Latent Markov Factor Analysis for Exploring Measurement Model Changes in Time-Intensive Longitudinal Studies

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Content

- **ESM**: Opportunities and methodological challenge
- **Latent Markov factor analysis** (LMFA)
- **Simulation**: Performance of LMFA
- **Application**: Adolescents' affect ratings in different contexts

Opportunities

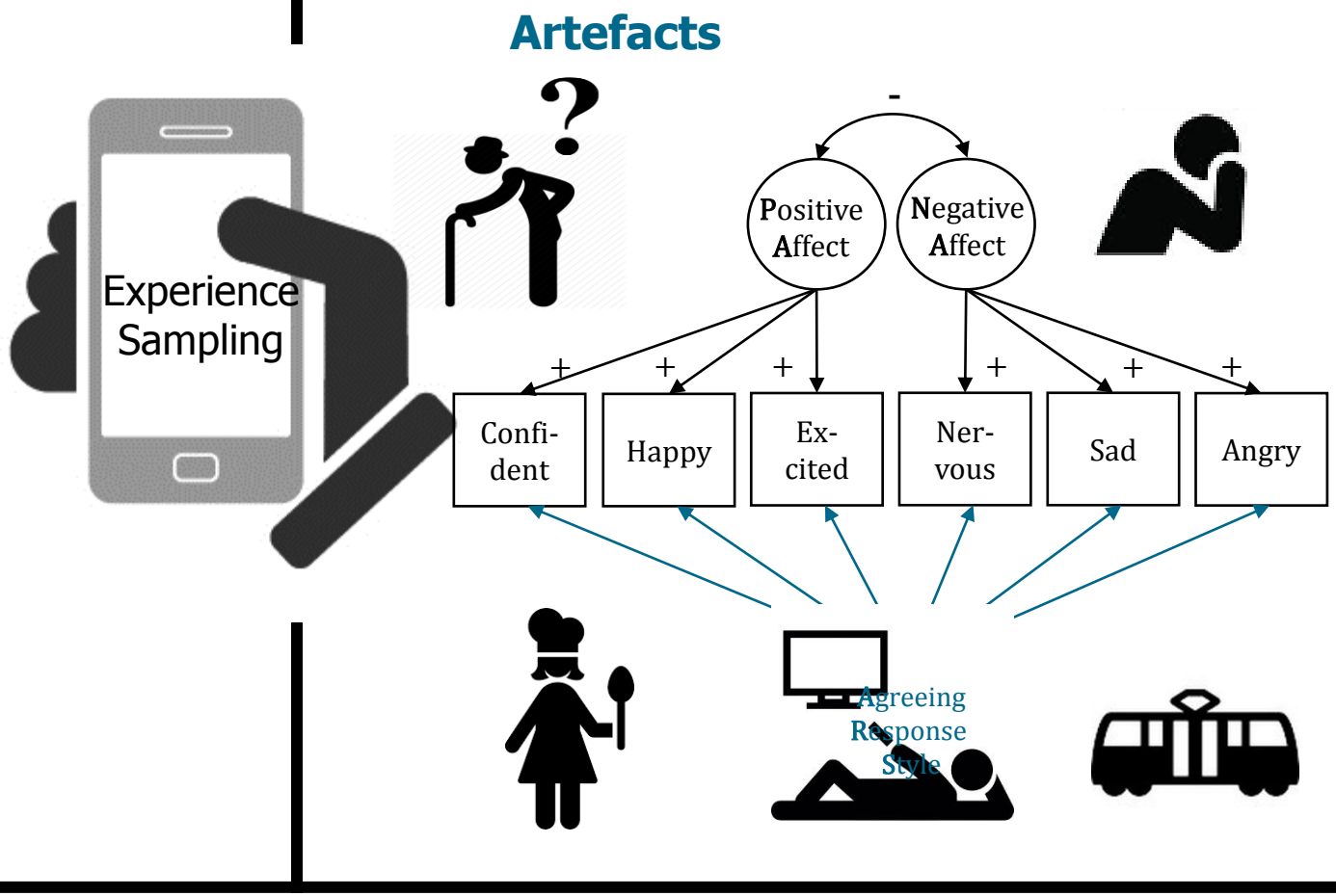
measure psychological 'constructs' in daily life

ecologically valid data

many subjects/many time points

personalized life-style advice/therapy

Challenge





Within Person

Ignoring

→ **Misinterpreting changes in item scores as increase in e.g., NA**

→ **No Measurement Invariance**

Opportunities

measure psychological 'constructs' in daily life

ecologically valid data

many subjects/many time points

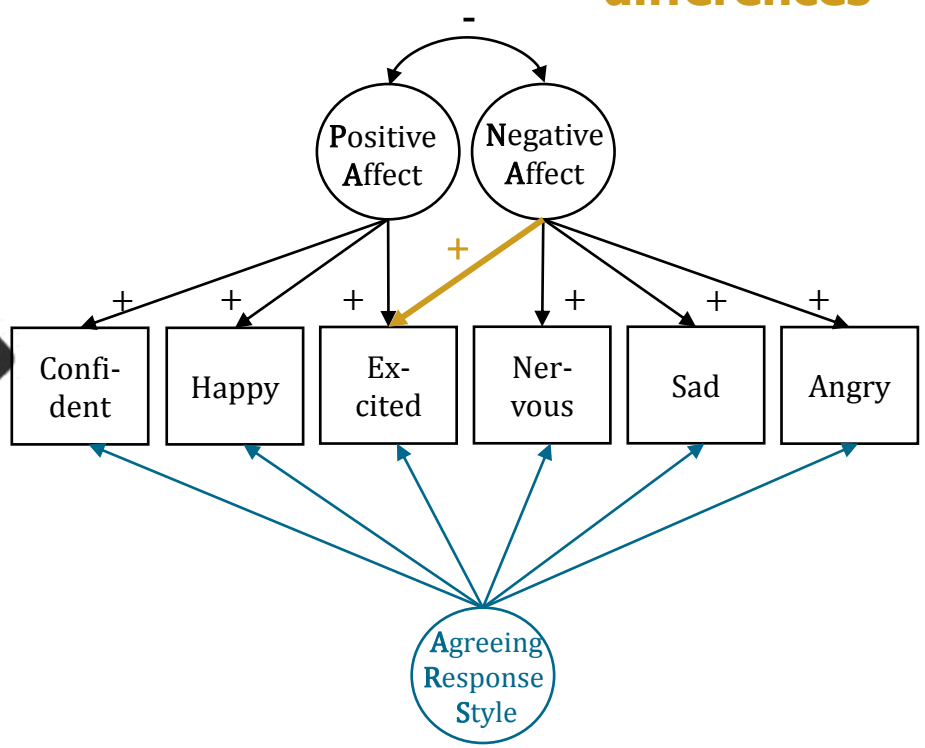
personalized life-style advice/therapy



Challenge

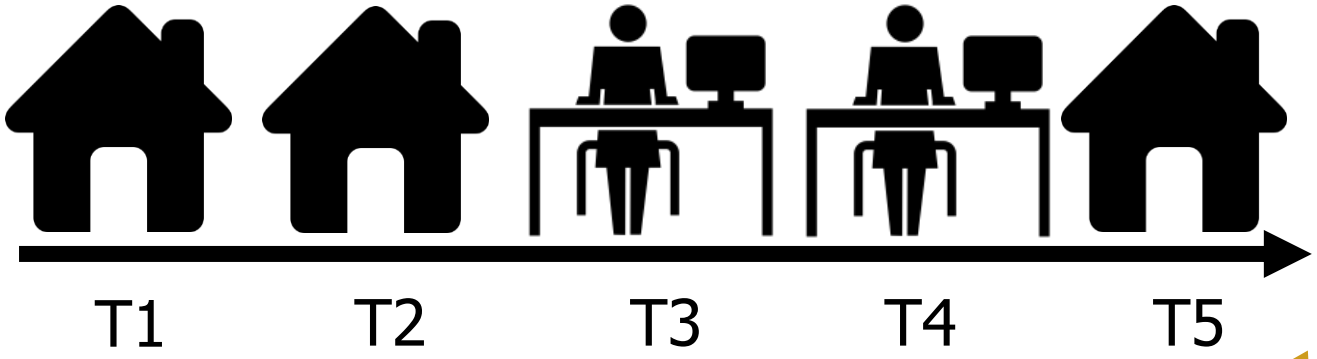
Artefacts

Substantive differences



Substantive differences

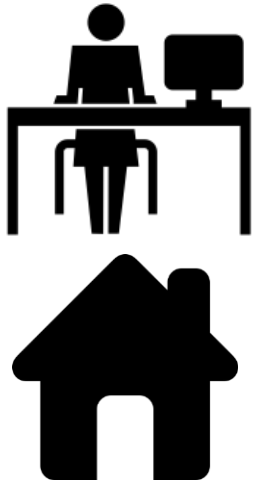


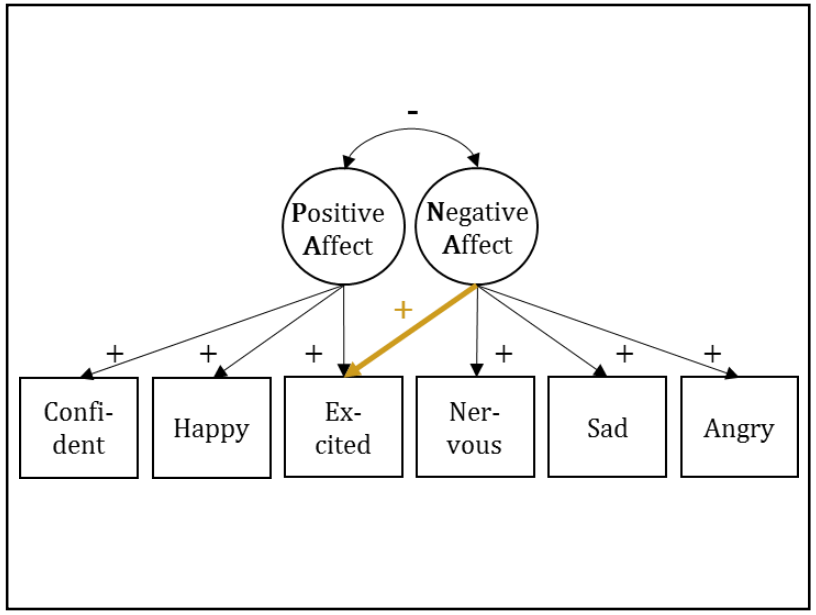


Ignoring

→ **Think your emotions are stable although PA is higher at home**

Context





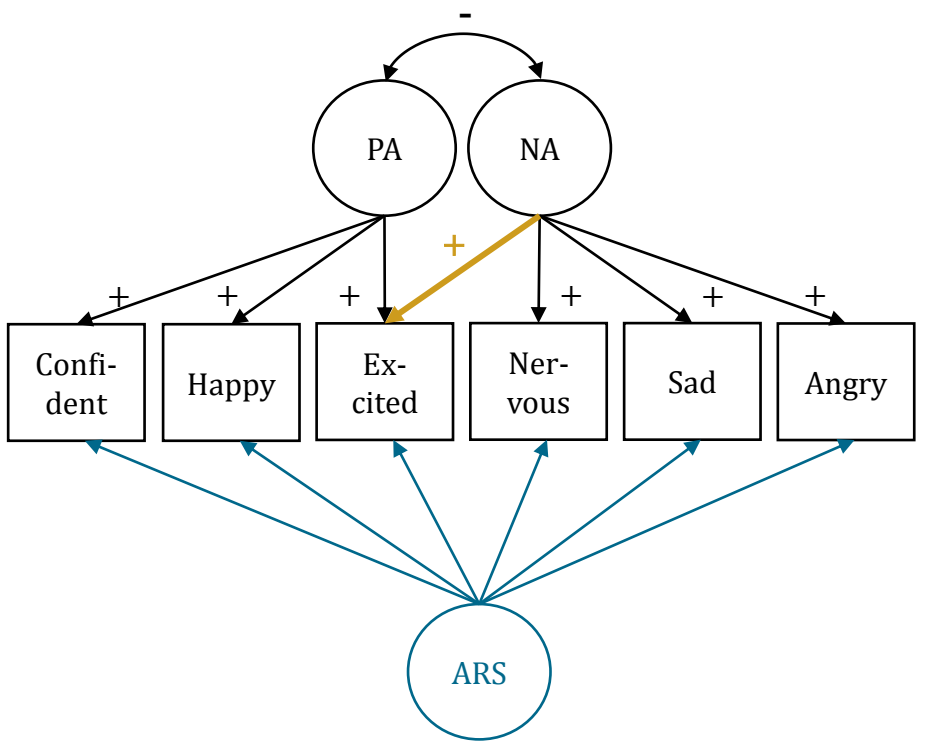
Switch between different MMs

Existing methods

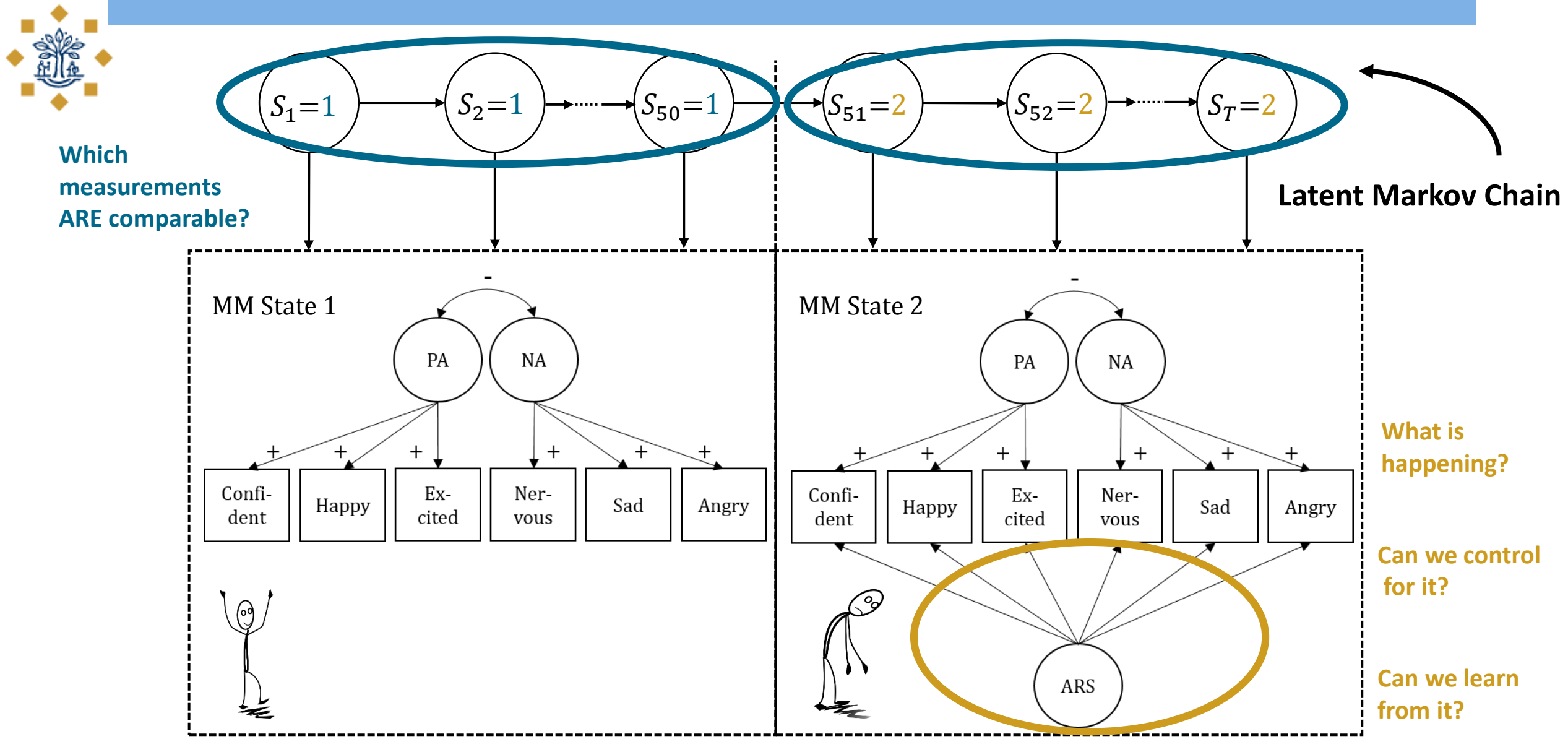
Measurement invariance: Yes or No ?

→ No MI: No insight

- **for which subjects?**
- **for which time-points?**
- **No pinpointing**



Structure Assumed (confirmatory)


Which measurements ARE comparable?
$S_1=1$
$S_2=1$
$S_{50}=1$
$S_{51}=2$
$S_{52}=2$
$S_T=2$
Latent Markov Chain
MM State 1
MM State 2
PA
NA
Confi-dent
Happy
Ex-cited
Ner-vous
Sad
Angry
ARS
What is happening?
Can we control for it?
Can we learn from it?

Building blocks of Latent Markov Factor Analysis

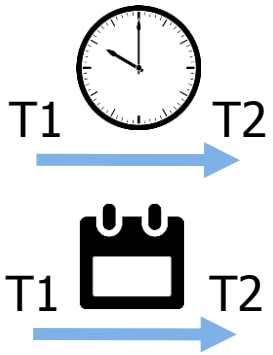
1) Latent Markov Model: A latent class model that allows for transitions

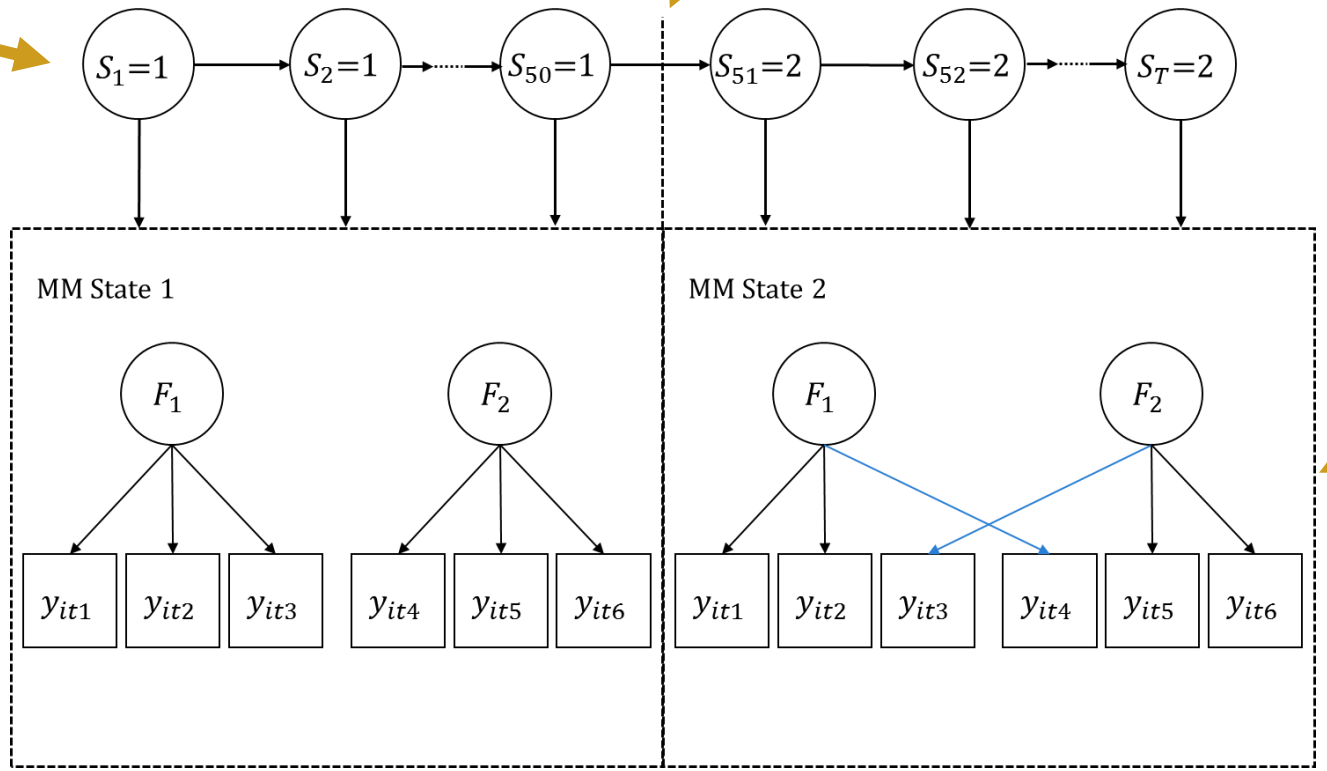
initial state probability

$$\pi = (1/3, 1/3, 1/3)$$

transition probability

$$P = \begin{bmatrix} 0.97 & 0.03 \\ 0.02 & 0.98 \end{bmatrix}$$



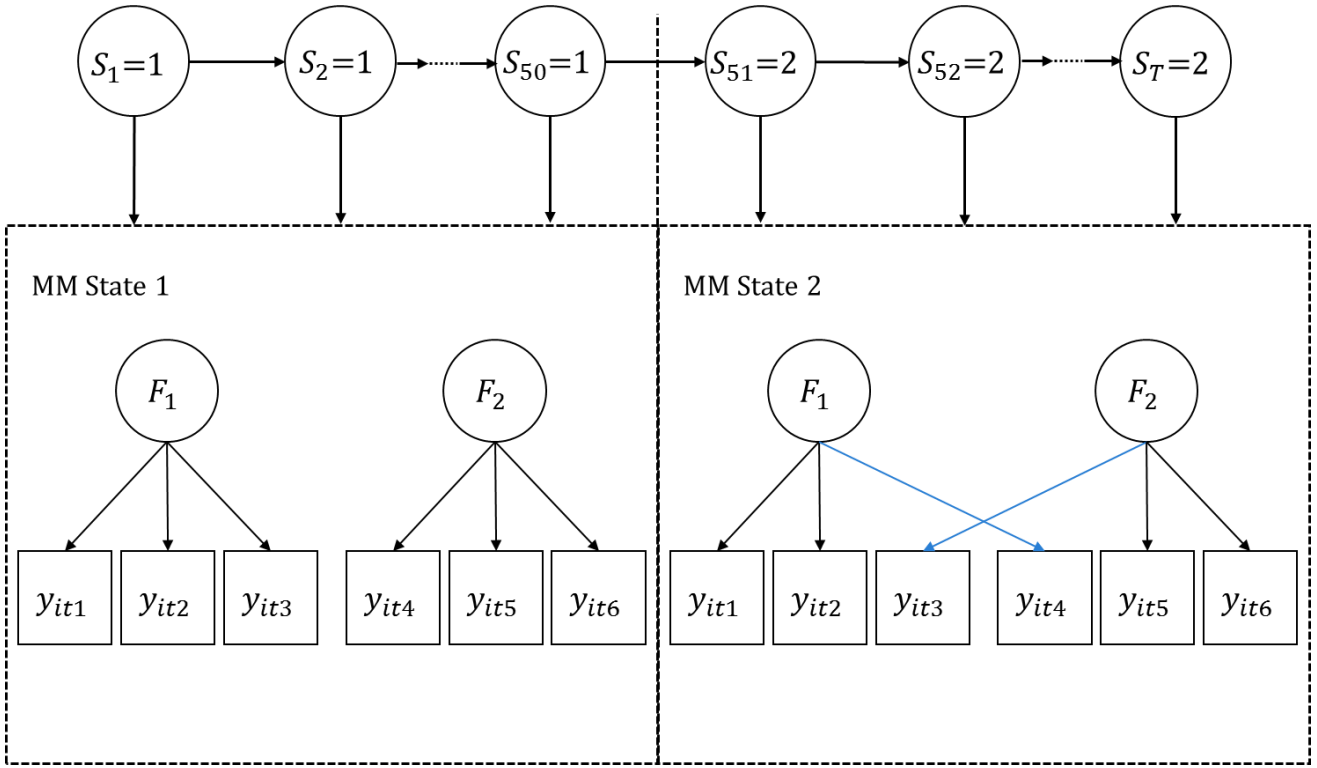


2) Factor analysis per state

observations defined by

- multivariate Gaussian mixture models depending on states
- a state-specific intercept vector θ_s
- a state-specific covariance matrix Σ_s

Simulation Study:
How well does latent Markov factor analysis perform in recovering states and factor loadings?



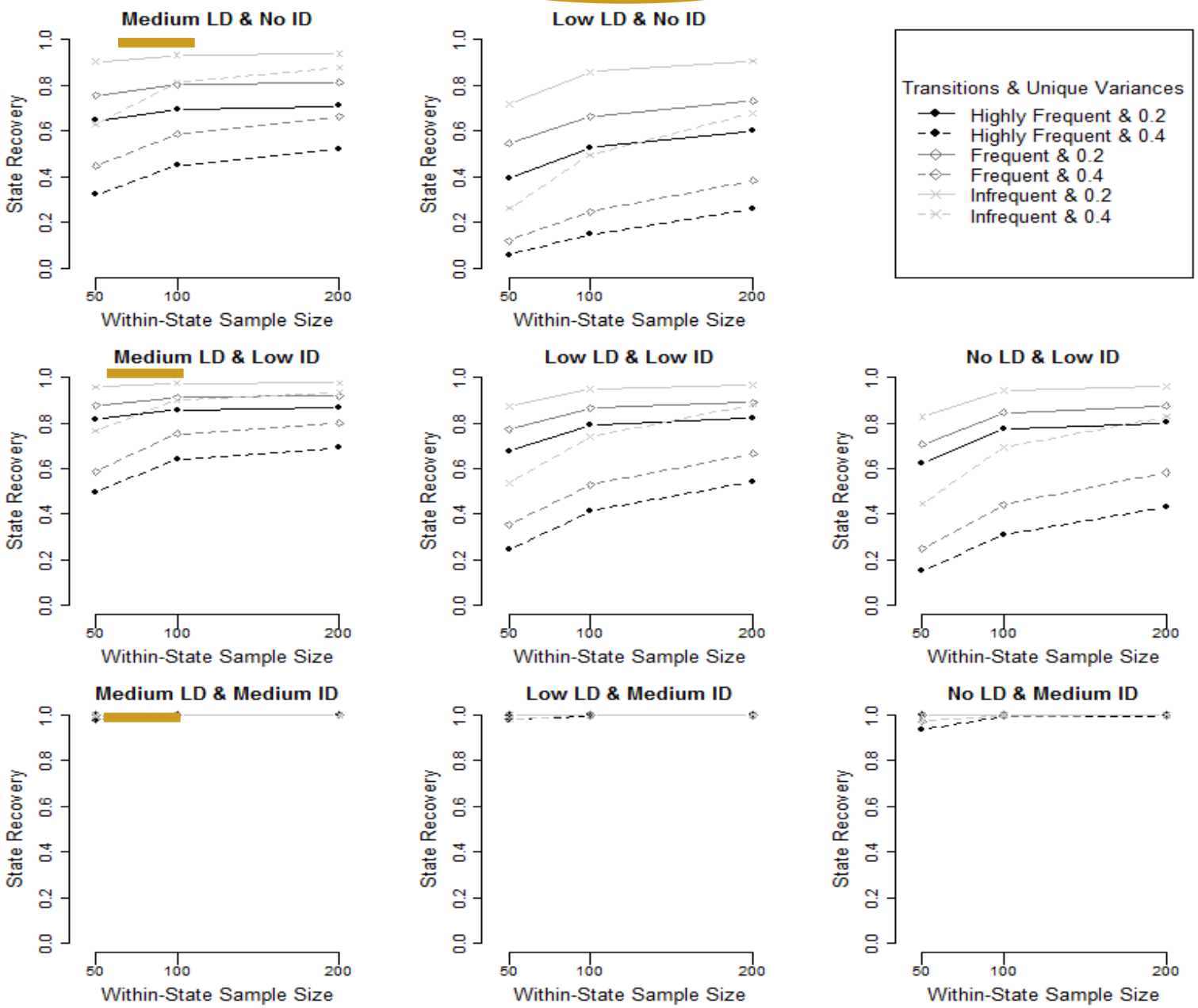
LATENT GOLD

Vermunt & Magidson (2013)

Loading Difference

Y-Axis: *ARI*

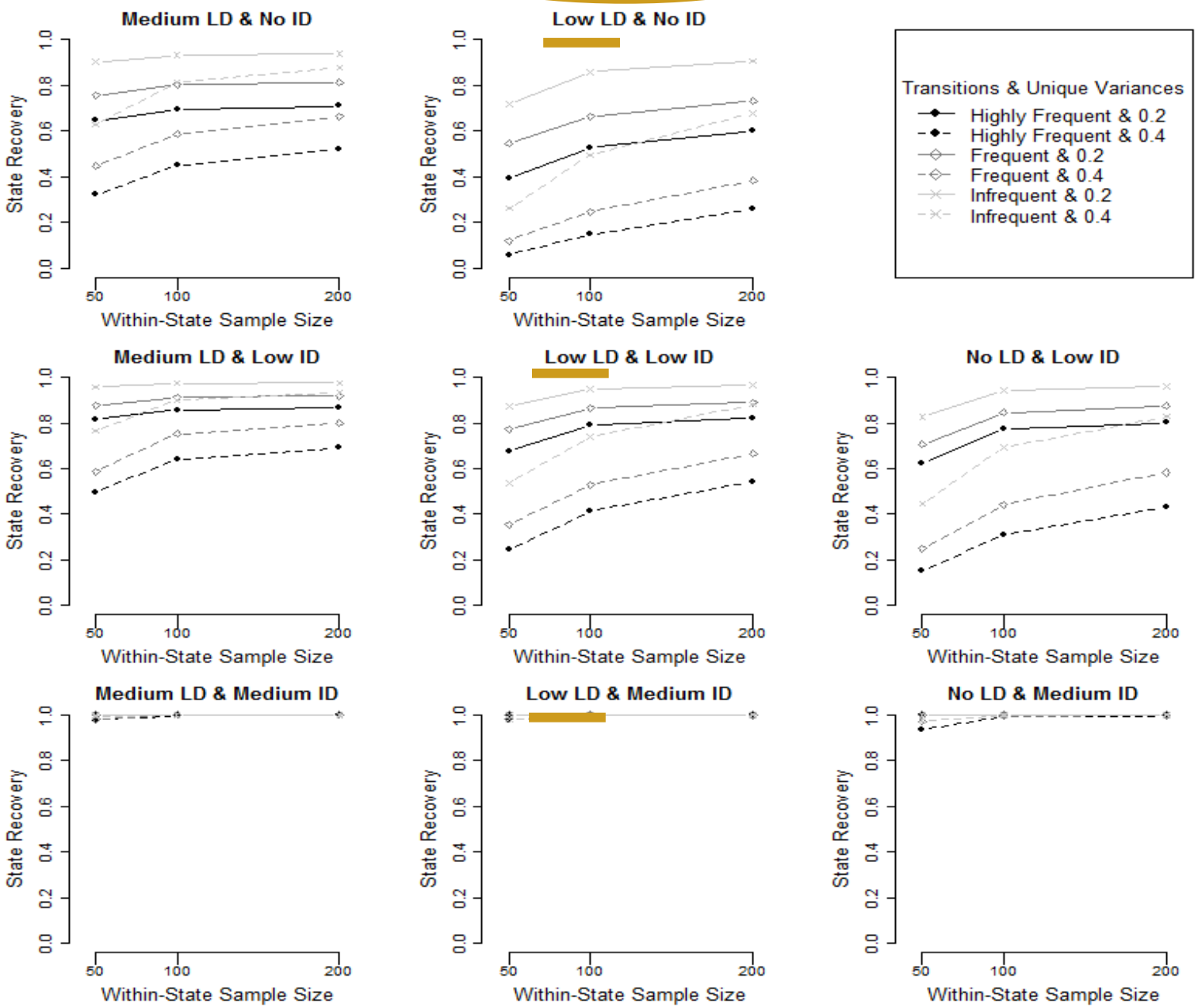
Intercept Difference



Loading Difference

Y-Axis: *ARI*

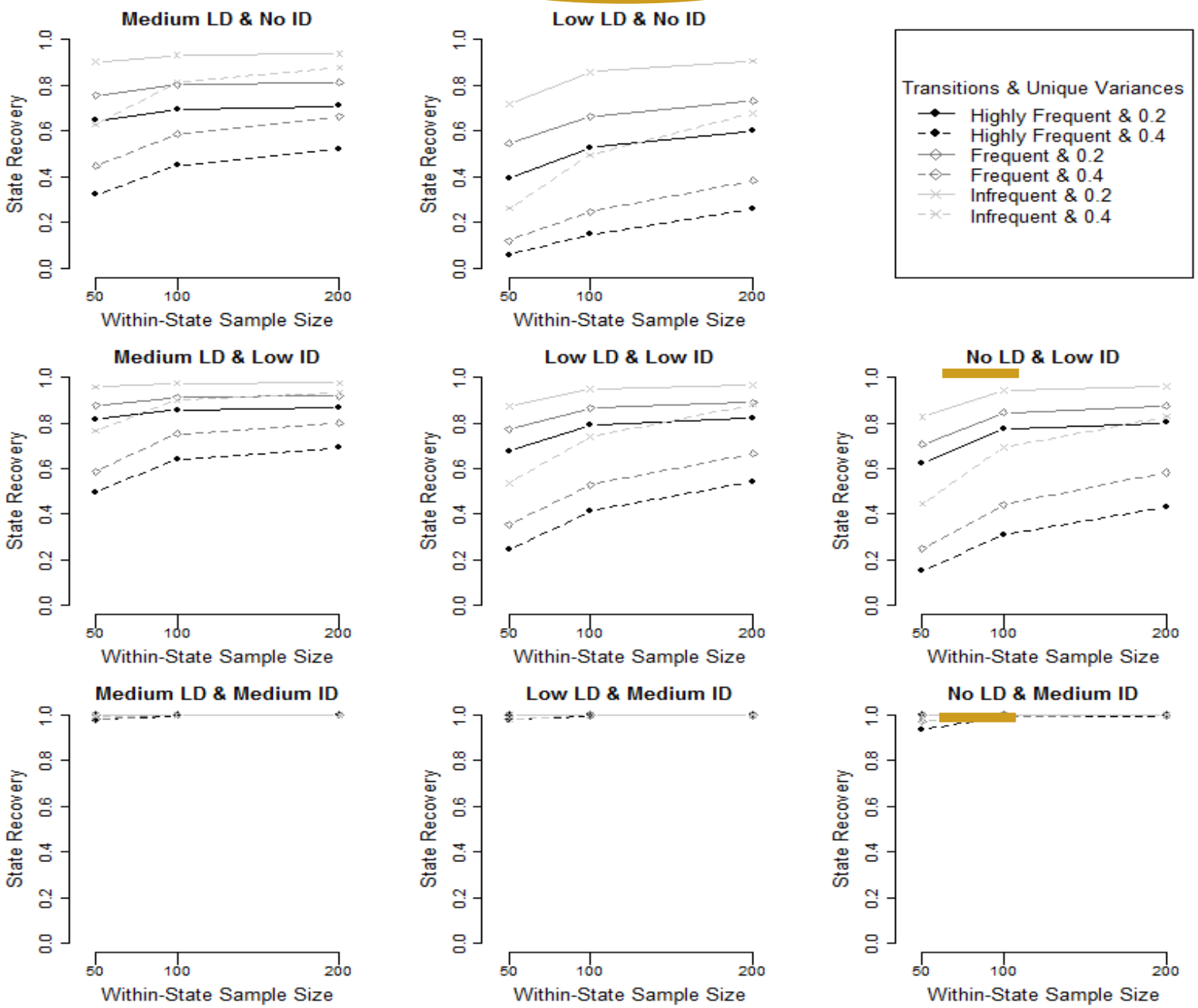
Intercept Difference



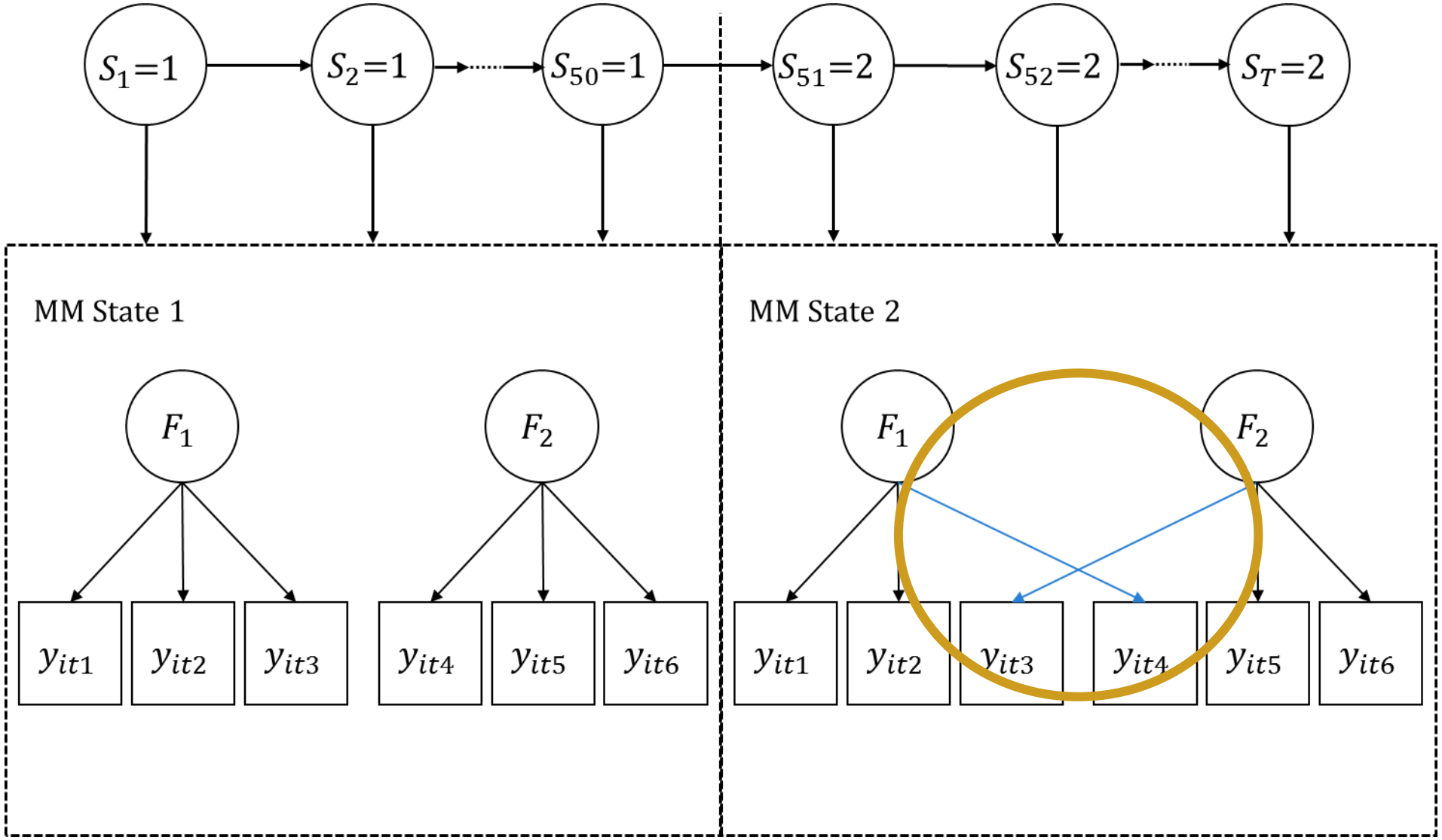
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Y-Axis: *ARI*

Intercept Difference

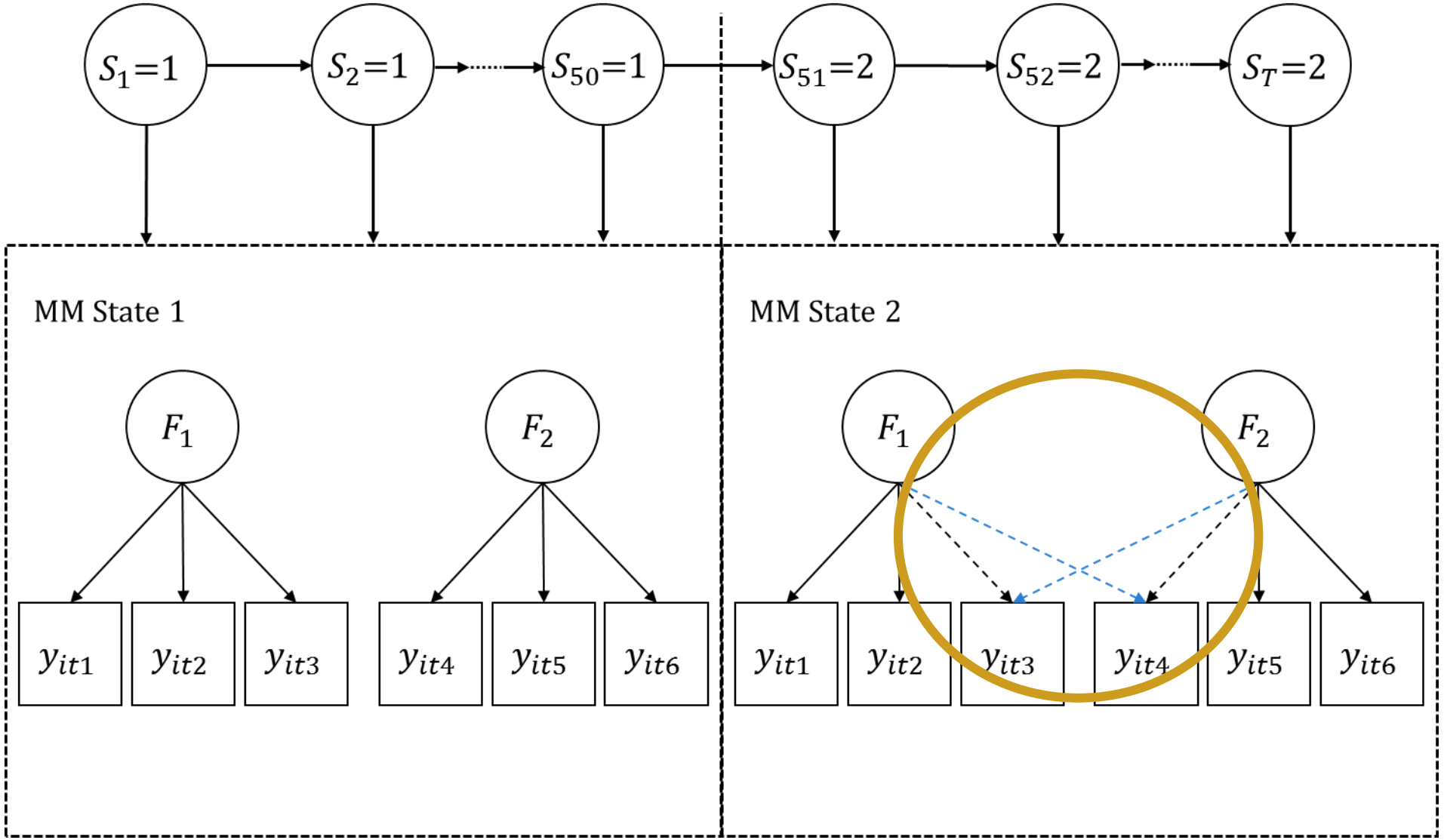


Medium LD: Difference was a Shifted loading



Tucker's congruence coefficient
φ = .80

Low LD: Difference was an added cross-loading

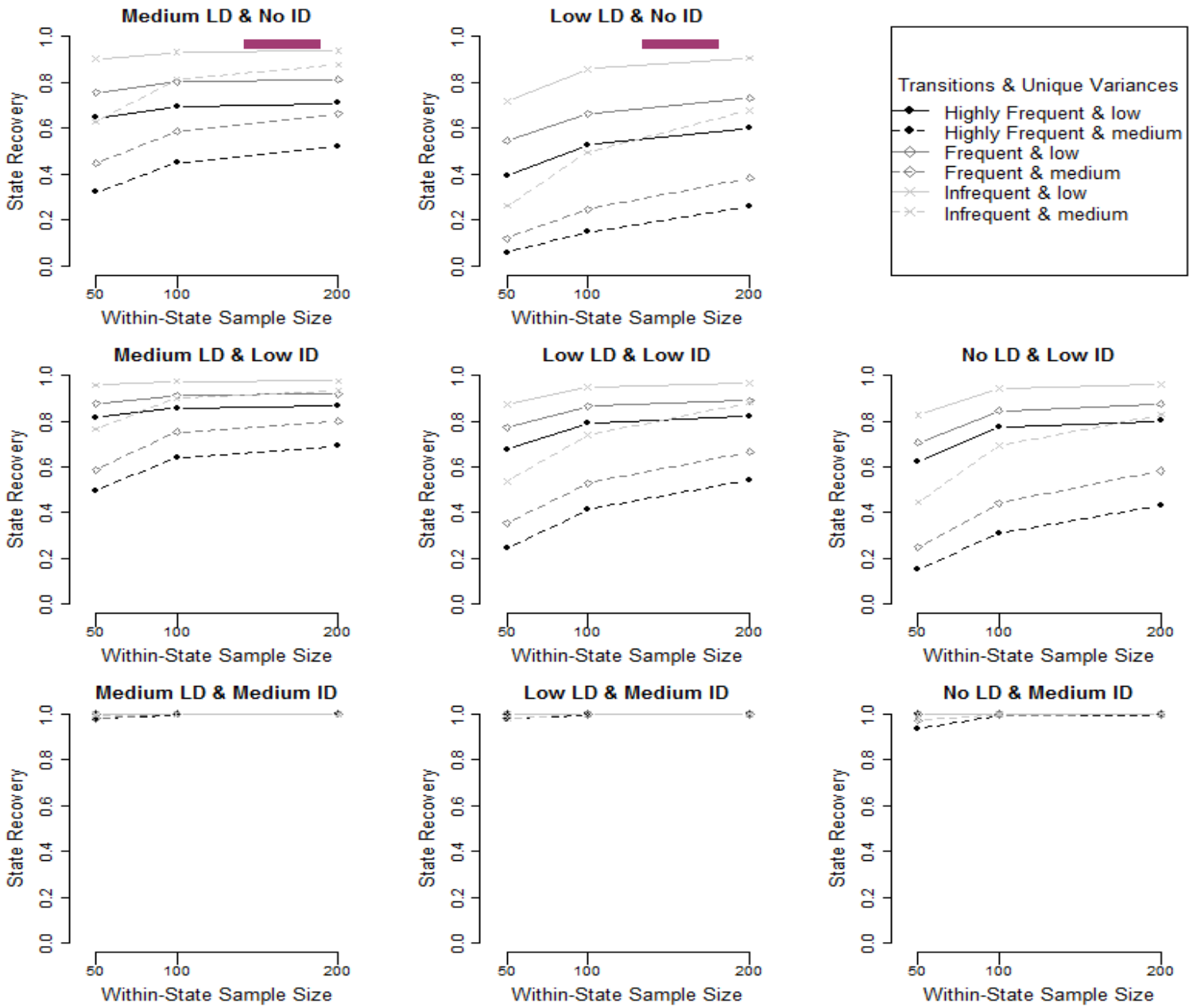


Tucker's congruence coefficient
φ = .94

Loading Difference

Y-Axis: *ARI*

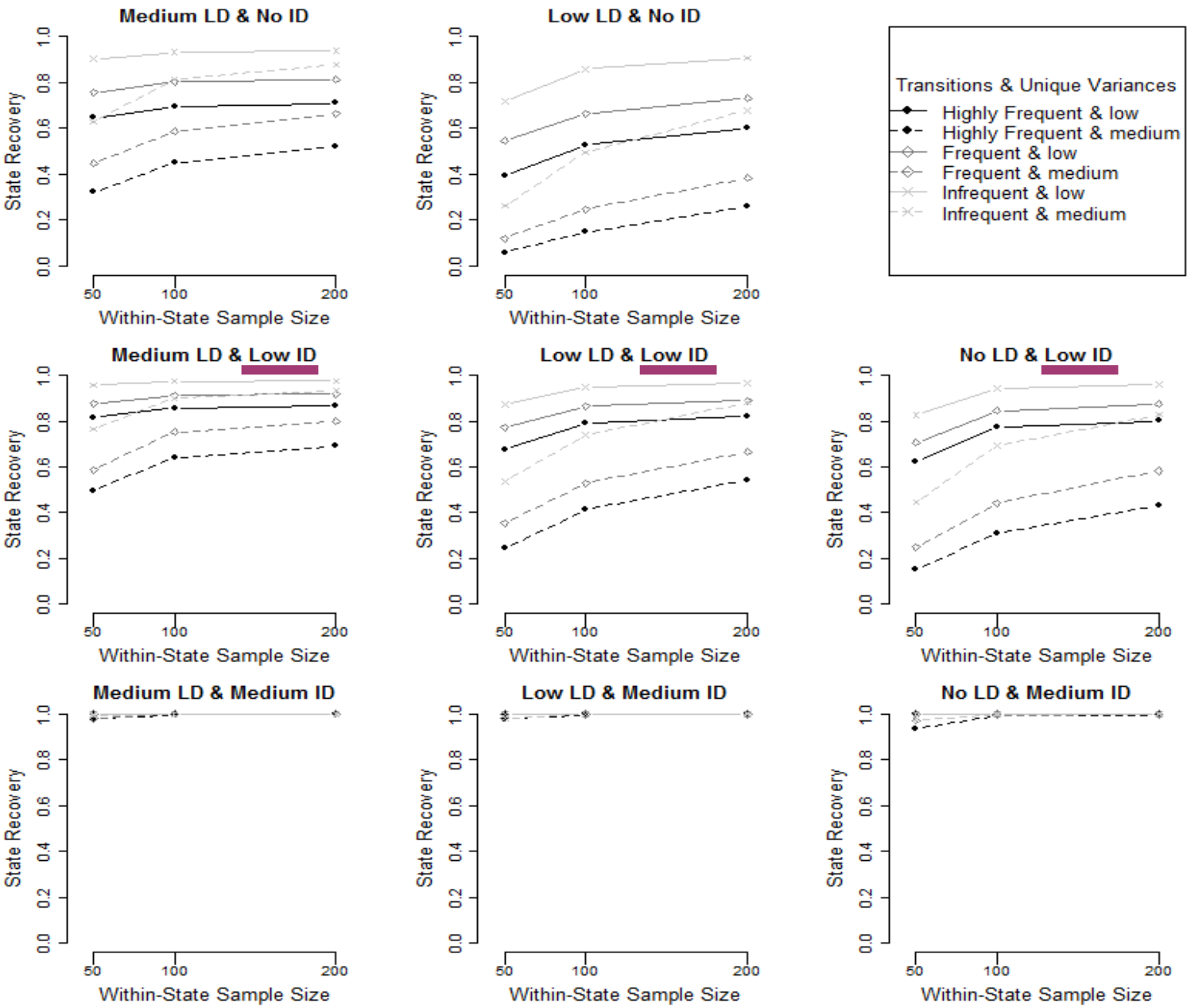
Intercept Difference



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Y-Axis: *ARI*

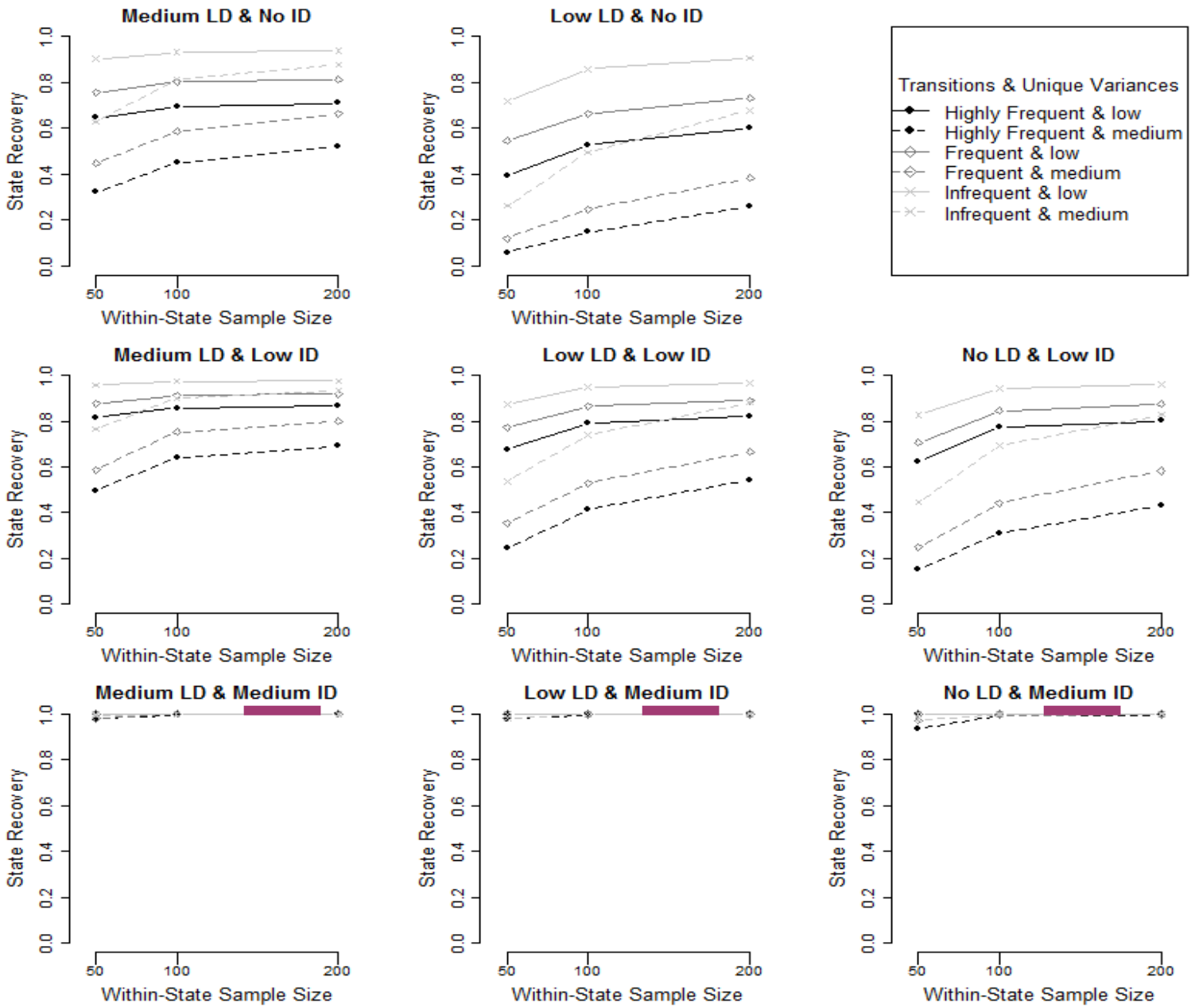
Intercept Difference



Loading Difference

Y-Axis: *ARI*

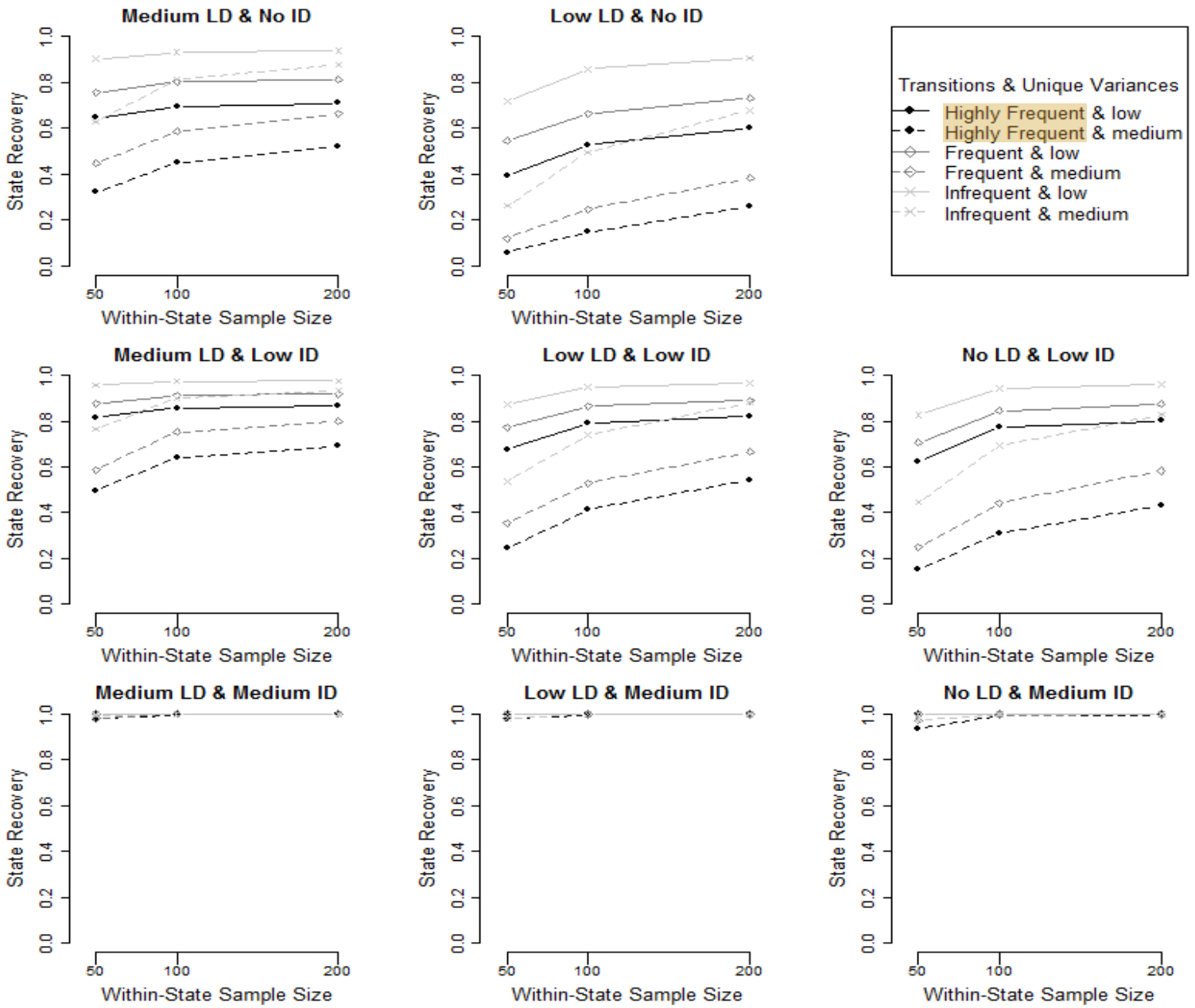
Intercept Difference



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Intercept Difference

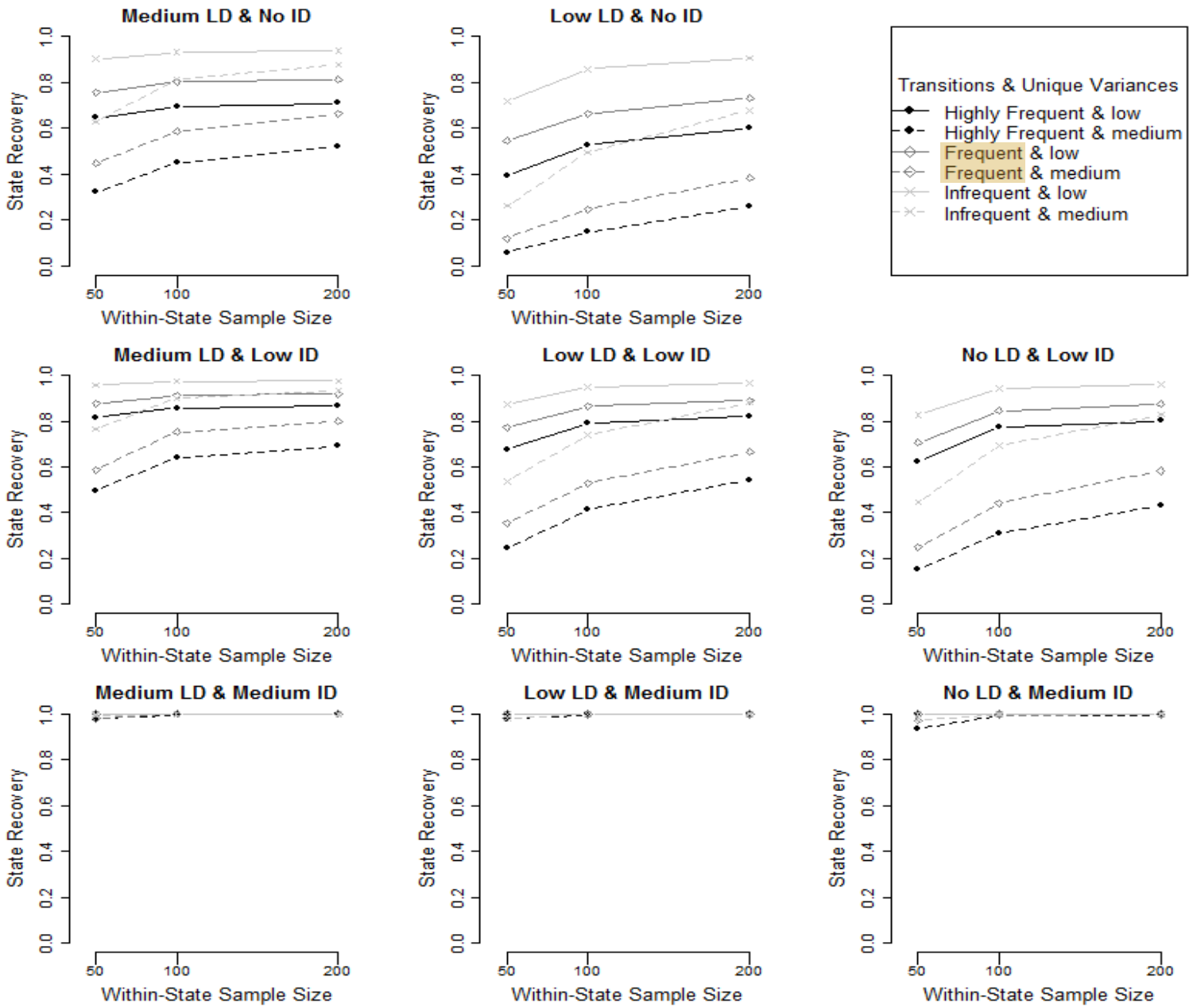
Y-Axis: *ARI*



Loading Difference

Y-Axis: *ARI*

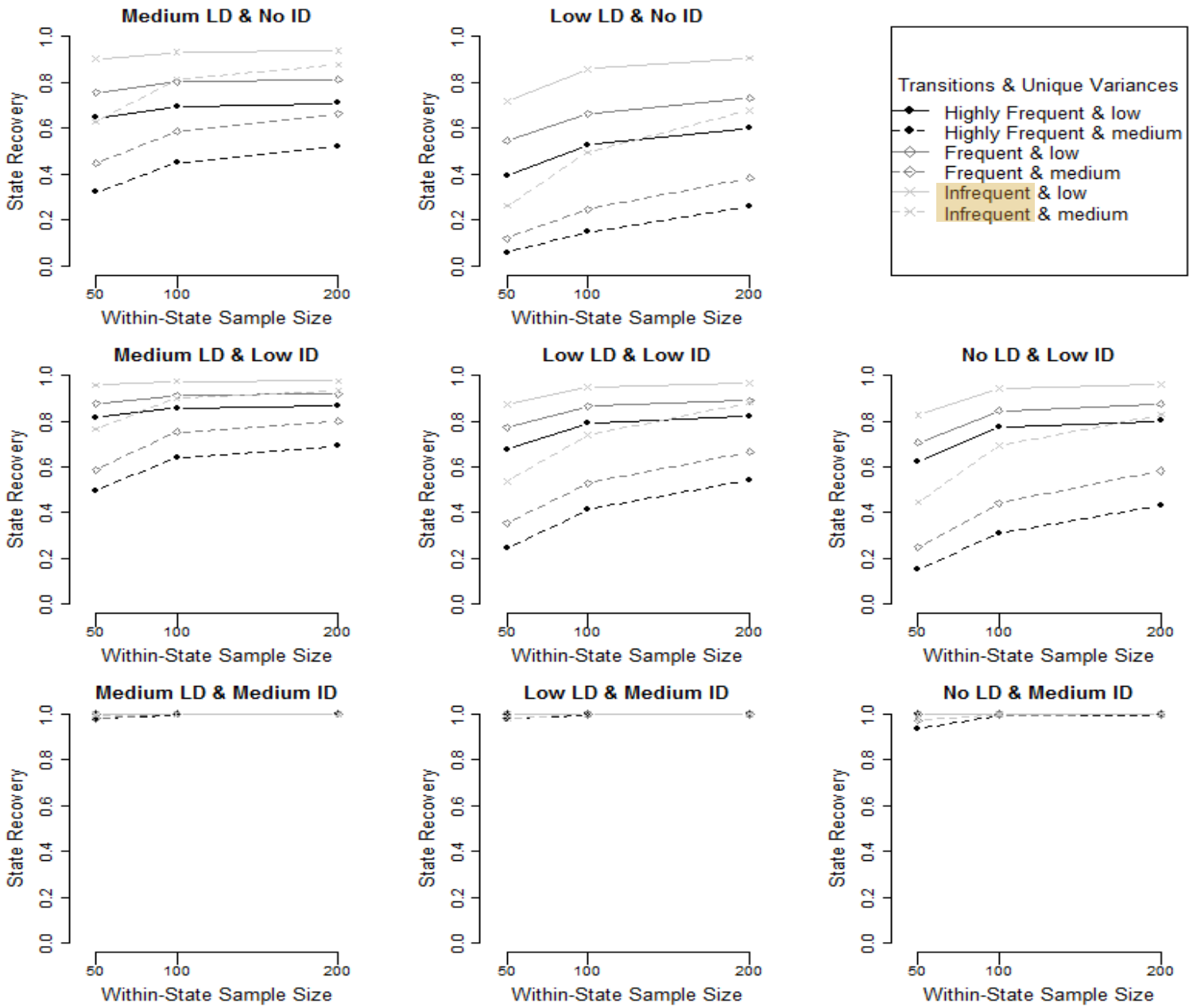
Intercept Difference



Loading Difference

Y-Axis: *ARI*

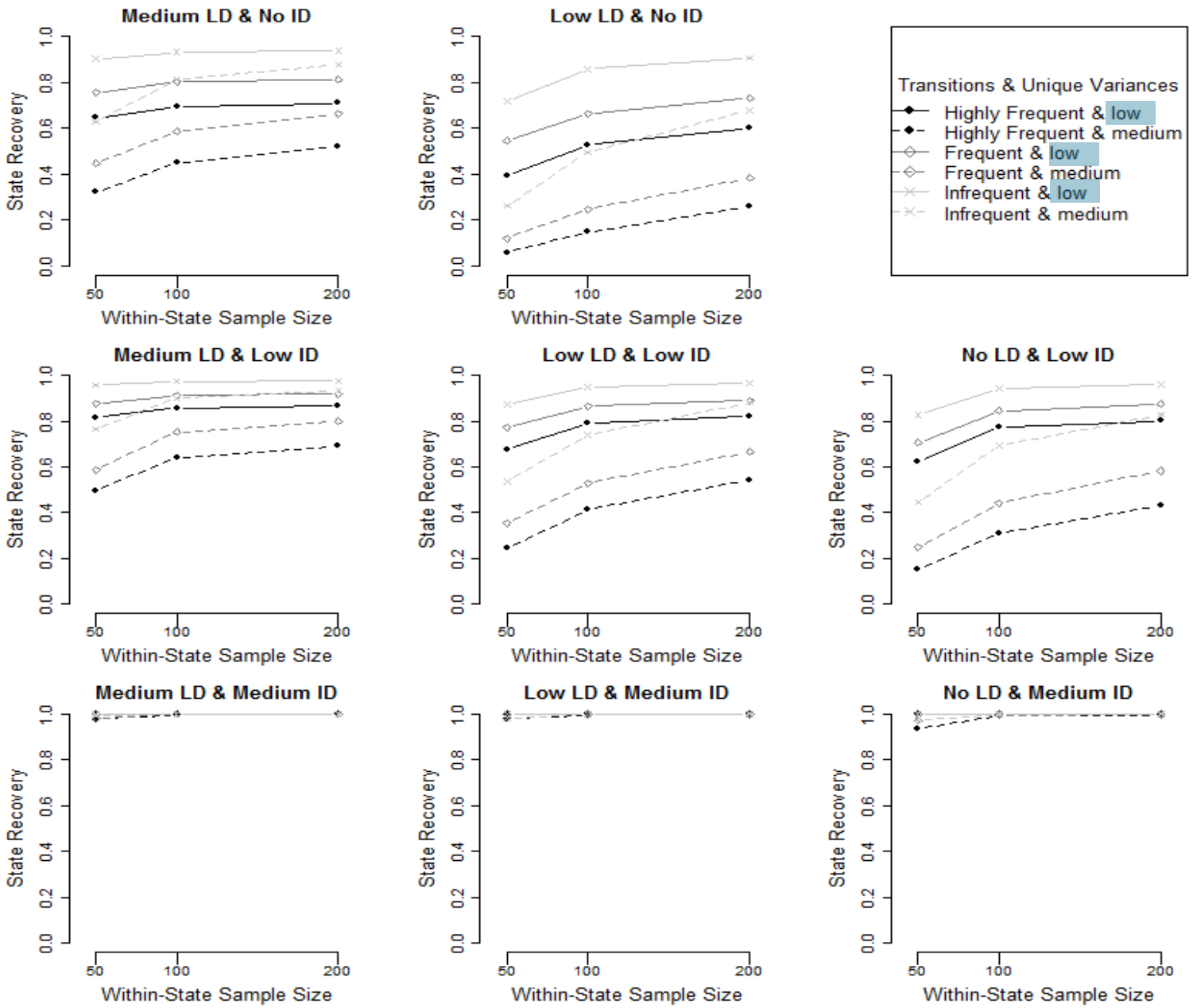
Intercept Difference



Loading Difference

Y-Axis: *ARI*

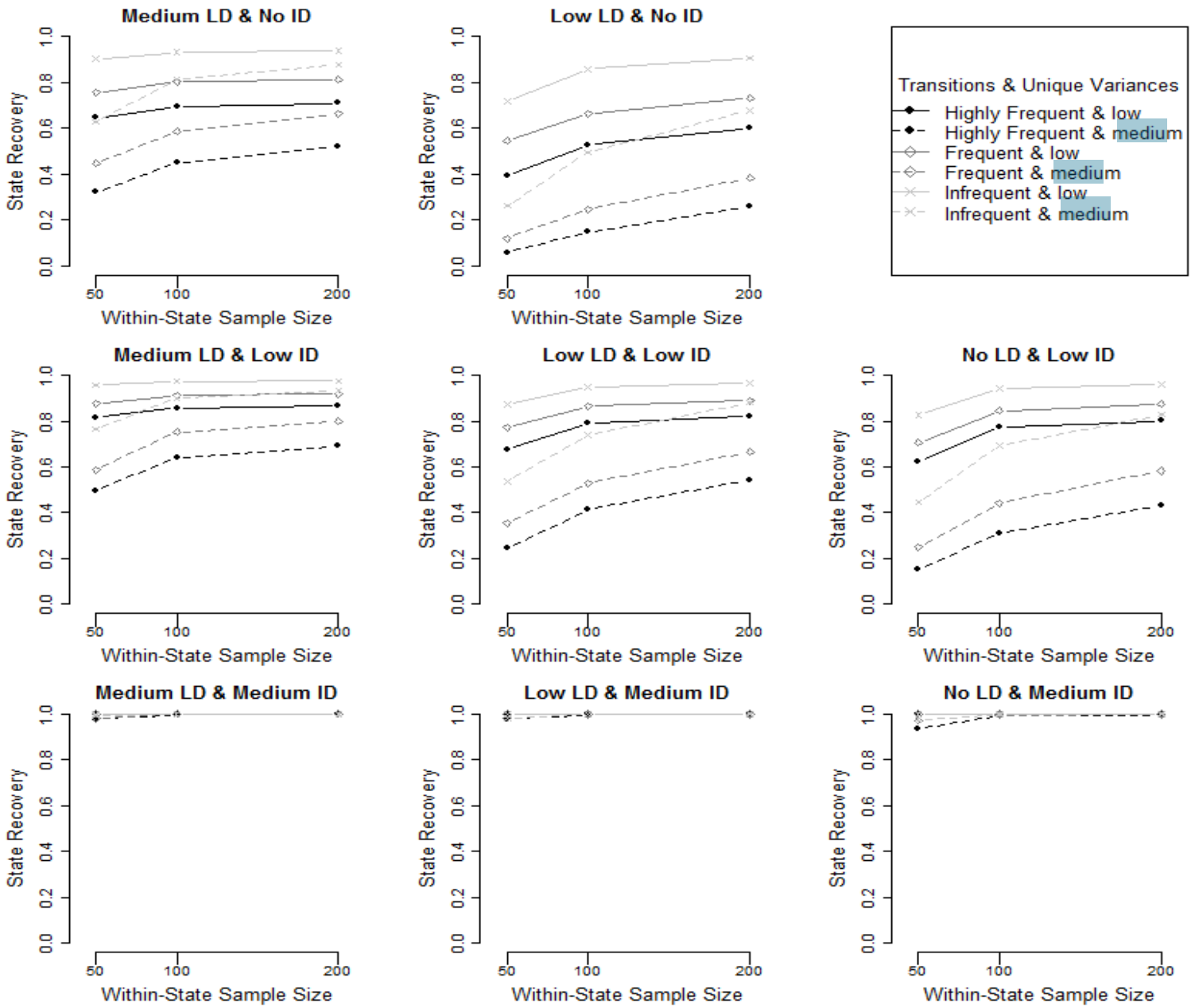
Intercept Difference



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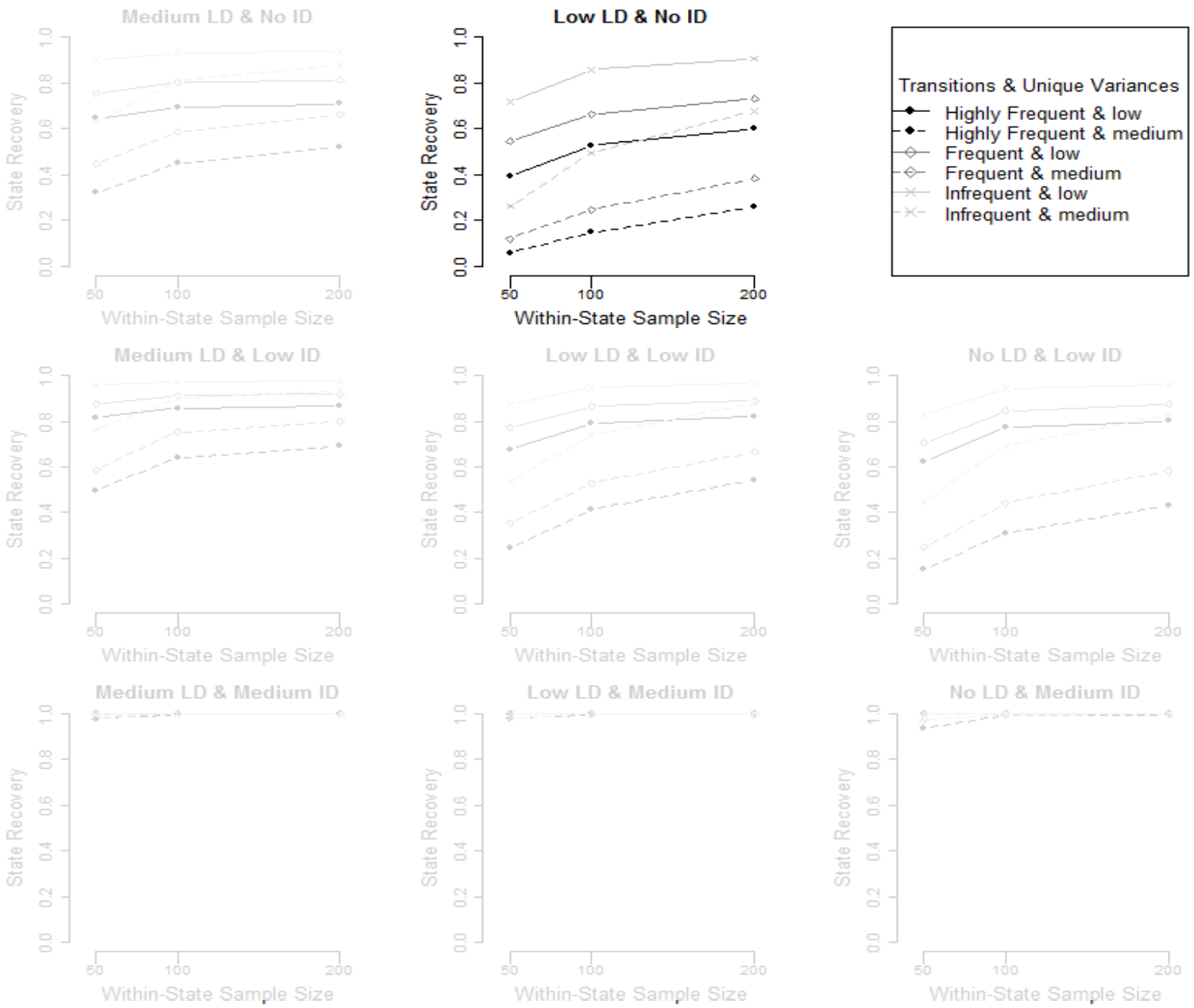
Y-Axis: *ARI*

Intercept Difference

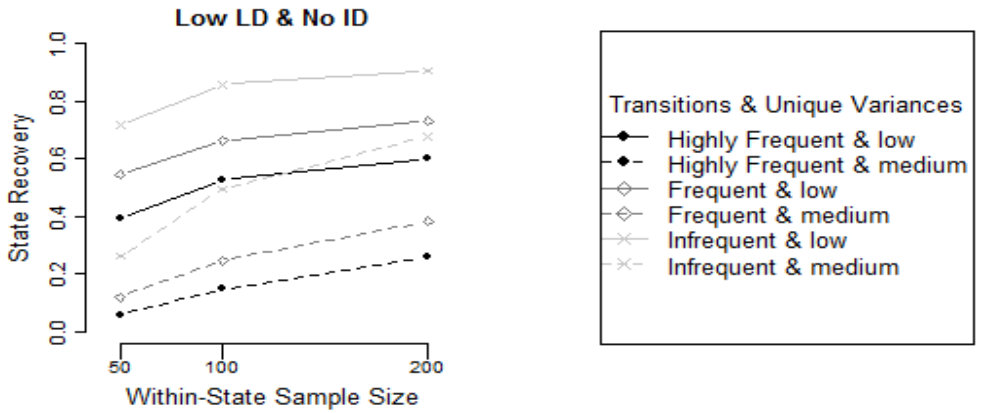


Y-Axis: *ARI*

Intercept Difference



Y-Axis: *ARI*



Infrequent
Frequent
Highly frequent

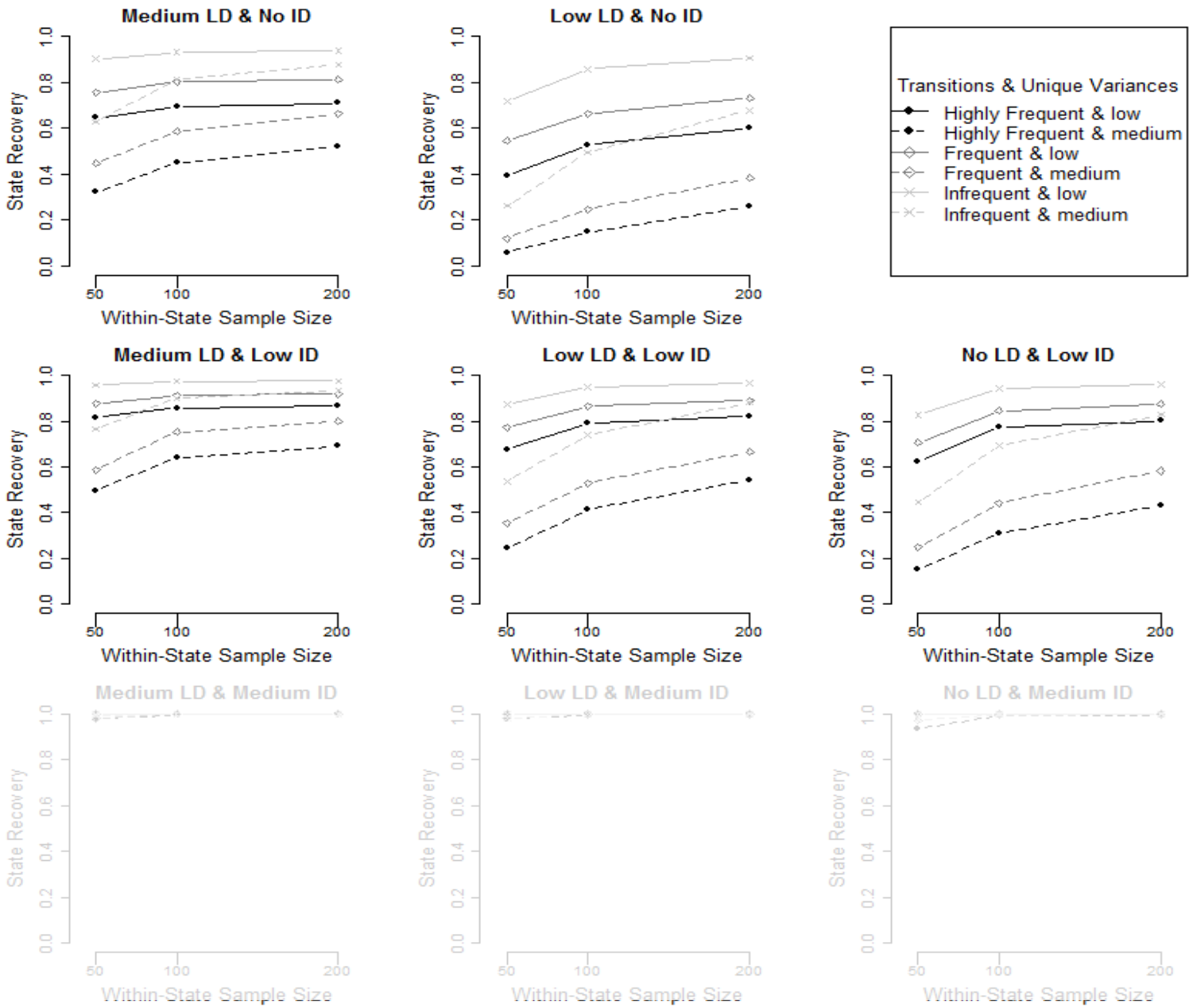
Low unique variances

Medium unique Variances

Loading Difference

Y-Axis: *ARI*

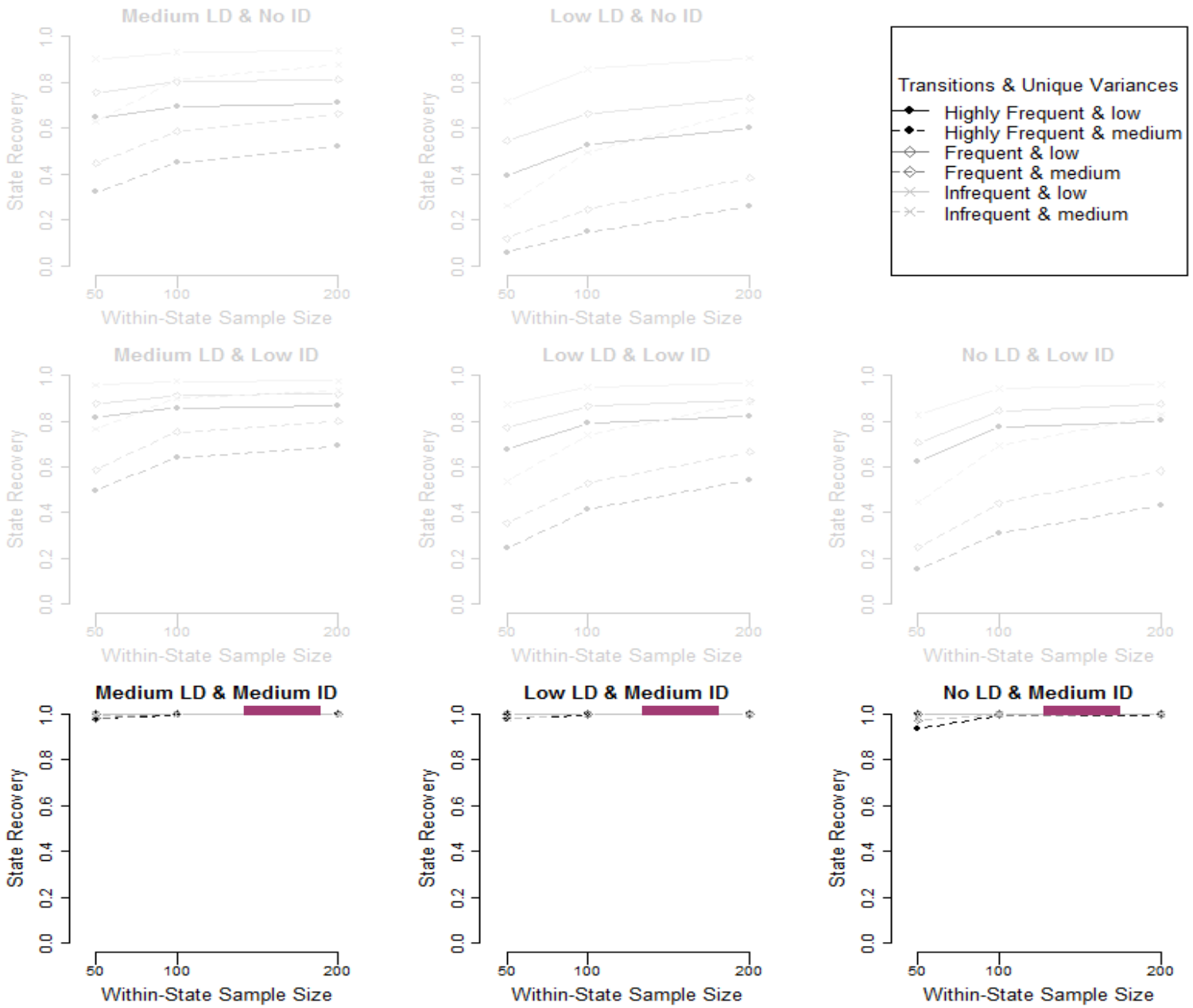
Intercept Difference



Loading Difference

Y-Axis: *ARI*

Intercept Difference



Loading Recovery

Mean Tucker's congruence coefficient over states and factors

True → Λ_f^{sT}, Estimated → Λ_f^{sM}

$$\frac{\sum_{s=1}^{S}\sum_{f=1}^{F}\phi(\Lambda_f^{sT},\Lambda_f^{sM})}{\sum_{s=1}^{S}F^S} = .98\,(SD = 0.05)$$

Application

Keijsers, Hillegers and Hiemstra (Grumpy or Depressed project, 2017)

Tilburg Experience Sampling Center

- **Affect** measures of adolescents (12 Items)
  - Rated degree of : "I feel happy; energetic; angry;…"
  - Filled in the measurements in different contexts:



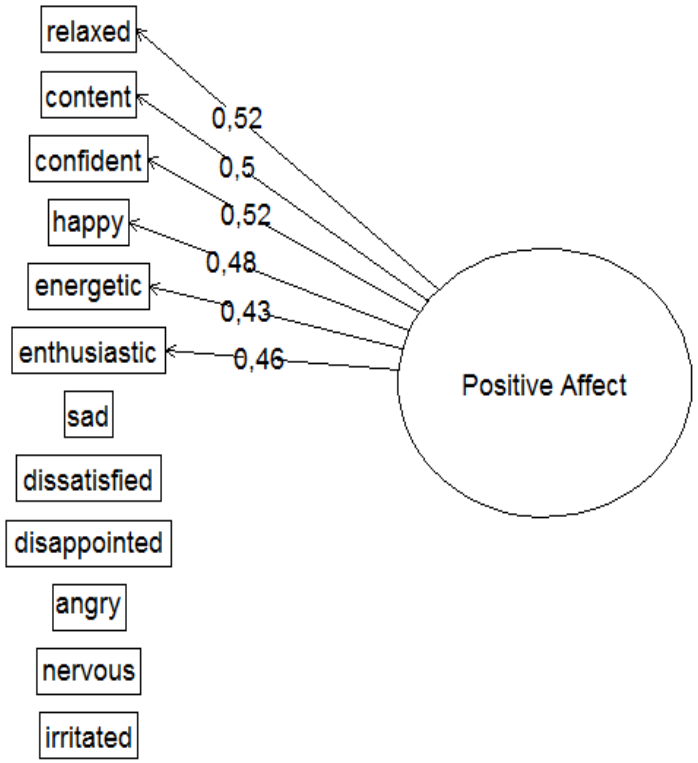
- Remember the **Challenge**: The MM can change within a person over time
  - **Artefacts**
  - **Substantive changes**

- There were indeed 2 states **!**

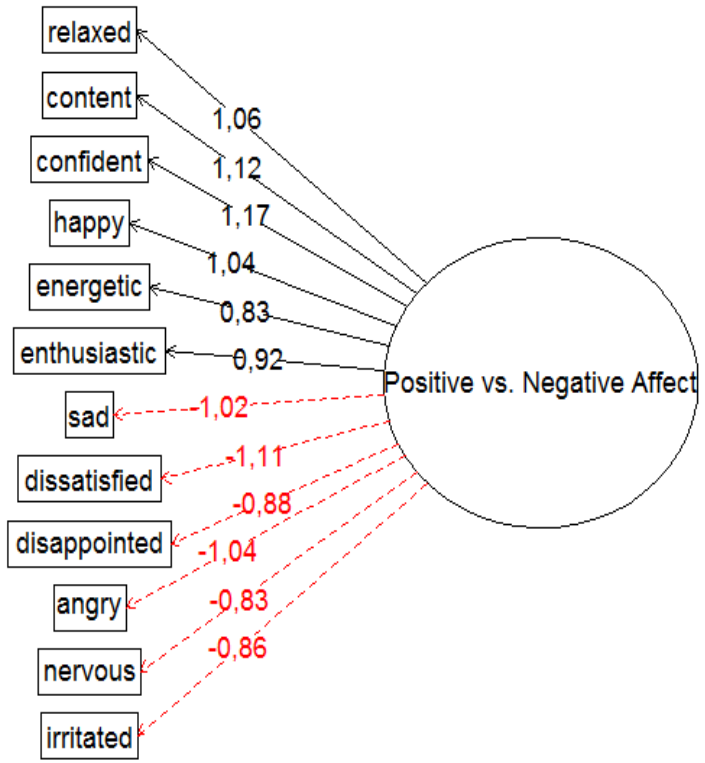
Step 1: Investigating the States

Loading differences

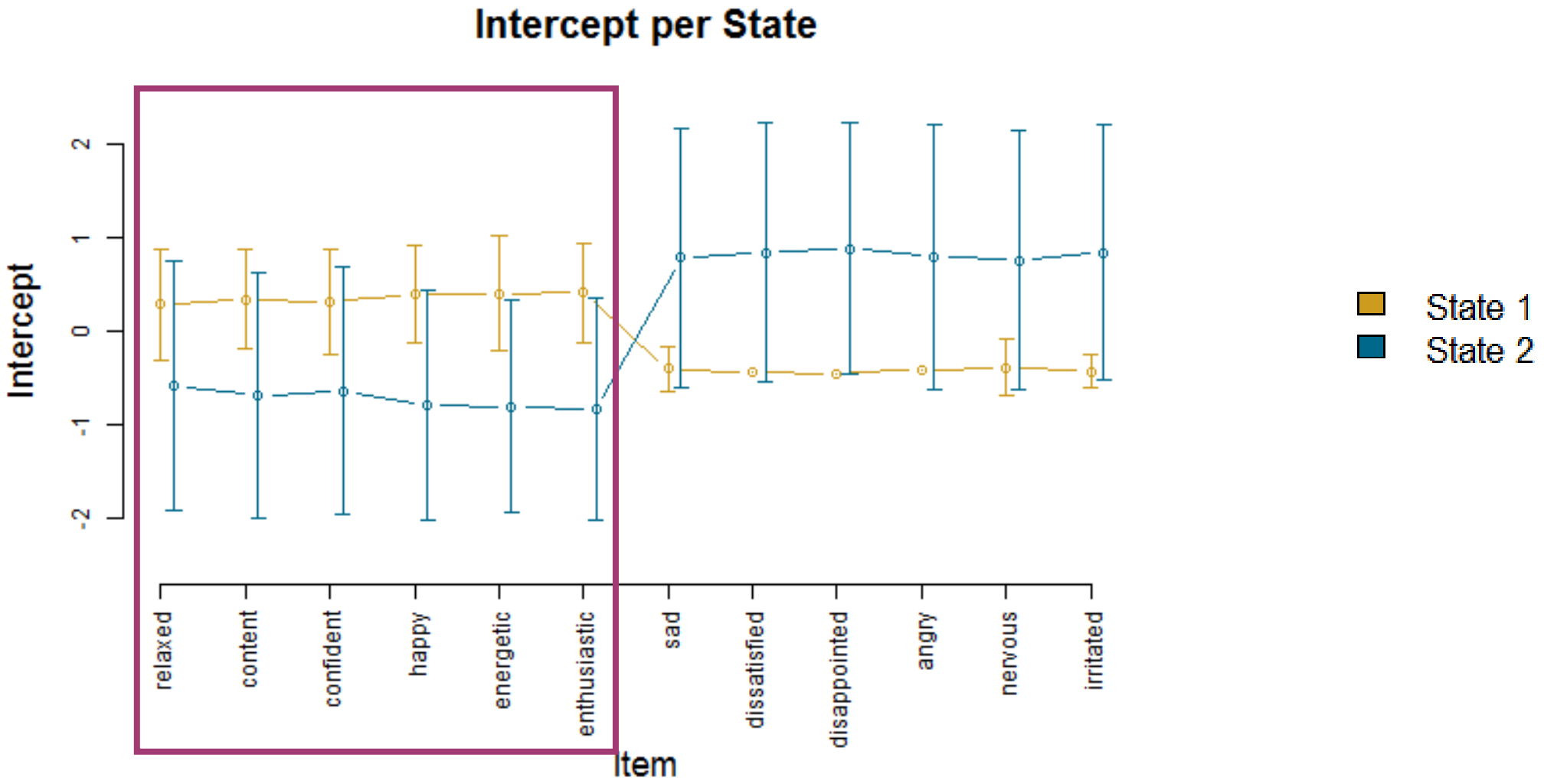
State 1



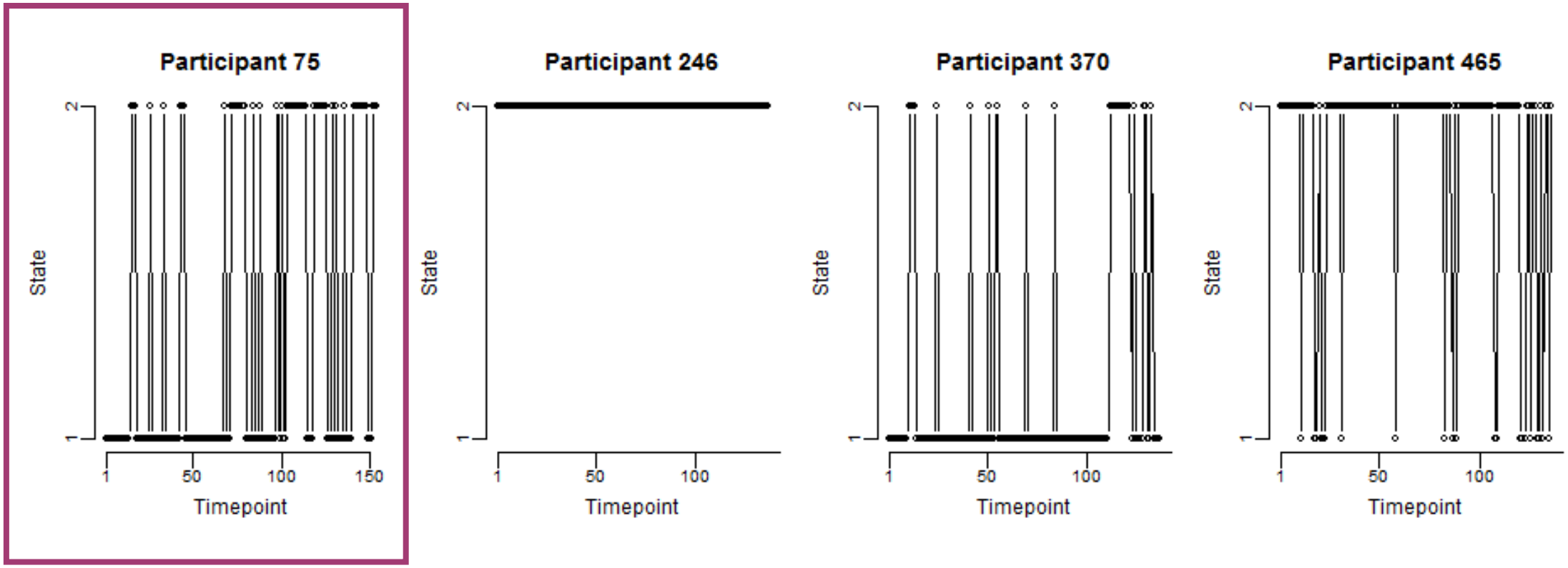
State 2



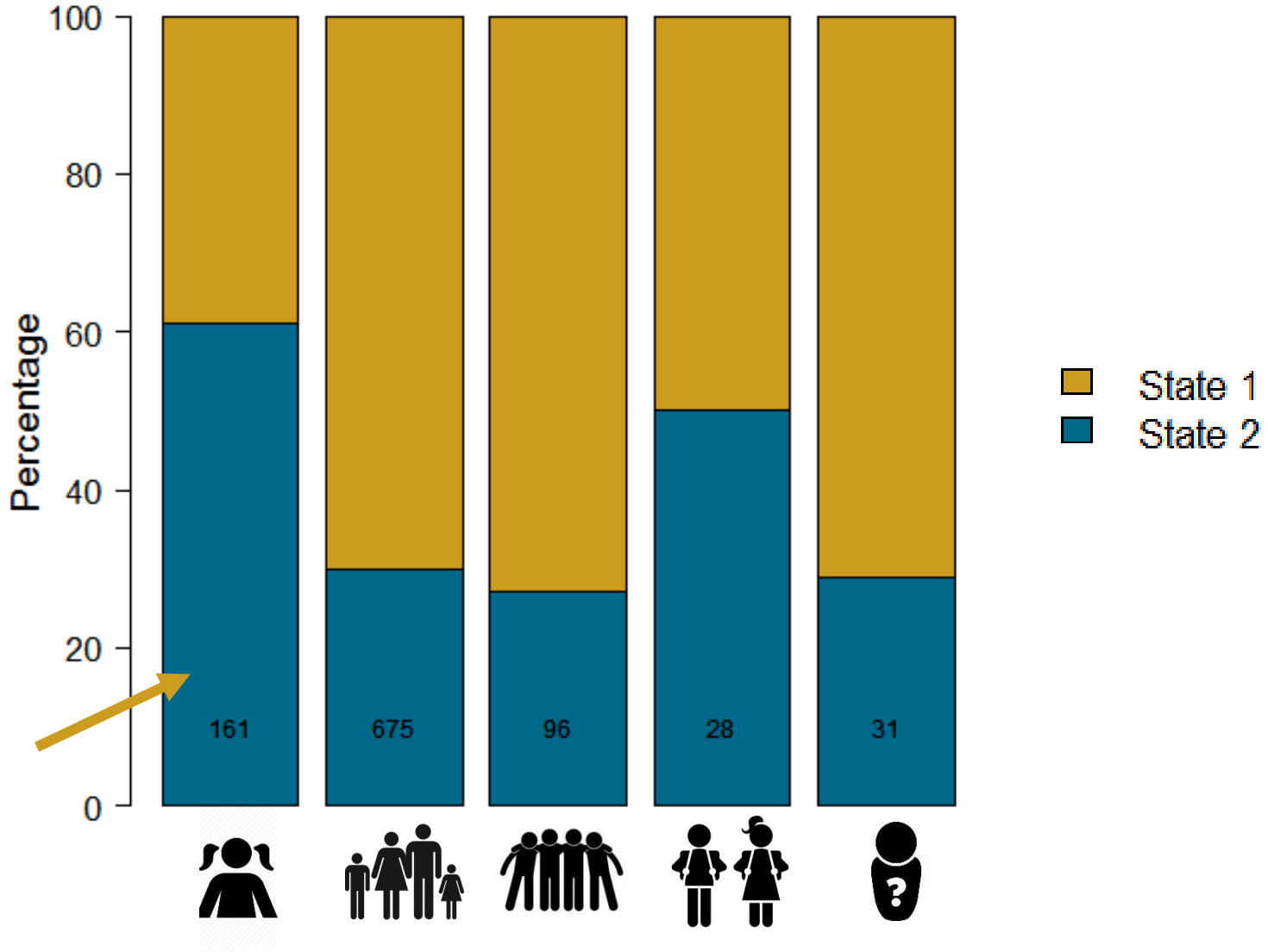
Intercept differences



Step 2: What do the individual changes between the states look like?



Step 3: How are the states related to the contexts?



Summarized: LMFA is an innovative approach…

…that detects and models changes in MM over time

- Can we control for artefacts?
- Can we learn from substantive changes?

…that shows which subjects and which time-points are comparable!

→safeguards valid conclusions

Thank you for your attention!

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Latent GOLD

- Vermunt, J. K., & Magidson,J.(2013). *Technical guide for Latent GOLD 5.0: Basic, advanced, and syntax*. Belmont, MA: StatisticalInnovations.

- Website: http://www.statisticalinnovations.com/

Tilburg Experience Sampling Center

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- Website: https://twitter.com/tilburgu_tesc?lang=en

