Using Latent State-Trait Theory to Analyze Intensive Longitudinal Data

By Sebastian Castro-Alvarez, dr. Jorge Tendeiro, prof. dr. Rob Meijer, dr. Laura F. Bringmann,
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States and Traits

States

Traits
States and Traits

States

Variability

Within

Situational

Traits
States and Traits

States
- Situational
- Anxiety
- Variability
- Mood
- Within

Traits
States and Traits

States
- Variability
- Mood

Traits
- Person’s Disposition
- Stability

Situational
- Anxiety

Within
- Between
States and Traits

States
- Variability
- Mood
  - Within

Traits
- Situational
- Anxiety
- Between
- Intelligence
- Person’s Disposition
- Neuroticism
- Stability
- Traits
States and Traits

States

Mood

Anxiety

Intelligence

Traits

Neuroticism
States and Traits

States

Mood
Anxiety
Neuroticism
Intelligence

Traits
Latent State-Trait Theory (LST)
Longitudinal SEM
Latent State-Trait Theory (LST)
Measurement Error
Latent State-Trait Theory
Latent State-Trait Theory
Latent State-Trait Theory
Latent State-Trait Theory
Latent State-Trait Theory

Total Variance of $Y_{ij}$
Latent State-Trait Theory

Total Variance of $Y_{ij}$

- Reliability
- Measurement Error
Latent State-Trait Theory

Total Variance of $Y_{ij}$

Reliability
Latent State-Trait Theory

Total Variance of $Y_{ij}$

- Consistency
- Occasion Specificity

Theory
Intensive Longitudinal Data
Intensive Longitudinal Data

Context Matters!
Intensive Longitudinal Data

Positive Emotions
Negative Emotions
Tension

Day

Context Matters!
Can We Study States and Traits with Intensive Longitudinal Data?
Are We Studying States and Traits with Intensive Longitudinal Data?
Are We Studying States and Traits with Intensive Longitudinal Data?
Multilevel Analysis

Dynamic SEM

Multilevel - (Vector) Autoregressive

Time Series Analyses

Are We Studying States and Traits with Intensive Longitudinal Data?

States = Within Variation

Traits = Between Variation
Are We Studying States and Traits with Intensive Longitudinal Data?

LST?

States = Within Variation

Traits = Between Variation
LST and Intensive Longitudinal Data

Multistate-singletrait (MSST)  

States and Traits
LST and Intensive Longitudinal Data

States and Traits

Common-Unique Trait-State (CUTS)
LST and Intensive Longitudinal Data

States and Traits

Autoregressive Effect

Trait-State-State-Occasion (TSO)
LST and Intensive Longitudinal Data

Multistate-singletrait (MSST)

Common-Unique Trait-State (CUTS)

Trait-State-Occasion (TSO)
LST and Intensive Longitudinal Data

Multistate-singletrait (MSST)

Common-Unique Trait-State (CUTS)

Trait-State-Occasion (TSO)

Multilevel SEM
Multistate-Singletrait (MSST)
Multistate-Singletrait (MSST)
Multistate-Singletrait (MSST)
Multistate-Singletrait (MSST)
Common-Unique Trait-State (CUTS)
Common-Unique Trait-State (CUTS)
Trait-State-Occasion (TSO)
Trait-State-Occasion (TSO)

**Within Model**

- $O_t$ to $Y_1$, $Y_2$, $Y_3$ via $\lambda_s$
- $O_{t-1}$ to $Y_2$, $Y_3$ via $\lambda_s$
- $Y_1$ to $\varepsilon_1$
- $Y_2$ to $\varepsilon_2$
- $Y_3$ to $\varepsilon_3$

**Between Model**

- $Y_1$ to $\xi_1$
- $Y_2$ to $\xi_2$
- $Y_3$ to $\xi_3$
Simulation Study

When is the multilevel version preferable over the single level version?
Simulation Study

When is the multilevel version preferable over the single level version?

Are these models suitable to analyze intensive longitudinal data?
Simulation Study

Base Model

MSST

CUTS

TSO
Simulation Study

Base Model | Number of Measurements
--- | ---
MSST | 30
CUTS | 60
TSO | 90
Simulation Study

Base Model | Number of Measurements | Proportion of Missing Values
---|---|---
MSST | 30 | 0%
CUTS | 60 | 10%
TSO | 90 |
## Simulation Study

### Base Model

<table>
<thead>
<tr>
<th>Number of Measurements</th>
<th>MLE</th>
<th>BAYES</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSST</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ML-MSST</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>CUTS</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ML-CUTS</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>TSO</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>ML-TSO</td>
<td>x</td>
<td>✓</td>
</tr>
</tbody>
</table>
# Simulation Study

## Base Model

<table>
<thead>
<tr>
<th>Number of Measurements</th>
<th>Base Model</th>
<th>MLE</th>
<th>BAYES</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>✅</td>
<td>✅</td>
</tr>
</tbody>
</table>

## Proportion of Missing Values

<table>
<thead>
<tr>
<th>Proportion of Missing Values</th>
<th>MLE</th>
<th>BAYES</th>
</tr>
</thead>
<tbody>
<tr>
<td>X100</td>
<td>✅</td>
<td>✅</td>
</tr>
</tbody>
</table>
Number Successful Analyses

![Graph showing successful analyses for MSST, Cuts, and TSO models.](image-url)
Number Successful Analyses
Number Successful Analyses

Timeout
Number Successful Analyses

Timeout
Errors
Improper Solutions
Number Successful Analyses

![Graph showing the number of successful analyses for different models and measurement times.](chart.png)
Number Successful Analyses

![Graph showing successful analyses for MSST, Model Cuts, and TSO across different measurement times and percentage of missingness. The graph compares different methods: Wide, Long, MLE, and Bayes.]
Number Successful Analyses

MSST  |  Model  | TSO

Number of Successful Analyses

Number of Measurement Times x Percentage of Missingness

Wide  |  Long  | MLE  | Bayes
Accuracy

BIAS

AbBIAS

RMSE
Accuracy

BIAS

AbBIAS

RMSE
Accuracy

BIAS

AbBIAS

RMSE
Accuracy

Number of Measurement Times vs. Bias Consistency Y3
- MSST
- CUTS
- TSO

Number of Measurement Times vs. Bias Specificity Y3
- MSST
- CUTS
- TSO

Percentage of Missingness
- Wide
- Long
- MLE
- Bayes
Accuracy
Conclusions

If model converges, Multilevel LST = Single-level LST.
Conclusions

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Single-level LST is time consuming and can fail when the number of measurements increases.
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Single-level LST is time consuming and can fail when the number of measurements increases.

The TSO seems robust and should be used to study states and traits in intensive longitudinal data.
Conceptual Conclusions

ML-(V)AR with measurement error (Schuurman & Hamaker, 2018) \(\approx\) TSO model with one indicator.
Conceptual Conclusions

ML-(V)AR with measurement error (Schuurman & Hamaker, 2018) ≈ TSO model with one indicator.

These models can be easily extended within the DSEM framework.
Thank you