

Modelling intra-individual differences in variability using 4-level hierarchical dynamic structural equation models (DSEM):

How to optimally trade-off fixed and random effects with respect to model complexity?

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INTRODUCTION

- Children show individual differences in how variable they are
- Variability in (mean) reaction time exists at multiple levels:
 - trial-to-trial
 - session-to-session
 - day-to-day

Research questions

- Does variability at these timescales correlate?
- Is variability consistent across cognitive domains?

Problems

When estimating variability in means across three timescale:

- Need to correct for clustering and autoregressive effects
 - Requires 4-level, Dynamic Structural Equation Models (DSEM)
 - Unavailable in proprietary software → built in-house using (R)Stan
- Amount of data decreases as levels increase
 - Balance theoretical appropriate model specification with power for finding meaningful individual differences

ANALYSIS

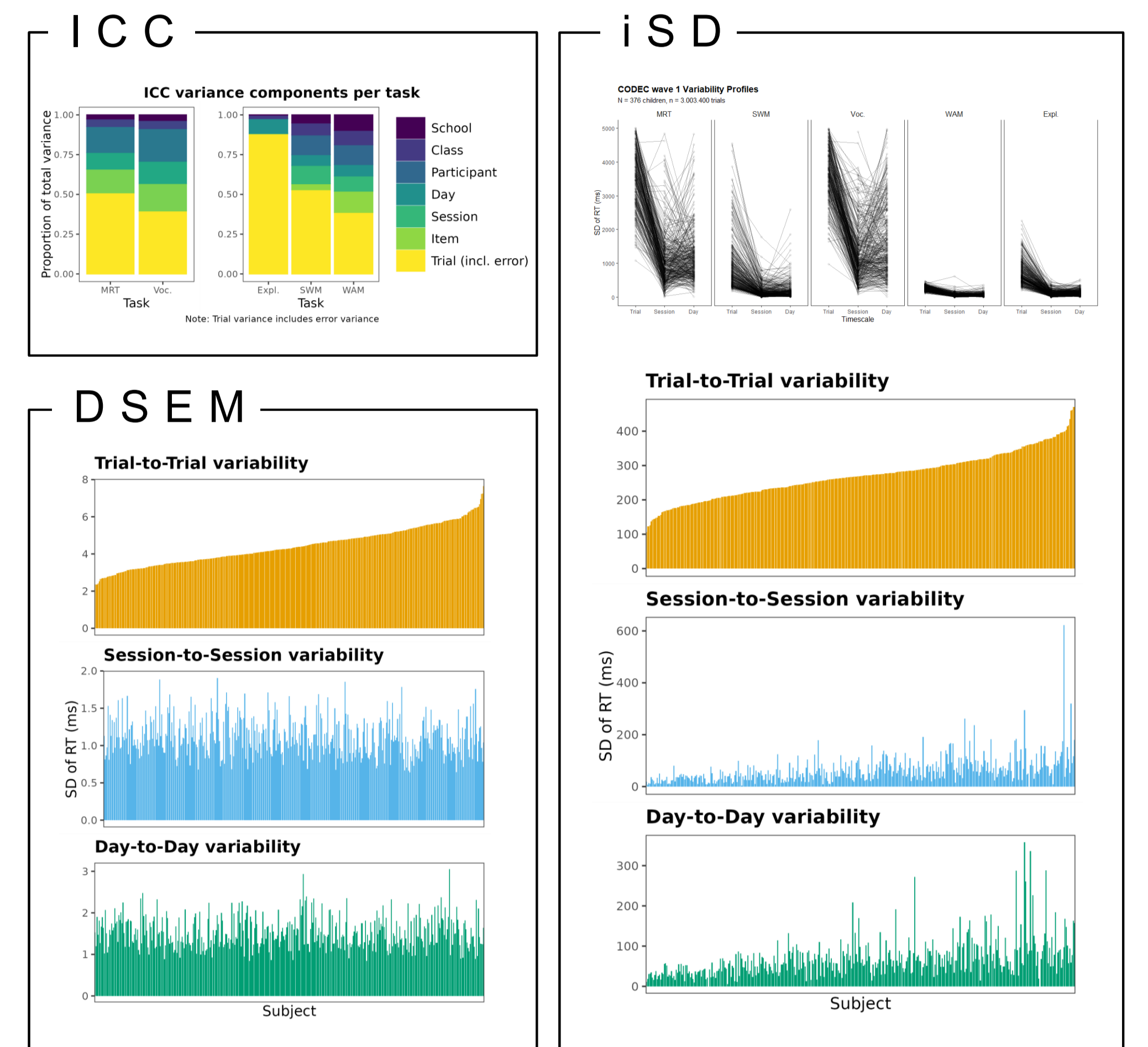
FIXED vs RANDOM



Definitions of variability

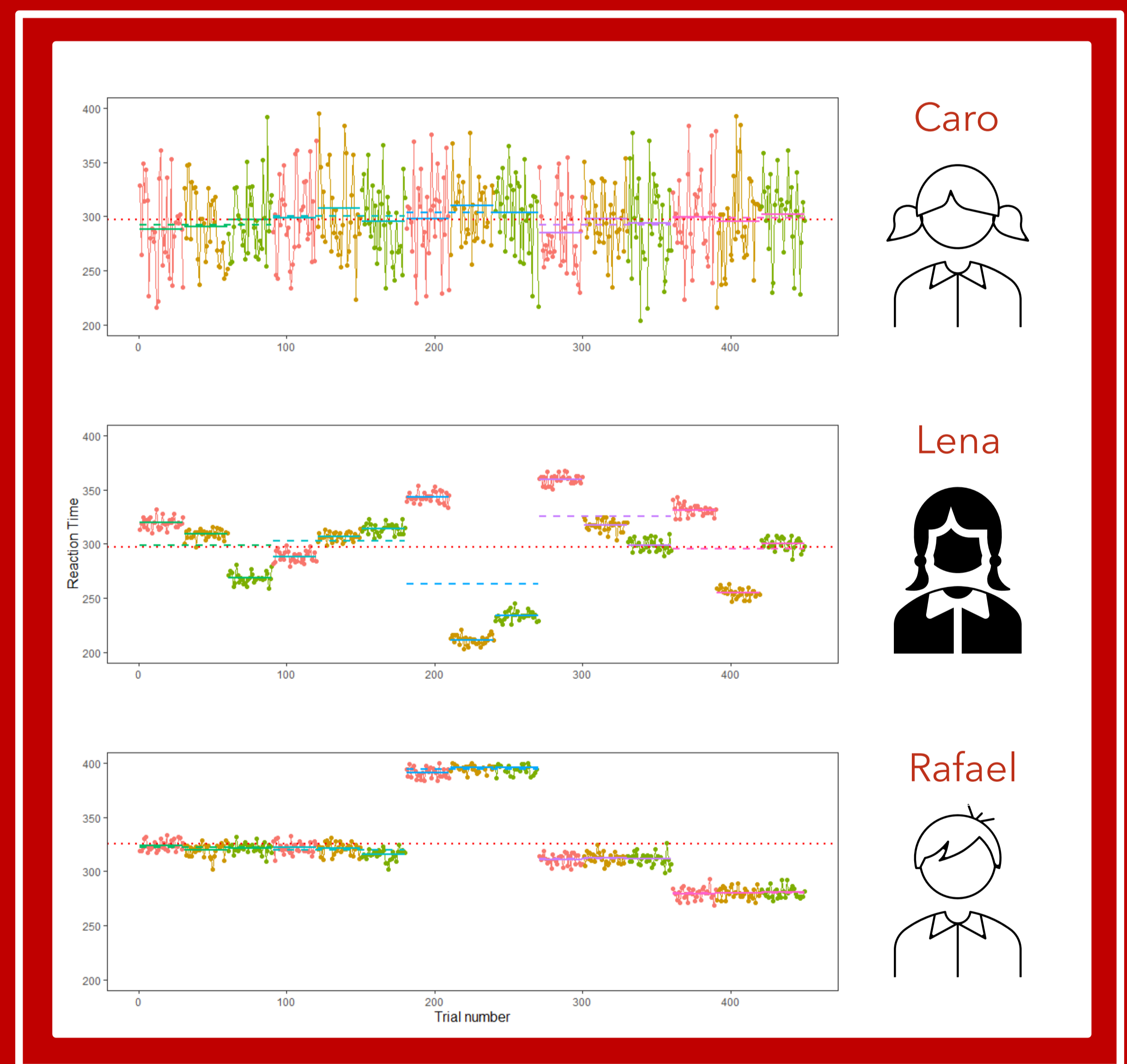
- Day-to-day variability is the variance of the subject-specific day means around the subject's week mean
- Session-to-session variability is the variance of the subject-specific session means around the respective day mean
- Trial-to-trial variability is the residual variance at the session level

RESULTS



Modelling variability using 4-level multilevel DSEM: fixed vs. random effects

Visualise variability at three different timescales using our Shiny app



EXTRA

Correlations across timescales and tasks (iSD)

Distribution of iSD variability estimates

SIMULATION

Example:

- Input parameters based on WAM task
- 100 subjects

FORMULAS

Location model:

Level 1: trial

$$Y_{pdst} = \mu_{pds} + \phi_{pds} * Y_{pds(t-1)} + \epsilon_{pdst}$$

Level 2: session

$$\mu_{pds} = \mu_{pd} + u_{pds}$$

$$\phi_{pds} = \phi_{pd}$$

Level 3: day

$$\mu_{pd} = \mu_p + u_{pd}$$

$$\phi_{pd} = \phi_p$$

Level 4: subject

$$\mu_p = \mu_0 + u_p$$

$$\phi_p = \phi_0 + f_p$$

Scale model:

$$\log(\sigma_{pdst}^2) = \alpha_0 + \alpha_p$$

Variability definitions:

Trial-to-trial: $\sigma_{trial}^2 \stackrel{def}{=} \sigma_{\epsilon_{pdst}}^2$
 Session-to-session: $\mu_{pds} \sim normal(\mu_{pd}, \sigma_{session})$
 Day-to-day: $\mu_{pd} \sim normal(\mu_p, \sigma_{day})$

STUDY

The CODEC study

600 children, 3 years with one burst-week of testing each; 5 days, 3 sessions, 3 games per session

- Working memory
- Processing speed
- Exploration
- Fluid reasoning
- Vocabulary

iSD VS. DSEM

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