is statistical tool for identifying unobserved groups (i.e., classes) and assigning group membership for individual cases. Correctly deciding on the number of latent classes can be essential to LCA. Traditional approaches to guiding the decision on the number of classes include using model fit measures, such as Akaike's Information Criterion (AIC), Bayesian Information Criterion (BIC) and so forth. The issue with this information criterion (IC) based approach is that the number of latent classes heavily relies on the performance of model selection techniques, which has been criticized throughout the methodological literature. In this paper, we propose an alternative approach, which applies the Bayesian non-parametric method in LCA. Specifically, we estimate the number of latent classes using the Dirichlet process (DP) mixture

modeling technique. Instead of assuming a fix number of classes, DP estimates the number as a parameter and allows this parameter to change with the data. One of the benefits of this non-parametric method is that it can be more flexible in a dynamic modeling framework and a large-scale data analysis situation. We conduct a simulation study that examines and compares DP with two traditional LCA approaches including the IC-based method and the k-means clustering method. We hypothesize that DP will outperform the traditional LCA methods when the number of classes is getting larger and when the class proportions are getting more extreme. Implications and recommendations to the applied researchers will be discussed.

51. Analyzing student high school mathematics among STEM college graduates: Hierarchical Cluster Analysis Heatmap and Latent Class Analysis

Yihan Zhao & Alex J. Bowers

The purpose of this study is to connect recent innovations in mixture modeling and latent class analysis (LCA) with "big data" visual analytics, namely cluster analysis heatmaps, to provide a novel means to visualize the full data patterns in LCA studies. While LCA is a well-known method to identify homogenous subgroups within heterogeneous data, researchers have lacked a means to visualize the individual patterns within the latent classes. Alternatively, cluster analysis heatmaps have been used extensively for the last 20 years to visualize large datasets and cluster individual data patterns. In this study we present a combination of the methods and illustrate with an example, in which we first identify a four subgroup LCA of students' mathematics attitude in high school based on 12 survey items from the nationally generalizable dataset Education Longitudinal Study of 2002 (ELS:2002), (n=3,389). We then visualize the entire set of data patterns within each latent class using cluster analysis heatmaps in which each student's responses is represented by color blocks (from red to blue). This form of LCA and heatmap visualization provides a novel means for researchers and practitioners to visualize the richness of the data around progression in high school through college into STEM.

DATIC Workshops 2017

Structural Equation Modeling using Mplus
Instructor: *D. Betsy McCoach* June 5th-9th, 2017
This introductory workshop on Structural Equation Modeling covers basics of path analysis, confirmatory factor analysis, and latent variable modeling. Using Mplus, participants will learn how to build, evaluate, and revise structural equation models. Although the workshop does not require any prior knowledge or experience with SEM, participants are expected to have a working knowledge of multiple regression, as well as some experience using a statistical software program such as SPSS.

Longitudinal Modeling using MPlus
Instructor: *D. Betsy McCoach* June 15th-17th, 2017
During this a three-day workshop, students will learn how to model longitudinal data using Mplus. The workshop focuses on fitting and interpreting autoregressive and growth curve models in Mplus. Specifically, we will cover linear, polynomial, multiphase, non-linear growth curve models, multivariate growth curve models, autoregressive models, and hybrid autoregressive/growth models for both observed variables and latent constructs. Some prior knowledge and experience in Structural Equation Modeling is recommended.

Dyadic Data Analysis Using Multilevel Modeling with R
Instructors: *David A. Kenny & Randi Garcia* June 19th-23rd, 2017
The workshop on dyadic data analysis will focus on data where both members of a dyad are measured on the same set of variables. Among the topics to be covered are the actor-partner interdependence model, the analysis of distinguishable and indistinguishable dyads, mediation and moderation of dyadic effects, and over-time analyses of dyadic data. All analyses will be conducted using R, but no prior knowledge or experience with R is required. Participants are expected to have a working knowledge of multiple regression or analysis of variance. (*This workshop is sold out for 2017. Check back in late 2017 for information about the 2018 workshop*.)

Multilevel Modeling Using HLM
Instructor: *D. Betsy McCoach* July 17-21, 2017
This workshop covers basics and applications of multilevel modeling with extensions to more complex designs. Participants will learn how to analyze both organizational and longitudinal (growth curve) data using multilevel modeling and to interpret the results from their analyses. Although the workshop does not require any prior knowledge or experience with multilevel modeling, participants are expected to have a working knowledge of multiple regression as well as some experience using statistical software (such as SPSS, SAS, R, Stata). All analyses will be demonstrated using the software HLMv7. Instruction will consist of lectures, computer demonstrations of data analyses, and hands-on opportunities to analyze practice data sets using HLM. The workshop emphasizes practical applications and places minimal emphasis on statistical theory. The workshop takes place in a computer lab, so you do not need to bring a laptop or software. The workshop is limited to 24 participants.

For more information, visit our website: www.datic.uconn.edu

Call for proposals: 2018 Modern Modeling Methods (M^3) conference

The Modern Modeling Methods (M^3) conference is an interdisciplinary conference designed to showcase the latest modeling methods and to present research related to these methodologies. The 8th annual M^3 conference will be held May 21nd-24th, 2018 at the University of Connecticut. Keynote speakers for the 2018 conference include Dr. Tenko Raykov (MSU) and Dr. Peter Molenaar (Penn State).

Submissions for the 2018 conference are due 2/1/18. We welcome both methodological research papers and papers that illustrate novel applications of methodological techniques in the area of modeling, broadly defined. Papers related to multilevel modeling, structural equation modeling, mixture modeling, longitudinal modeling, and item response theory are especially encouraged. Given the interdisciplinary focus of the conference, it is completely acceptable to present papers that have been published or presented elsewhere. Presenters may select the length of the session that they prefer: 30 minutes, 60 minutes, or 90 minutes. We also welcome proposals for multi-paper symposia on thematically grouped topics. Generally, symposia sessions are 90 minutes in length. We are also soliciting proposals for the poster. Students are also encouraged to submit proposals, especially for the poster session.

Conference proposals for the Modern Modeling Methods conference may fall into one (or more) of four categories: Methodological Innovation, Methodological Application, Methodological Illustration, or Methodological Evaluation. Methodological Innovation proposals introduce a new technique. Methodological Evaluation proposals present the results of empirical research evaluating a methodology. Most often, these will involve simulation studies. Methodological Application proposals present the methods and results of a real research study in which the technique was used. Methodological Illustration proposals provide a pedagogical illustration of when and how to use the technique; these papers are designed to help the audience be able to implement the technique themselves.

There are three different types of presentations: Paper sessions (in which authors submit a paper), Symposia (in which a group of authors submit a set of related talks/papers), and posters. Methodological Research paper proposals should be no longer than 1000 words and should include purpose, background, methods, results, discussion, and significance. Methodological Illustration paper proposals should be no longer than 1,000 words and should include a description of the methodology to be illustrated as well as an outline of the paper/talk. Proposals for symposia should be include titles, authors, an abstract for the symposium, and brief descriptions/abstracts for all of the paper presentations within the symposium. Symposium proposals may be longer than 1000 words if needed, but they should be less than 2000 words. Proposals for the poster session need only submit an abstract: the 1000 word proposal is ***not*** required for poster session proposals.

Proposals for the 2018 conference are due February 1st , 2018. Notifications of presentation status will be emailed by February 19th, 2018. For more information about the conference and to submit conference proposals, please visit http://www.modeling.uconn.edu/ .

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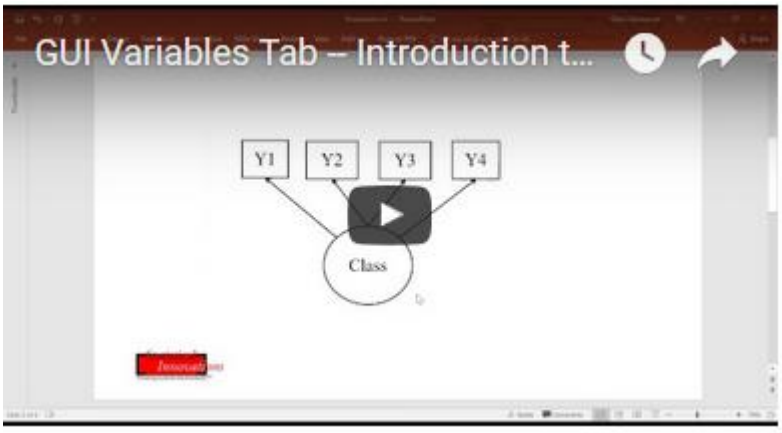

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