Number of Subjects and Time Points Needed for Multilevel Time Series Analysis: A Monte Carlo Study of DSEM in Mplus Version 8

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July 10, 2017

[1] Joint work with the Mplus team.

Outline

Example: For a group of individuals that has quit smoking, smoking urge is measured several times a day for 30 days. The difference in weight before quitting and at the end of the study, was measured.

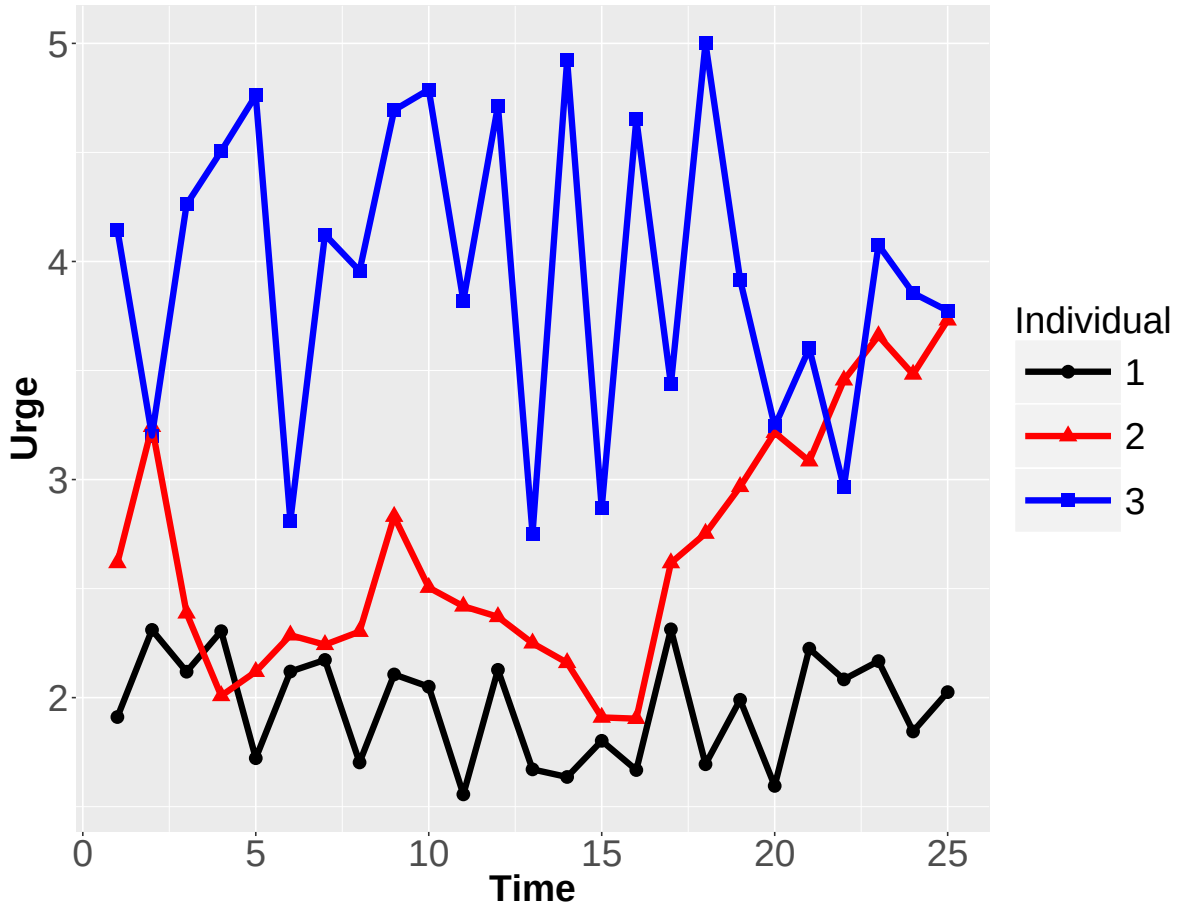
- What "kind" of urge process is associated with large weight gains?

This example will be used throughout the presentation, also for the generated data to make the results easier to follow.

What features of the urge process might differ between individuals?

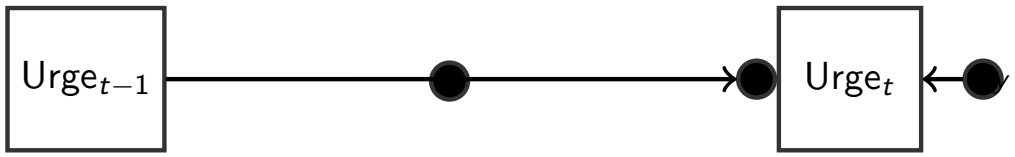
- Random mean
- Random autocorrelation
- Random residual variance

Random=individual specific

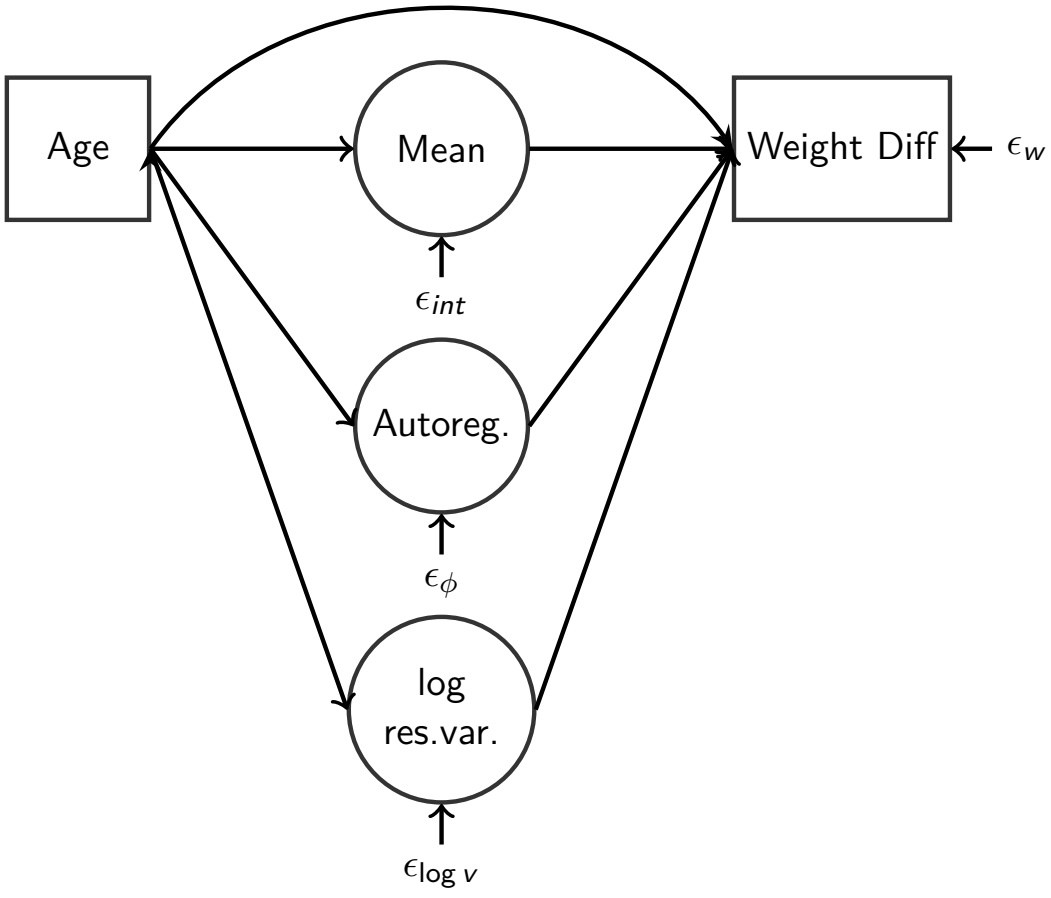


- Can the random coefficients be predicted by some covariate such as age, gender, health?
- Can the random coefficients be used as predictors for e.g. weight changes?
- With the new DSEM modelling framework these three random coefficients can be utilized as **both independent and dependent variables** (Asparouhov et al., 2017).

Within (level-1)
Variation across time



Between (level-2)
Variation across individuals



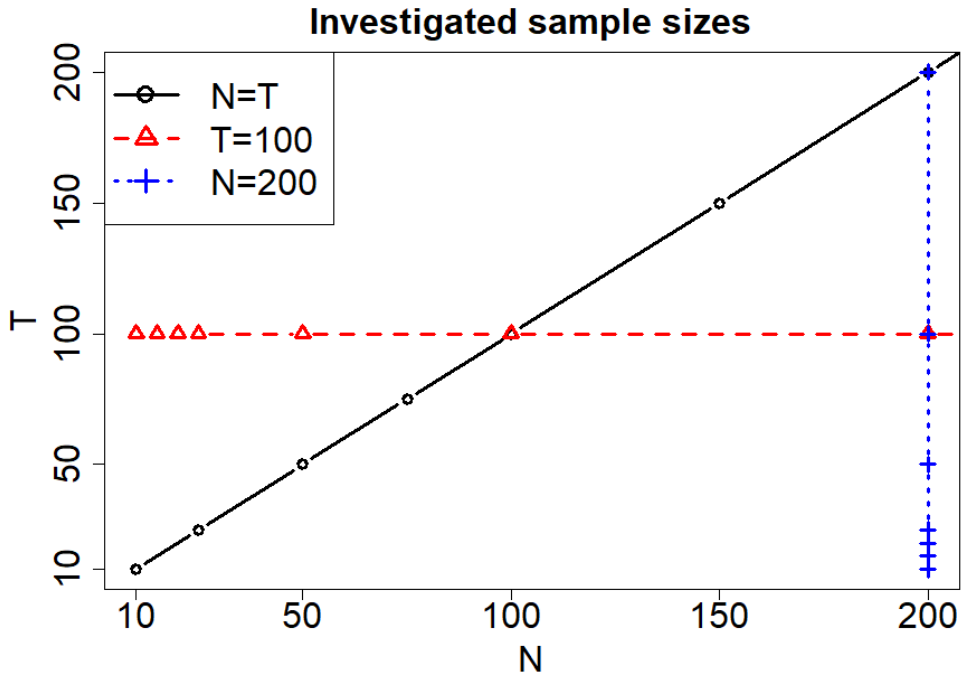
Regress the difference in weight on the random coefficients and Age.

This model (2) is covered by the simulation study

Consider three processes with different number of individuals (N) and number of time points (T):

- Self reported smoking urge:
  - Cheap and easy to collect with high frequency for many individuals with smart phone applications→ Large N and T
- Blood sugar level:
  - Gives measure every minute→ Large T
  - Expensive device limits number of participants→ Small N
- Cognitive ability measured by psychologist:
  - Expensive to include many participants→ Small N
  - Expensive to measure at many time points→ Small T

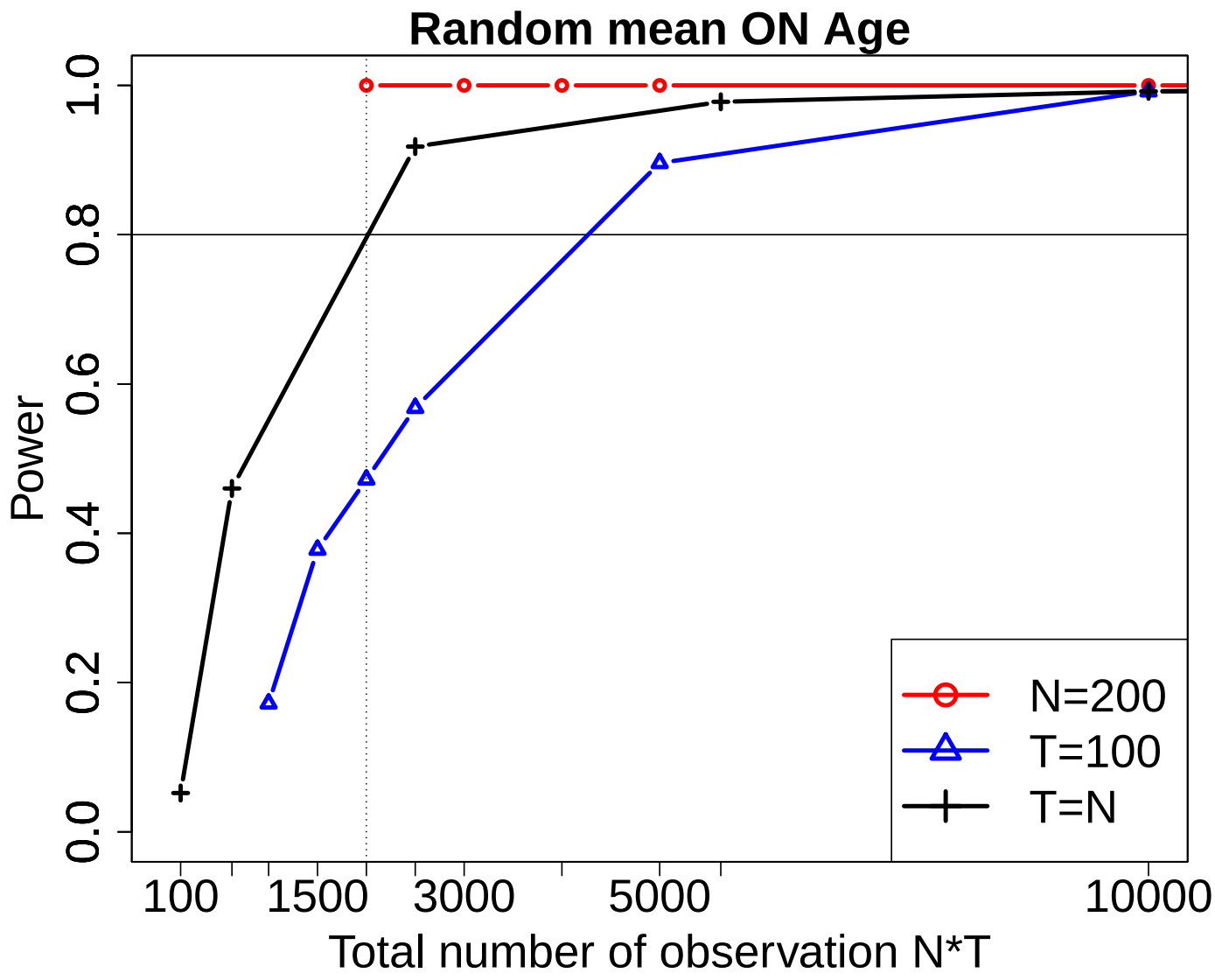
- What sizes of N and T are needed for good estimation of the DSEM models?
- Can large N compensate for small T and vice versa?
- The study considered three cases:
  1. N=200, combined with different T
  2. T=100, combined with different N
  3. N=T

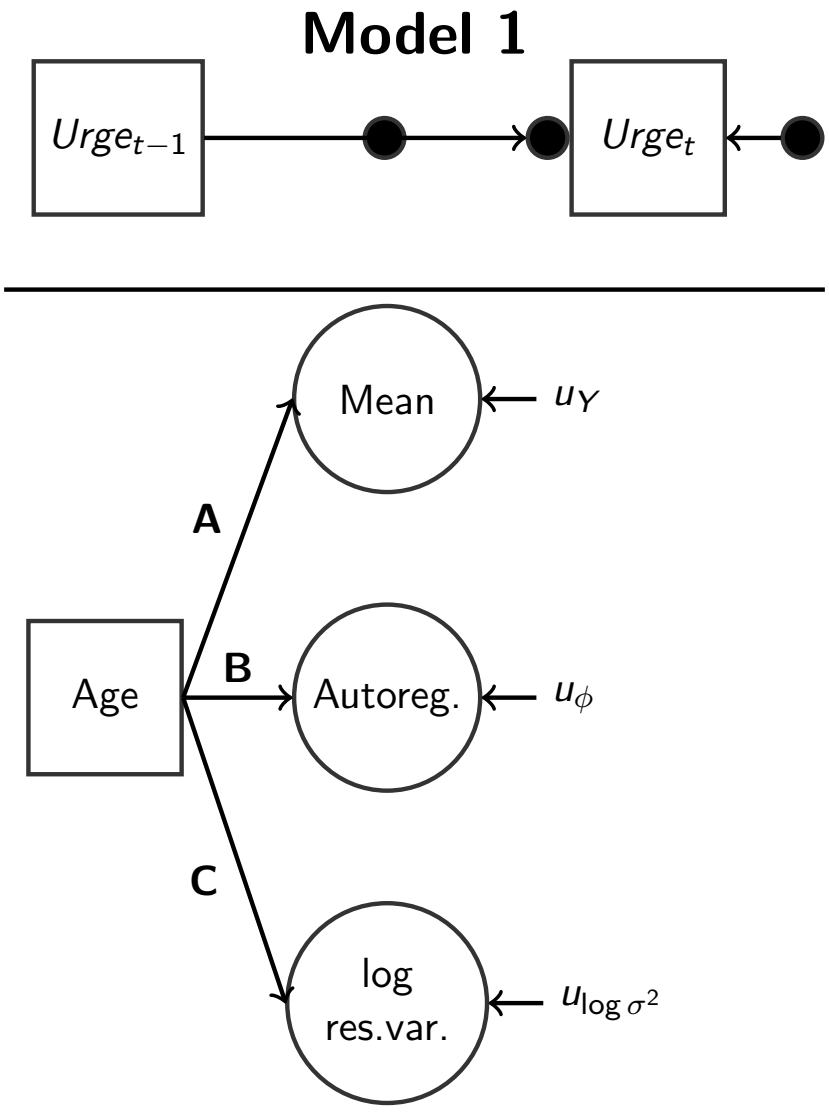


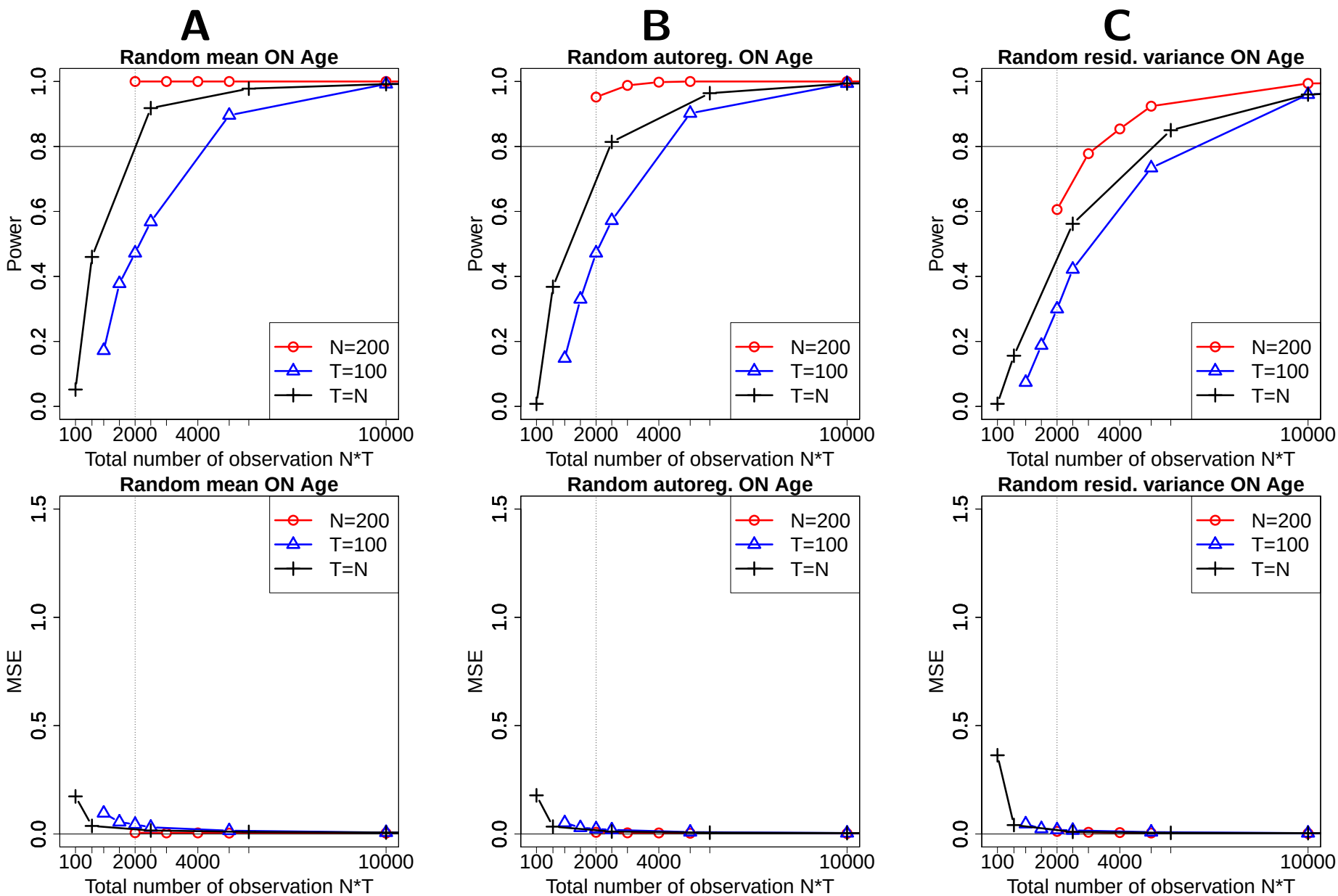
Total number of observations, N*T

- T=10, N=200 → 10*200=2000
- T=100, N=20 → 20*100=2000
- T=45, N=45 → 45*45=2025

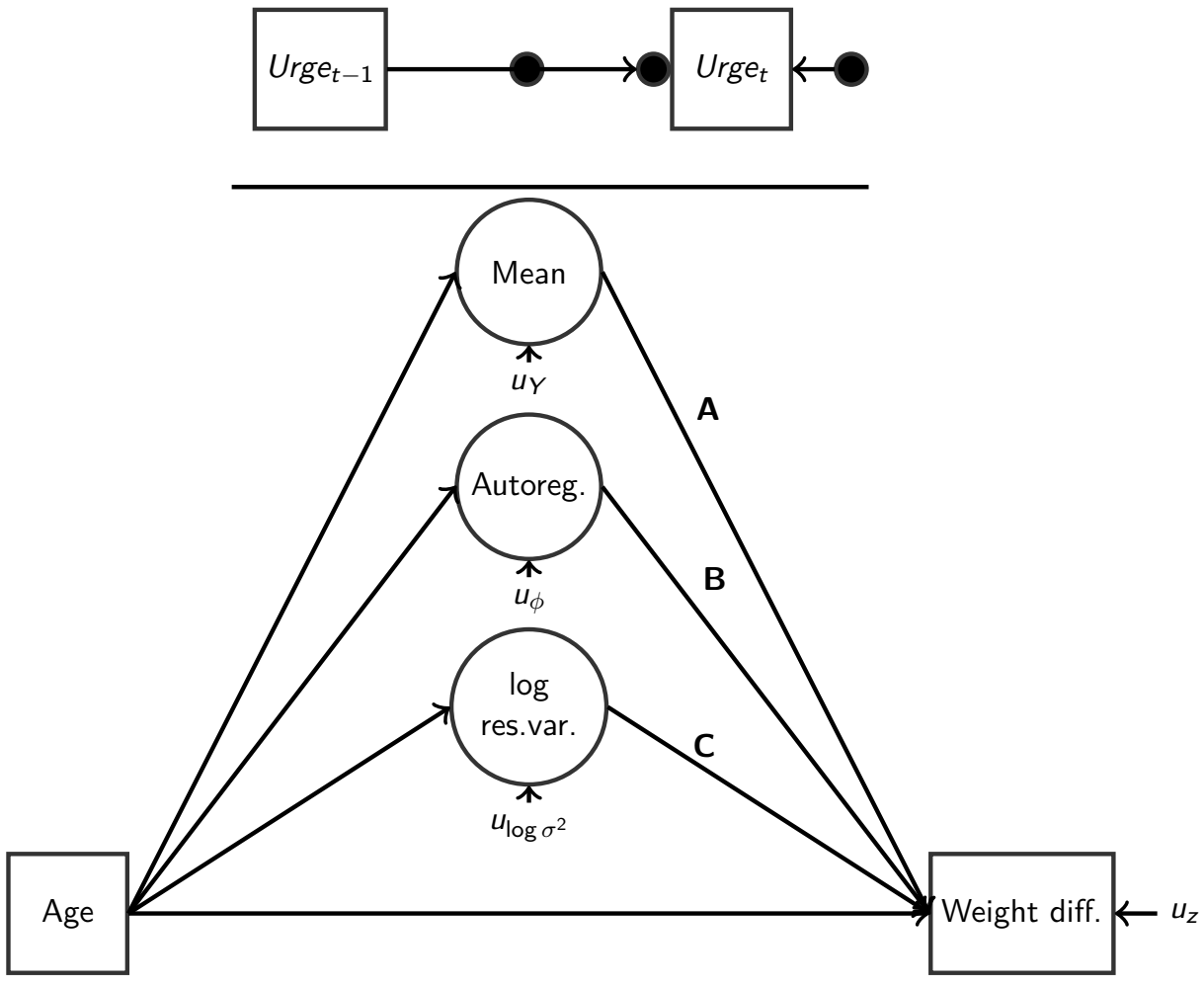
Using the total number of observations as a common scale simplifies the comparison of different N and T allocations

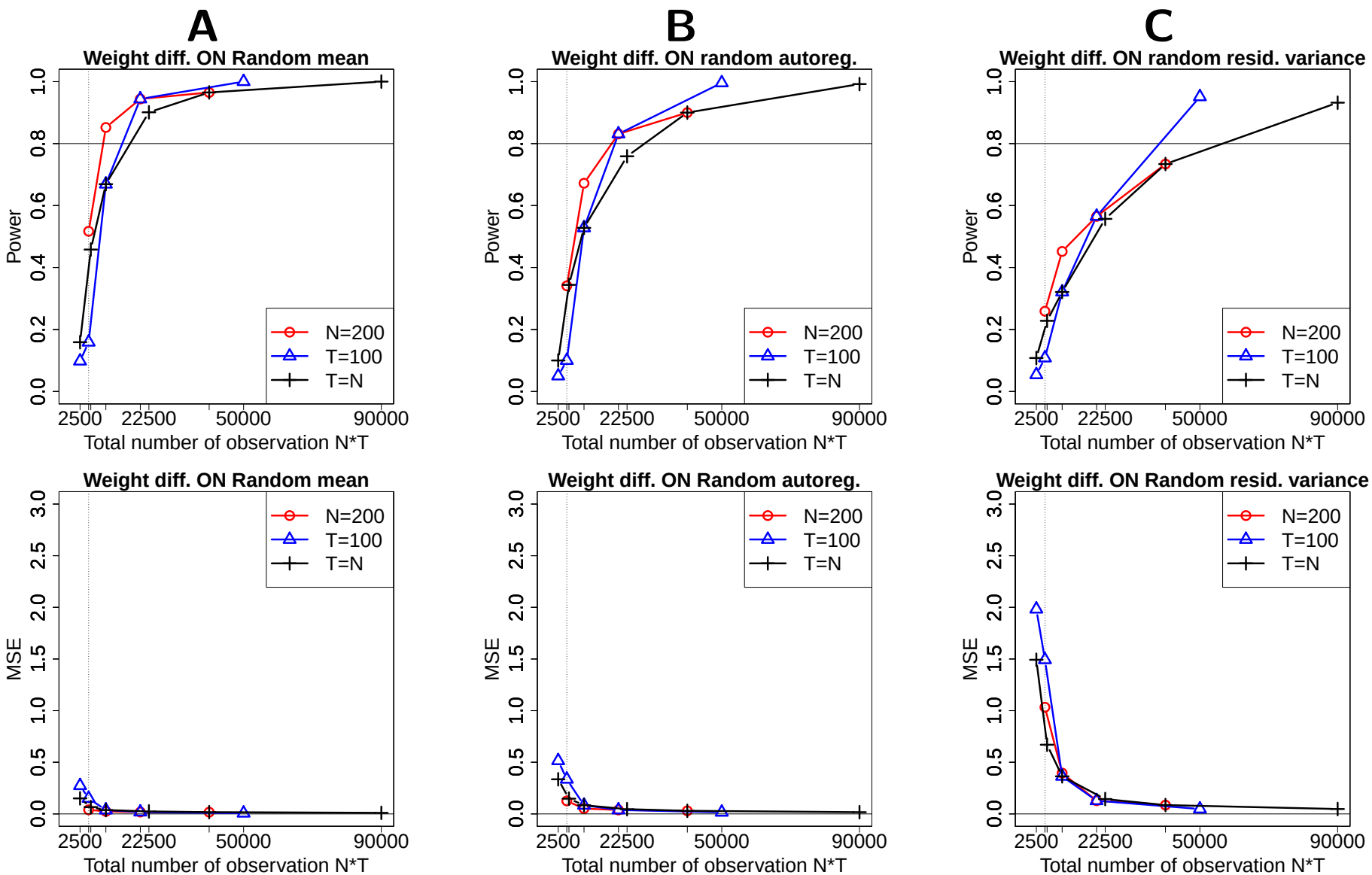

Random mean ON Age
Power
0.0
0.2
0.4
0.6
0.8
1.0
100
1500
3000
5000
10000
Total number of observation N*T
N=200
T=100
T=N

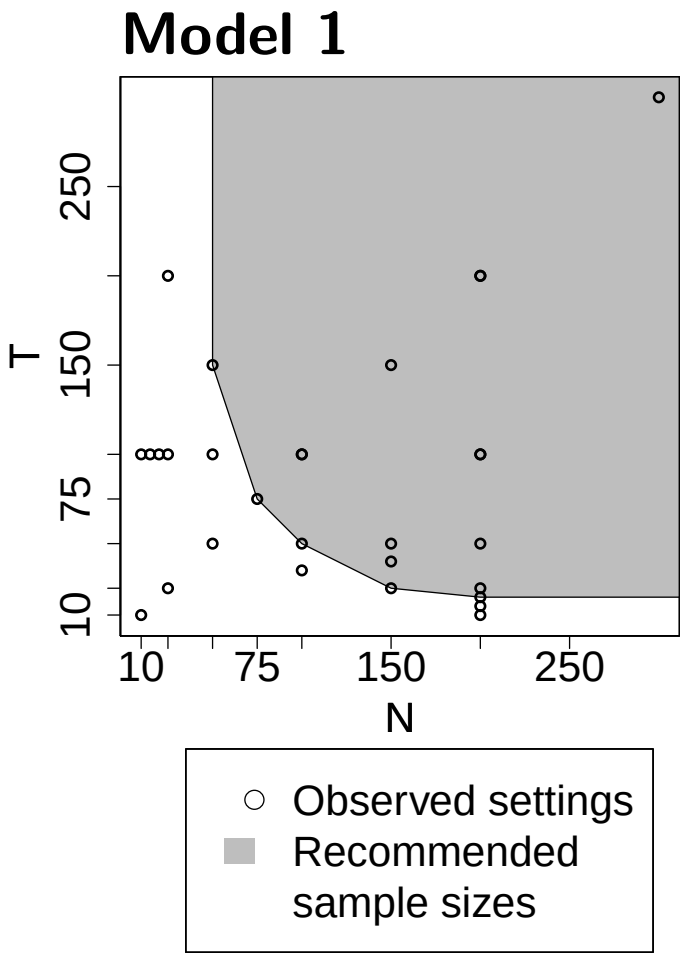

Model 1
$Urge_{t-1}$
$Urge_t$
Mean
u_Y
A
Age
B
Autoreg.
u_ϕ
C
log
res.var.
$u_{\log \sigma^2}$

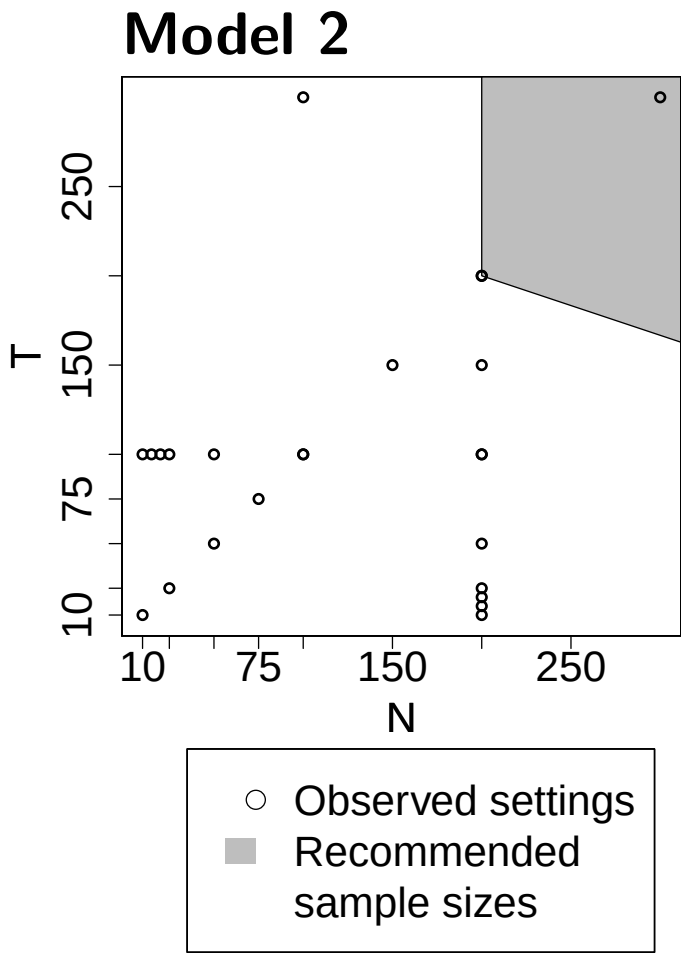

A
Random mean ON Age
B
Random autoreg. ON Age
C
Random resid. variance ON Age
Power
MSE
Total number of observation N*T
N=200
T=100
T=N
0.0
0.2
0.4
0.6
0.8
1.0
0.5
1.5
100
2000
4000
10000

Model 2


$Urge_{t-1}$
$Urge_t$
Mean
u_Y
A
Autoreg.
u_ϕ
B
log
res.var.
$u_{\log \sigma^2}$
C
Age
Weight diff.
u_z


A
Weight diff. ON Random mean
B
Weight diff. ON random autoreg.
C
Weight diff. ON random resid. variance
Power
MSE
Total number of observation N*T
2500
22500
50000
90000
N=200
T=100
T=N
0.0
0.2
0.4
0.6
0.8
1.0
0.5
1.5
2.0
2.5
3.0


Model 1
T
10
75
150
250
N
10
75
150
250
Observed settings
Recommended sample sizes


Model 2
T
10
75
150
250
N
10
75
150
250
Observed settings
Recommended sample sizes

Conclusion:

- Large N can compensate for small T better than vice versa
- The regressions of the random coefficients (Model 1) have lower sample size demands than regressions using the random coefficients as predictors (Model 2)
- Random mean has lower demands than random autoregressive coefficient and residual variance (Model 1 and 2)
- For Model 1 I would recommend T larger than 25, and N larger than 200.
- For Model 2 I would recommend T and N larger than 150. This model is only reasonable if the effect sizes of the slopes of the regression on the random coefficients are at least moderately large.
- In the paper we consider 9 model variations.

General setup:

- The usual Monte Carlo function in Mplus Version 8 was used (Muthén and Muthén, 2017).
- Batches of simulations were run and summarised with `MplusAutomation` (Michael N. Hallquist) in R.
- Three (sometimes four) parallel Mplus applications running on each computer.
  - The computer supports 8 threads
  - Each simulation uses 2 threads by the `processors=2;` option

- `biter=(5000);`
  - Convergence
  - Coverage
  - Power
- Autoregressive parameters > 1
  - Non-stationary - Exploding time series
  - Mplus detection limit - Helps, but only for large T?
  - The `Results = res.dat;` option allows for manual checks.

Learn more about DSEM and time intensive data analysis:

- Several interesting talks at IMPS next week
  - Pre conference workshop
  - Invited ILD Symposium: Intensive Longitudinal Data: Past, Present, and Future. Thursday, 8:30 a.m.-10:00 a.m., KO2-F-180
- August 17-18: 2-day short course at Johns Hopkins University

Thank you!

Asparouhov, T., Hamaker, E., and Muthen, B. (2017). Dynamic Structural Equation Models. *Unpublished*, pages 1–56.

Muthén, L. K. and Muthén, B. O. (2017). *Mplus User ' s Guide 8*.