Contribution ID: **207** Type: **Oral Presentation**

Residual Dynamic Structural Equation Modeling for Analyzing Interindividual Variability in Intensive Data from Factorial Experiments

Thursday 24 July 2025 11:00 (15 minutes)

Oral presentation

Residual Dynamic Structural Equation Modeling for Analyzing Interindividual Variability in Intensive Data from Factorial Experiments

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Abstract

Introduction. The collection of intensive longitudinal data in experimental factorial designs has become more common in social and behavioral sciences. This creates the need for more advanced analytical methods that can model complex within-person processes and between-person differences. Residual Dynamic Structural Equation Modeling (RDSEM) provides a strong framework by combining multilevel, time-series, and latent variable modeling, which is estimated using Bayesian methods. RDSEM allows for interindividual differences in custom contrasts, dynamic autoregressive processes, and explains interindividual differences interindividual variability by modeling within residual variance as a function of covariates, rendering RDSEM a useful method for analyzing experimental data. This presentation demonstrates the application of RDSEM to an intensive eye-tracking dataset, showing its advantages in analyzing fine-grained longitudinal experimental data.

Methods and Results. We used RDSEM to analyze eye-tracking data from a reading 2x3 within-subject experiment with children, investigating the development of reading efficiency in elementary school. The outcome was reading time at a word level. Custom contrasts were used to specify reading efficiency as differences in reading time between experimental conditions. We estimated and compared three models: ANOVA, which aggregated data within conditions to estimate average effects and interindividual variability in contrasts; LMM, which accounted for within- and between-person as well as time-varying covariates, but lacked interindividual differences in residual variances; and RDSEM, which included time-varying covariates such as landing position within words, modeled autoregressive effects between residuals, interindividual differences in autoregressive effects, and allowed within residual variance to be predicted by time-invariant covariates.
The results showed that RDSEM detected a significant autoregressive effect, meaning that viewing times for words were influenced by the difficulty of previous words. The inclusion of time-varying covariates showed that landing position was an important predictor of word reading time, confirming prior findings on skilled reading patterns. The model also showed that reading difficulties of children (RD) strongly predicted the within residual variance, meaning that children with RD had larger fluctuations in their residual variability over trials. Lastly, unlike LMM, RDSEM also made it possible to estimate random effects in residual variances and autoregressive effects, further explaining interindividual differences.

Discussion and Conclusion. The findings confirm that RDSEM is a valuable tool for modeling experimental factorial designs with intensive repeated measurements. RDSEM is particularly useful because it models dynamic within-person processes while also capturing interindividual differences in within residual variance and autoregressive effects. The ability to model within residual variance as a function of covariates provides a better understanding of variability in reading efficiency.

Keywords

DSEM; intensive data; interindividual differences

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Session Classification: Session 4 : "Structural equation models and model evaluation"

Track Classification: Statistical analyses: Statistical analyses