DND Longitudinal Analysis Training Seminar

Presenter: Simon Houle

Prerequisites. This seminar covers the basics of longitudinal analyses conducted within the Structural Equation Modelling (SEM) framework. To maximally benefit from this seminar, attendees should possess basic knowledge of statistical concepts of relevance to the SEM framework (e.g. Multiple Regression-MR, Confirmatory Factor Analysis-CFA, SEM, Model fit estimation, etc.). Although the majority of the content covered during this seminar is applicable to scale scores (or factor scores) rather than fully latent variables (except section two on measurement invariance), knowledge of SEM will greatly facilitate learning throughout this seminar. Moreover, basic familiarity with the statistical software M*plus* will help to maximally benefit from this seminar, as this software is the one that will be used in all practical examples provided throughout the seminar. This seminar will only be dealing with continuous variables using the Robust Maximum Likelihood (MLR) estimator. The course content will be delivered through a PowerPoint presentation, accompanied by M*Plus* syntax to demonstrate model estimation procedures. All of the course content (slides and M*Plus* syntax) will be provided free of charge to all participants and posted online on the website of Concordia's Substantive Methodological Synergy Research laboratory, and participants are encouraged to follow along on their laptops and take notes as they see fit.

- Knowledge of Structural Equation Modelling (MR, CFA, SEM)
- Knowledge of M*plus* statistical software

Overview

In the 21st century, data is often referred to as a commodity, synonymous to nothing less than money or gold, yet much less tangible than either. Contrary to popular belief, the worth of data does not come from how much of it one has, but rather, what can be learnt from that data that would otherwise have been impossible to know. More importantly, can the knowledge obtained via this data be used to guide decision-making processes in such a way as to provide a return on investment for the time and money spent collecting the data. The current seminar is designed to provide attendees with actionable knowledge pertaining to using longitudinal data, collected from psychometric measures, with the goal of improving employee well-being and organizational functioning over time. This seminar will broadly cover essentials of data collection for different types of longitudinal research questions, longitudinal measurement invariance of psychometric constructs, Autoregressive Cross-Lag Models, Latent Change Models, State-Trait Models, and Latent Curve Models. This seminar seeks to achieve a balance between theoretical and practical approaches to the collection and analyses of longitudinal data, with the goal of improving organizational practices through data driven recommendations to guide interventions. To this end, the seminar can be divided into four sections that will each be covered throughout the day: 1) Data collection; 2) Measurement Invariance; 3) Autoregressive Cross-Lag models and State-Trait Models; 4) Latent Change and Latent Curve models. At the bottom of each section is a list of recommended readings that may prove useful should anyone in attendance wish to go more in depth about any of the content covered during that section.

Section 1: Data Collection

Training: The goal of the first hour of the seminar will be to provide the various advantages of collecting longitudinal data concerning the richness of information it provides. Longitudinal data

allows for the direct identification of intra-individual change and stability, and inter-individual differences in intra-individual change and stability, as well as antecedents and outcomes of change and stability over time. It is also possible to monitor relations among variables over time to determine the strength and directionality of associations between them. As such, from the onset, there are many different paths to analyzing longitudinal data, and the selection of the appropriate path must be grounded in both theory and a deeper understanding of the passage of time in a research context. The first part of the training will be focused on familiarizing attendees with the different types of research questions that may be answered using longitudinal data and how to collect all the information that is needed to answer these questions.

Objectives: By the end of the first section, attendees should have a clear understanding of the importance of time as a critical and meaningful variable to take into account in every longitudinal study. Moreover, attendees will be trained on how to collect longitudinal data to monitor either the evolution of employees' responses to various psychological constructs over time (e.g. the course of employee fatigue over the work week), or the evolution of relations between constructs over time (e.g. the strength and directionality of association between employee fatigue and quality of sleep throughout the week).

Section 2: Measurement Invariance

Training. This section is the only section that is not applicable or useful for the analysis of scale scores. Tests of measurement invariance are an integral part of longitudinal analyses within the SEM framework in that they ensure that the measurement of constructs remains the same over time. That is, a construct that is estimated as the shared variance amongst a series of inter-related questions must display an equivalent pattern of responses across time to ensure that the meaning of the construct does not change, which would result in the construct losing its interpretability.

Attendees will be trained to conceptually understand and conduct tests of longitudinal measurement invariance using a well-recognized sequence of six tests (Millsap, 2011). These tests are conducted in the following sequence: (i) configural invariance (same model, including the same number of factors, with no additional constraint), (ii) weak invariance (same factor loadings), (iii) strong invariance (same factor loadings and items intercepts), (iv) strict invariance (same factor loadings, items intercepts, and items uniquenesses), (v) invariance of the latent variances and covariances; (vi) latent mean invariance.

Objectives. By the end of this section, attendees will be able to understand the conceptual and theoretical implications of longitudinal invariance testing. Moreover, examples and syntax will be provided as to ensure that attendees have everything they need to conduct these tests.

References

Marsh, H. W. (2007). Application of confirmatory factor analysis and structural equation modeling in sport/exercise psychology. In G. Tenenbaum & R. C. Eklund (Eds.), *Handbook of sport psychology* (pp. 774–798). New York, NY: Wiley.

Millsap, R.E. (2011). *Statistical approaches to measurement invariance*. New York: Taylor & Francis.

Morin, A.J.S., & Maïano, C. (2011). Cross-validation of the very short form of the Physical Self-Inventory (PSI-VS): Invariance across genders, age groups, ethnicities and weight statuses. *Body Image*, *8*, 404-410.

Zhang, X., Noor, R., & Savalei, V. (2016). Examining the effect of reverse worded items on the factor structure of the need for cognition scale. *PloS one*, *11*, e0157795.

Section 3: Autoregressive Cross-Lag Models and State-Trait Models

Training. Autoregressive cross-lagged models allow one to estimate the stability/instability of autoregressive and cross-lagged parameters between adjacent measurement points over time. They model the influence of “states” on later “states”. Understanding autoregressive cross-lagged models requires knowledge about the model intercept, autoregressive parameters, and cross-lagged parameters in order to model the strength of association between constructs while controlling for their initial levels. These longitudinal models can be implemented using only two

time points and are useful to test for the stability of constructs and their relations with other constructs over time (e.g. fatigue and quality of sleep). Measuring stability requires extending invariance testing to tests of predictive invariance, which will be covered in this section. State-Trait models are an extension of autoregressive cross-lagged models allowing to achieve a disaggregation of traits (stable levels on the variables of interest over time) and states (time-related deviations from the trait) and to test associations occurring at both levels.

Objectives. By the end of this section, attendees will be able to understand the types of research questions that can be answered using autoregressive cross-lagged models and state-trait models and how to use these models in practice. Moreover, examples of autoregressive cross-lagged and state-trait models and the accompanying syntax for M*Plus* will be provided to ensure that attendees have all the information and resources needed to conduct these analyses on their own data.

References

Cole, D.A., Martin, N.C., & Steiger, J.H. (2005). Empirical and conceptual problems with longitudinal trait-state- models: Introducing a trait-state-occasion model. *Psychological Methods*, *10*, 3-20.

Cole, D. A., & Maxwell, S. E. (2003). Testing meditational models with longitudinal data: Questions and tips in the use of structural equation modeling. *Journal of Abnormal Psychology*, *112*, 558–577.

Maxwell, S. E., & Cole, D. A. (2007). Bias in cross-sectional analyses of longitudinal mediation. *Psychological Methods*, *12*, 23–44.

Morin, A.J.S., Arens, A.K., Maïano, C., Ciarrochi, J., Tracey, D., Parker, P.D., & Craven, R.G. (2017). Reciprocal Relationships between Teacher Ratings of Internalizing and Externalizing Behaviors in Adolescents with Different Levels of Cognitive Abilities. *Journal of Youth and Adolescence*, *46*, 801-825.

Morin, A.J.S., Meyer, J.P., Bélanger, É., Boudrias, J.-S., Gagné, M., & Parker, P.D. (2016). Longitudinal associations between employees' perceptions of the quality of the change management process, affective commitment to change and psychological empowerment. *Human Relations*, *69*(3), 839-867. DOI: 10.1177/0018726715602046

Selig, J.P. & Preacher, K.J. (2009). Mediation models for longitudinal data in developmental research. *Research in Human Development*, *6*, 144-164.

Steyer, R., Schmitt, M., & Eid, M. (1999). Latent State-Trait theory and research in personality and individual differences. *European Journal of Personality*, *13*, 389-408.

Section 4: Latent Change Models and Latent Curve Models

Training. Autoregressive cross-lagged models are useful to monitor the influence of states on future states. State-Trait models extend these models to provide a way to disaggregate trait-level processes from state-level processes. However, these models both suffer from a key limitation stemming from their inability to study change occurring over time at the trait level. A solution to this limitation is provided by Latent Change Models and Latent Curve Models. In particular, Latent Curve Models allow one to synthesize individual trajectories using a few latent parameters through a restricted factor model that provides an average starting point (i.e. intercept) and trajectory (i.e. slope) for the entire sample. Latent Curve Models allow for a variety of non-linear parameterizations (e.g. quadratic, piecewise, multibase) to adequately reflect different types of trajectories. Attendees will be taught how to use Latent Curve Models to monitor inter-individual differences in intra-individual change and stability across a variety of important work-related outcomes such as employee commitment and well-being. A core practical limitation of Latent Curve model, however, is related to the fact that their estimation requires three or more measurement points. Latent Change Models can then come to our rescue, providing a way to assess change occurring over time at the trait level with only two time points. An example will be utilised to demonstrate different types of Latent Curve Models and Latent Change Models, and syntax will be provided covering different types of trajectories.

Objectives. By the end of this section, attendees should have a clear understanding of the different types of research questions that can be answered using Latent Curve Models and Latent Change Models to monitor how employees evolve over time on a series of important work-related constructs. The objective is for attendees to feel comfortable conducting Latent Curve Models and knowing where to look to solve any issues they may encounter.

References

Biesanz, J.C., Deeb-Soosa, N., Papadakis, A.A., Bollen, K.A., & Curran, P.J. (2004). The role of coding time in estimating and interpreting growth curve models. *Psychological Methods, 9*, 30–52.

Grimm, K.J., & Ram, N. (2009). Nonlinear growth models in Mplusand SAS. *Structural Equation Modeling*, *16*, 676-701.

Hancock, G.R., Harring, J.R., & Lawrence, F.R. (2013). Using latent growth modeling to evaluate longitudinal change. In G. R. Hancock & R. O. Mueller (Eds), *Structural Equation Modeling: A Second Course*, *2nd edition* (pp. 309-342). Greenwich, CO: IAP.

Mehta, P. D., & West, S. G. (2000). Putting the individual back into individual growth curves. *Psychological Methods, 5*, 23–43.

Preacher, K.J., & Hancock, G.R. (2015). Meaningful aspects of change as novel random coefficients: A general method for reparametrizing longitudinal models. *Psychological Methods*, *20*, 84-101.

Ram, N., & Grimm, K. (2007). Using simple and complex growth models to articulate developmental change: Matching theory to method. International Journal of Behavioral Development, 31, 303-316.

Wu, W., Selig, J.P., & Little, T.D. (2013). Longitudinal Data analysis. In T.D. Little (Ed.) *The Oxford Handbook of Quantitative Methods in Psychology*, *Volume 2*(pp. 387-410). New York: Oxford University Press.

Logistics

Where: Virtual via the O365 platform

Room: Webinars

Date: Tuesday, June 9th, 2020

Equipment: None

Cost: This seminar comes at no cost to the DND. I am providing this seminar as an equivalence to taking a graduate-level course worth 3 credits towards my doctorate degree. Both my supervisor and the head of the psychology graduate program at Concordia University (Dr. Andrew Chapman) have agreed that this one-day seminar, paired with my work accompanying one of the DND's articles through to publication (i.e. the autoregressive cross-lagged model of fatigue and quality of sleep), is worth the equivalent of a 3-credit course.

Schedule for June 9th:

8:30-9:30: Data Collection

9:30-10:30: Longitudinal Measurement Invariance (15-minute break at 10pm)

10:30-12:00: Autoregressive Cross Lag model and State-Trait Models

Schedule for June 16th:

8:30-9:30: Latent change models

9:30-10:00: Cross-sectional applications of latent change models

10:00-10:15: Break

10:15-12:00: Latent Curve Models

Background and Credentials:

As early as my first semester of graduate school, I became a teaching assistant (TA) for the undergraduate *Statistical Analysis 1* class, while also taking the *Statistical Analysis & Experimental Design* course, offered by Dr. Rex Kline, and required of all psychology graduate students. In my second semester, I completed the more advanced *Multivariate Statistics* (Latent Variable Modelling) graduate level course offered by Dr. Alexandre Morin (this class covers all of the content of the current proposition, and more), while continuing to TA for the undergraduate *Statistical Analysis 1* class. In my second year, I became a TA for Dr. Kline's *Statistical Analysis & Experimental Design* class, and was asked to repeat this TAship in my first year PhD. I am also currently a TA for Dr. Morin's *Multivariate Statistics* class, thus solidifying my teaching experience to graduate students. Teaching graduate students required me to dedicate a significant portion of my time to training in communication of statistical methods across a broad range of psychological domains, while staying true to statistical theory. This experience led me to become involved in the supervision of two Honours students (2018-2019, and 2019-2020) as well as one research intern (2019), in addition to collaborating with other lab members (visitors, postdoc, graduates). Interestingly, the research conducted by two of these students relies on Latent Curve Models, and my role is to guide and assist them through this analysis, which was particularly challenging considering that neither of the students had any experience with structural equation models prior to their work in the Substantive Methodological Synergy research laboratory. Moreover, I am in the process of completing my second internship for the Canadian Department of National Defense, where I am primarily tasked with assisting DND personnel with advanced statistical analyses (e.g. Autoregressive Cross-Lagged model; Latent Profile Analyses; Exploratory Structural Equation Modelling) and reporting the results in a fashion intended for publication in a scientific journal. Finally, my own master thesis relied on

longitudinal data analyses, combining longitudinal tests of measurement invariance, latent profile analyses, and latent transition analyses. My current Ph.D. thesis goes further, focusing on growth mixture models (a combination of latent curve models and latent profile analyses).

It is important to note that the content provided in this seminar overlaps with some sections of the *Multivariate Statistics* class taught by Dr. Morin, which I have already taken (with a final grade of A+) and in which I am currently TA. Dr. Morin and I have also reviewed the feasibility of covering this broad range of topics in a single day, and believe it to be possible by limiting the seminar to the analysis of continuous variables only. Introducing categorical variables can take an entire training on its own. Dr. Morin has also revised the current document, will review my training material, and has provided and will continue to provide feedback when necessary.