semnova: An R Package for Investigating Interindividual Differences in Experimental Effects on Latent Variables

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Affiliation

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Abstract

Introduction. Interindividual differences are a fundamental aspect of experimental research, yet many statistical methods primarily focus on estimating average effects, overlooking the variability in how individuals respond to experimental manipulations. Understanding these differences is essential for psychological and behavioral research, as it provides insights into the diverse ways individuals interact with experimental conditions. However, traditional statistical methods impose restrictive assumptions like sphericity, limiting their ability to account for individual variability and measurement error. To address these limitations, we introduce semnova, an R package designed to model interindividual differences in experimental effects using latent variables. By extending structural equation modeling (SEM), semnova provides a flexible framework that determines both mean effects and their variances, enabling a more comprehensive analysis of experimental data.

Methods and Results. semnova builds on the latent growth components approach, which can be used to model experimental effects as growth components using a customized contrast matrix. This approach allows researchers to estimate within- and between-subject interactions while simultaneously accounting for measurement error. A key feature of semnova is its ability to estimate not only mean effects but also their variability. This also facilitates the examination of how individual characteristics moderate effects of experimental manipulations. Furthermore, semnova supports a multi-group framework with stochastic group sizes and variance heterogeneity, making it applicable across diverse experimental designs. Full information maximum likelihood for handling missing data and robust estimators for dealing with non-normality are readily available.
To illustrate its capabilities, we apply semnova to a longitudinal study on children's reading efficiency, tracking their development from grade one to grade four. The dataset includes eye-tracking measures such as fixation duration, re-fixation time and total viewing duration. semnova is used to estimate latent growth trajectories and analyze the impact of experimental conditions, such as sentence type (regular vs. Landolt sentences) and dyslexia status, on reading efficiency. The model specification incorporates user-defined contrast matrices to capture complex interaction effects and includes latent variables to account for measurement error. Additionally, the method supports the examination of measurement invariance across different participant groups, ensuring that the observed effects are not confounded by structural differences in data measurement.

Discussion and Conclusion. Beyond longitudinal designs, semnova can be applied in various experimental paradigms, including ecological momentary assessment studies, where interventions are administered repeatedly over time. By bridging traditional experimental designs with modern SEM-based techniques, semnova empowers researchers with a robust and flexible tool to investigate individual differences in experimental effects. Future developments will further expand its functionality, enhancing its applicability in experimental psychology and related fields. The ability to assess sphericity violations, model latent growth trajectories and capture interindividual variability allows semnova to offer deeper insights into the mechanisms underlying experimental effects, making it a valuable resource for researchers seeking a more refined approach to statistical modeling.

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