SimTech

Institute for Visualization
and Interactive Systems

University of Stuttgart
Germany

Mixed-effects models in EEG

Statistically evaluating mixed-effects models for EEG analysis using large-scale simulations

January 20, 2023

Agenda

Recap → Results → Limitations → Discussion

Overview

Number of subjects

Number of items

Between-subject variability

Modelling Scheme

Analysis

Statistical Power

Overview

Number of subjects

1
2
⋮

Number of items

A
B

Between-subject variability

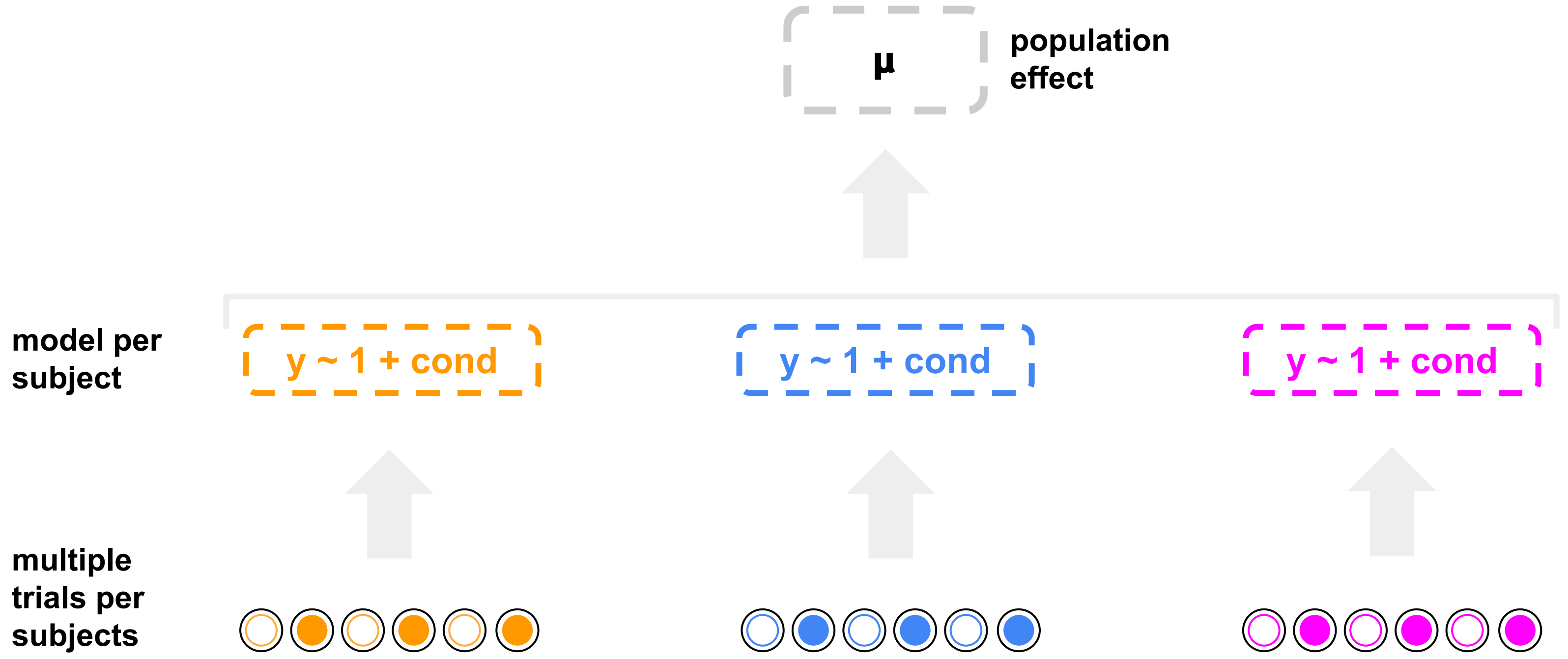
Modelling Scheme

Analysis

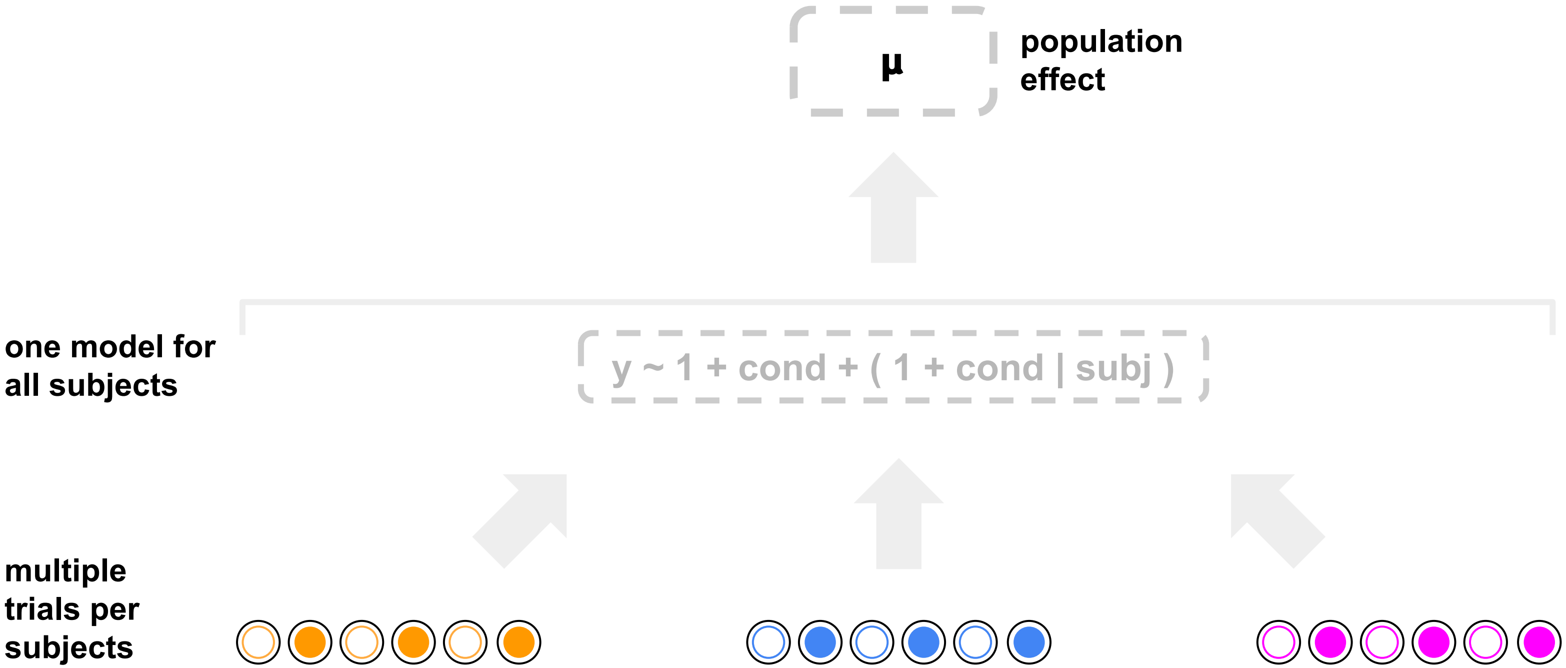
Statistical Power

Motivation? Many neuroscience studies have low statistical power
=> bad reproducibility
=> LMMs better in some cases?

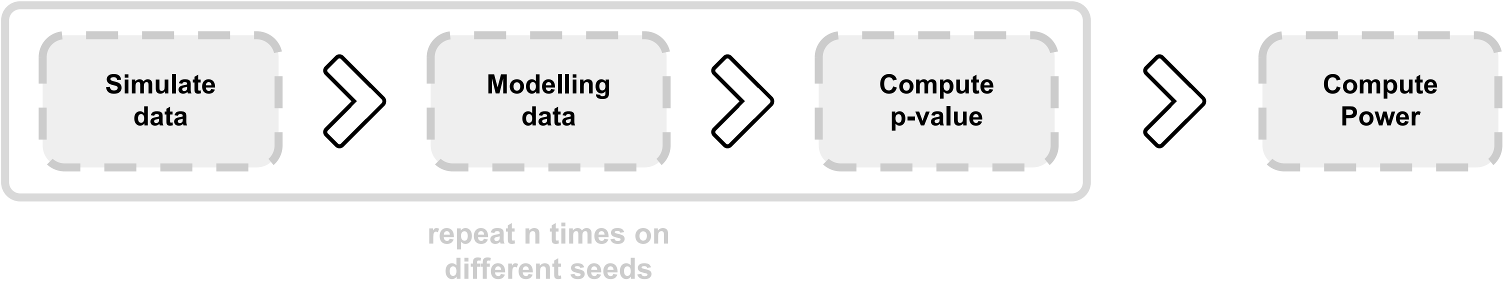
Two-stage approach



Linear mixed model approach



Approach


Simulate data
Modelling data
Compute p-value
Compute Power
repeat n times on different seeds

Simulation Toolbox

unfoldtoolbox / UnfoldSim.jl Public

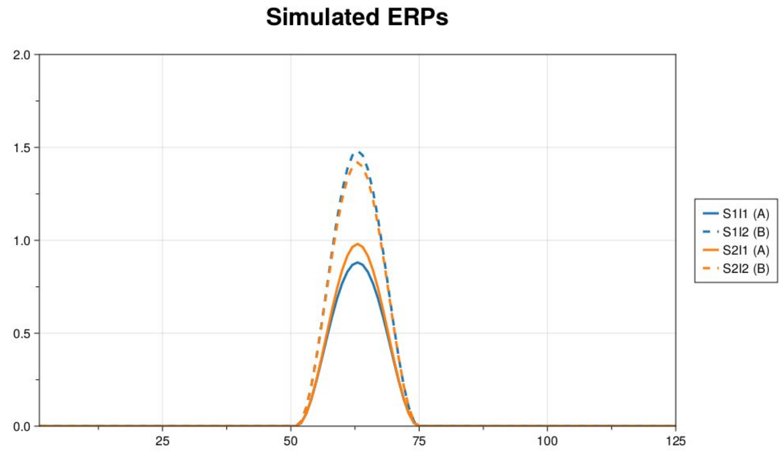
UnfoldSim

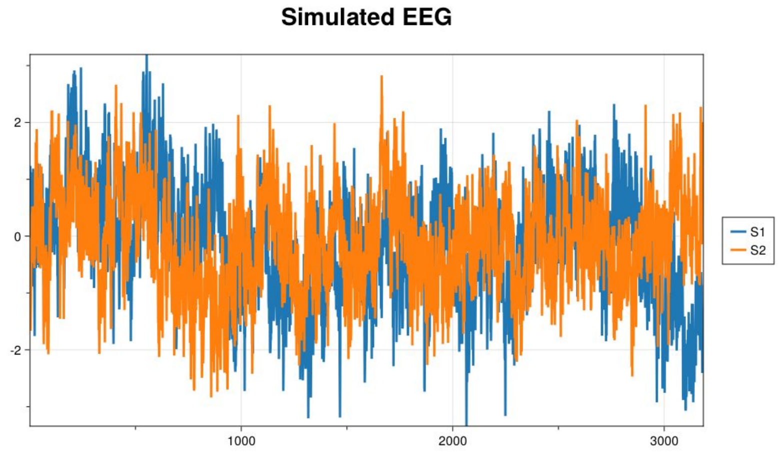
docs stable | docs dev | CI passing | codecov unknown

A package to simulate single timeseries model-based ERPs, fMRI activity, pupil dilation etc. If you have one channel, it is a timeseries of (overlapping) event-related activity and some noise - you might have fun here!

Note: Not released yet

Simulation Toolbox

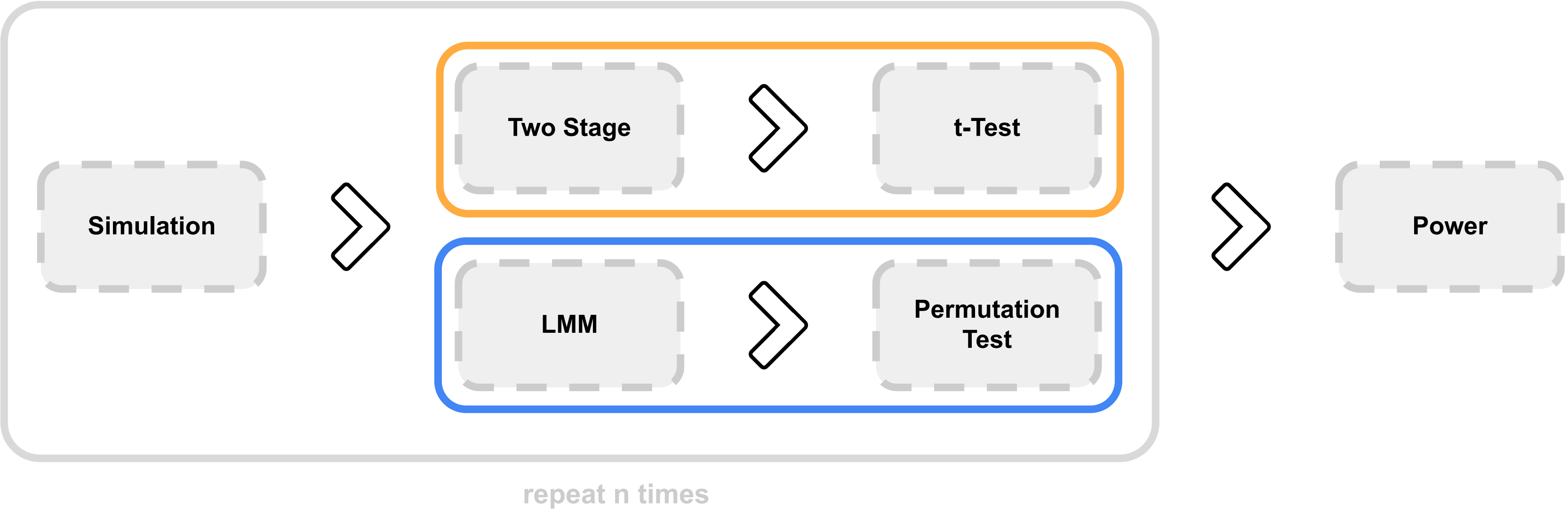




Used model notation:

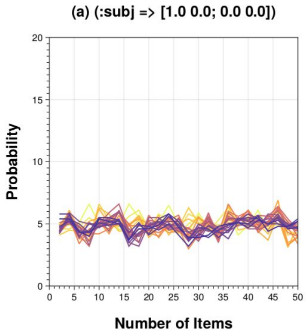
y ~ 1 + cond + (1 + cond | subj)

Computing p-values

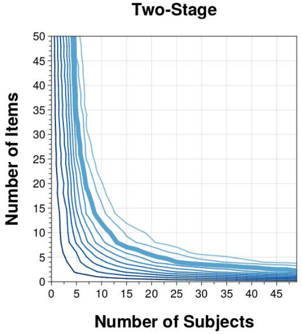


Two-stage vs LMM

Type 1 error



Power contour

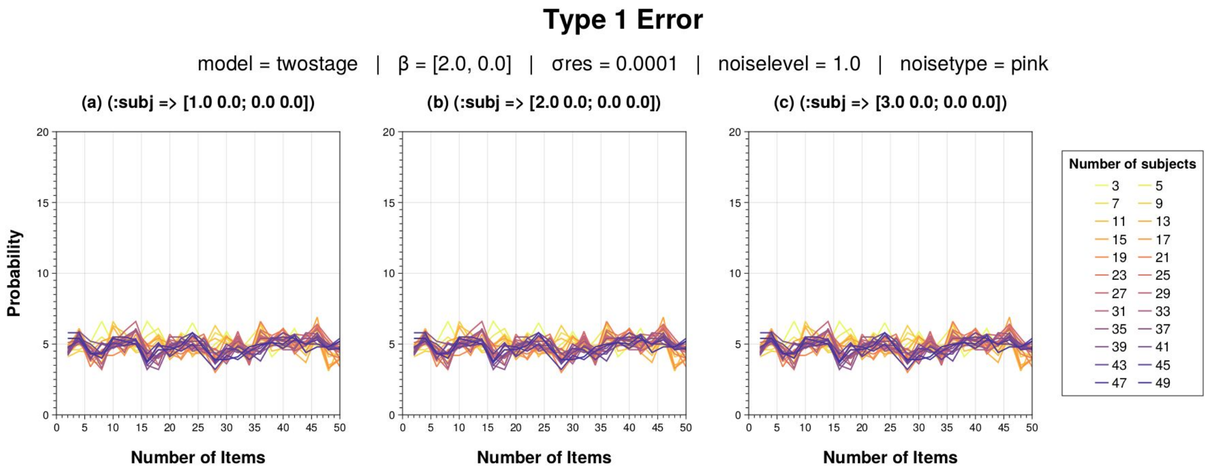


two-stage

Model

subj int

Varying

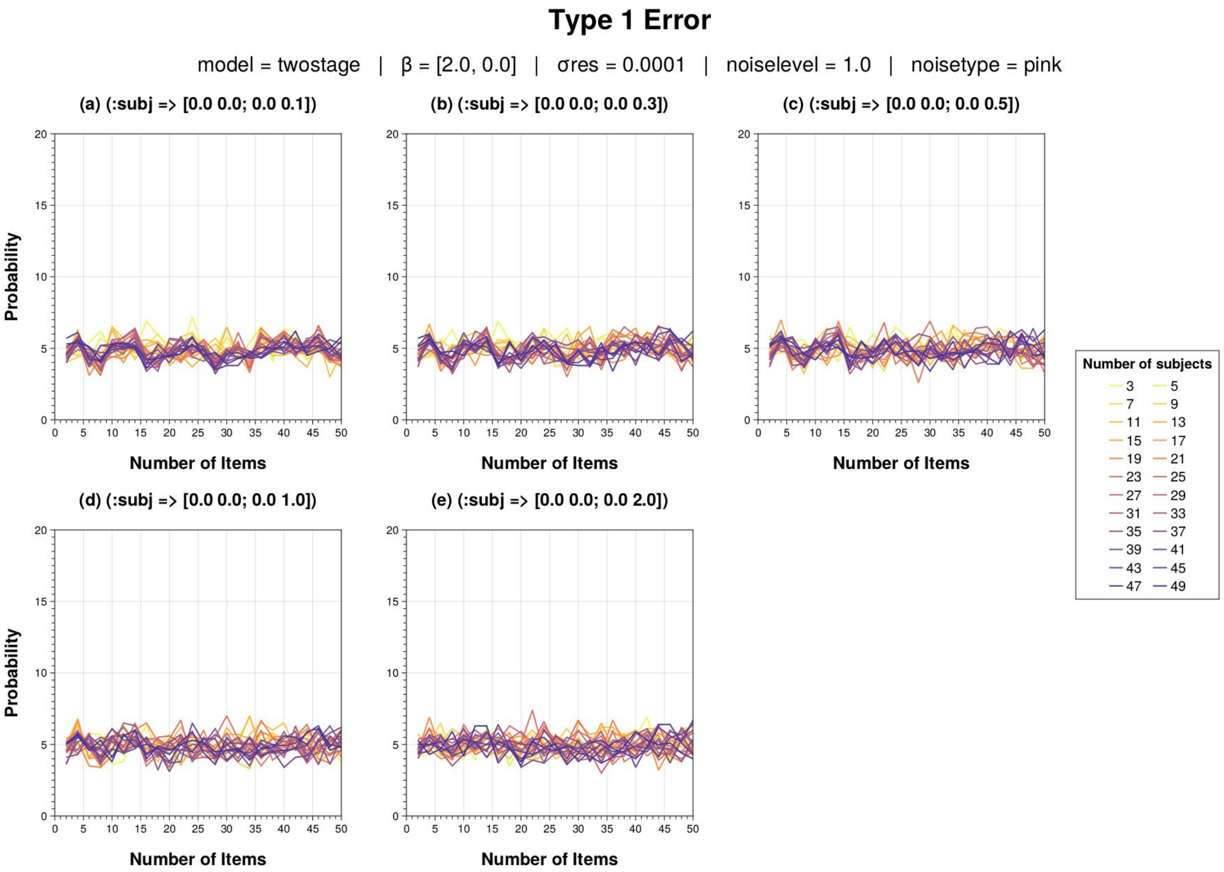


two-stage

Model

subj slope

Varying

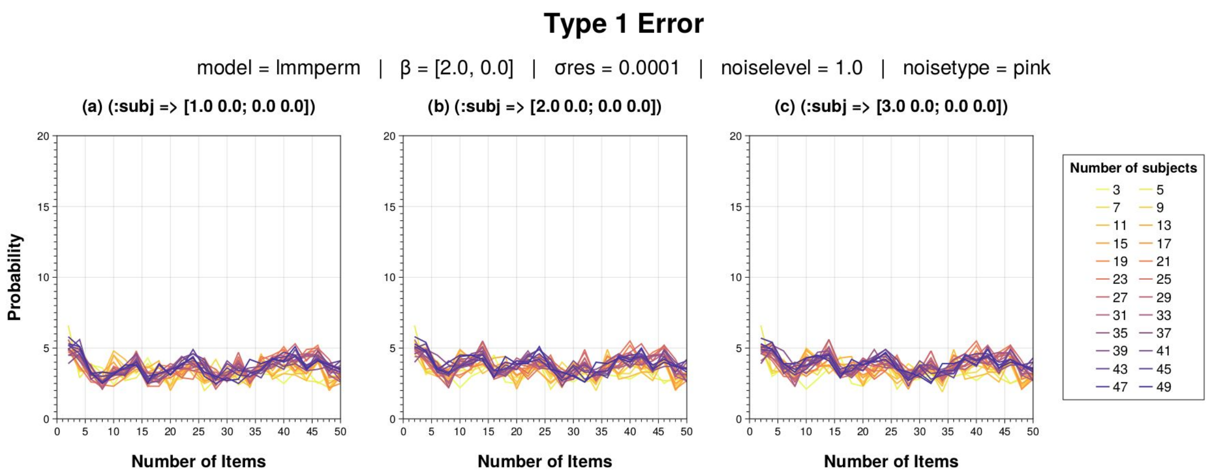


lmm

Model

subj int

Varying



lmm

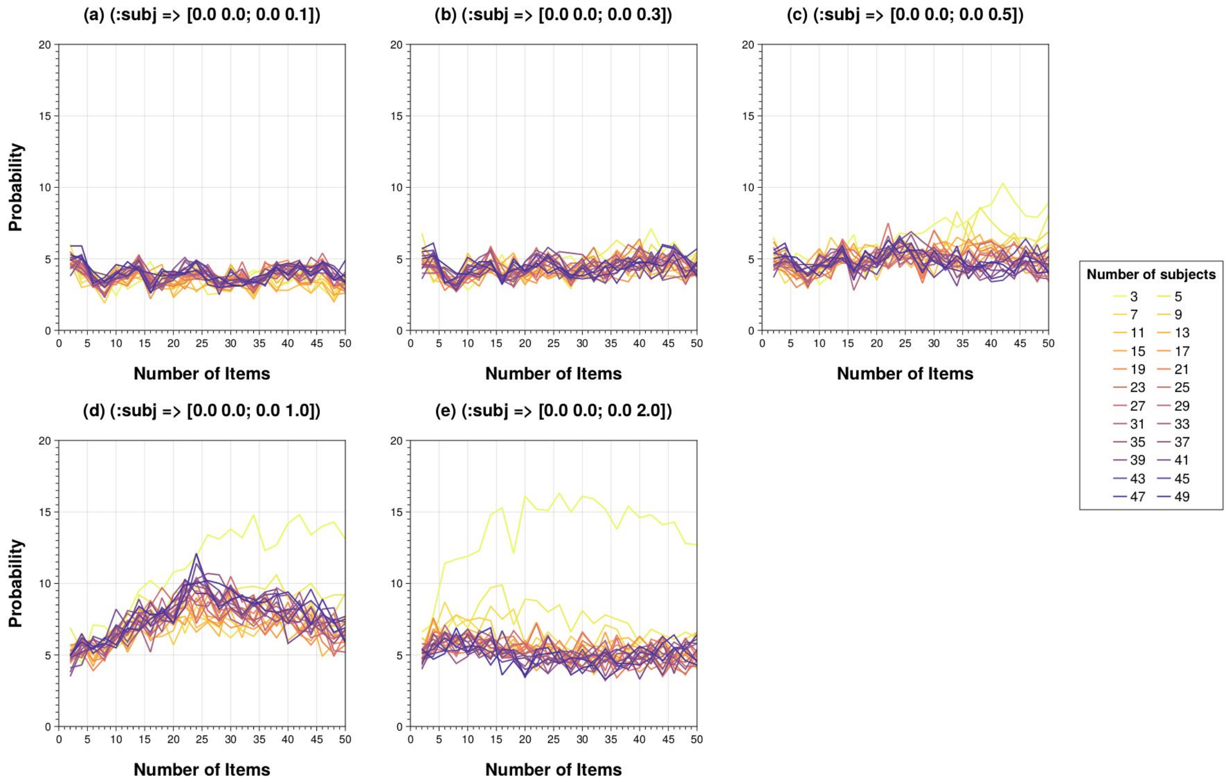
Model

subj slope

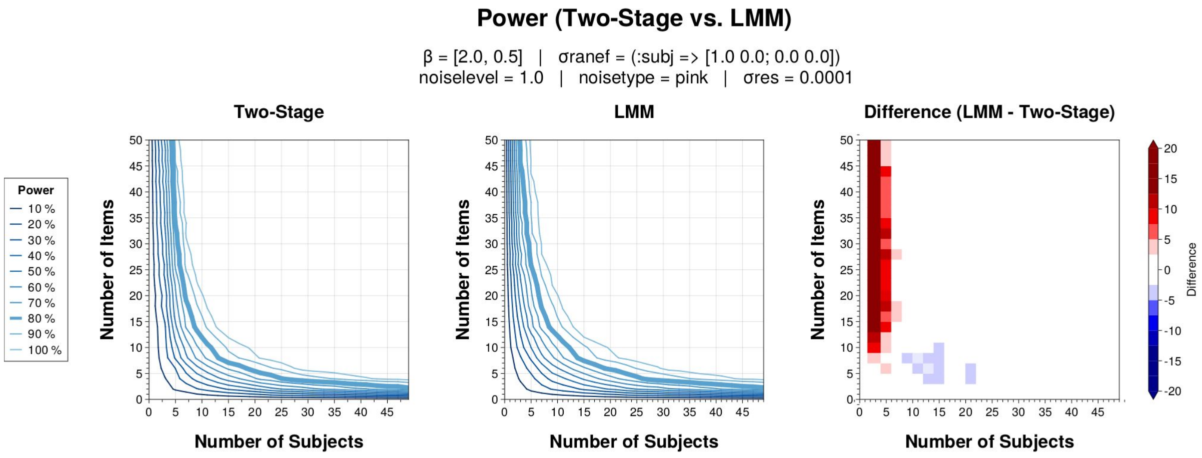
Varying

Type 1 Error

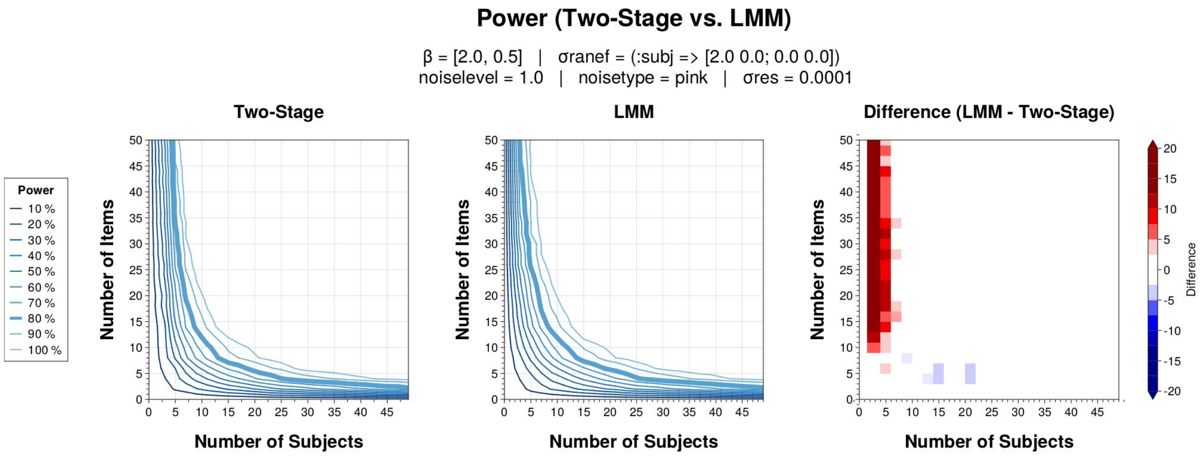
model = lmmperm | β = [2.0, 0.0] | σres = 0.0001 | noiselevel = 1.0 | noisetype = pink



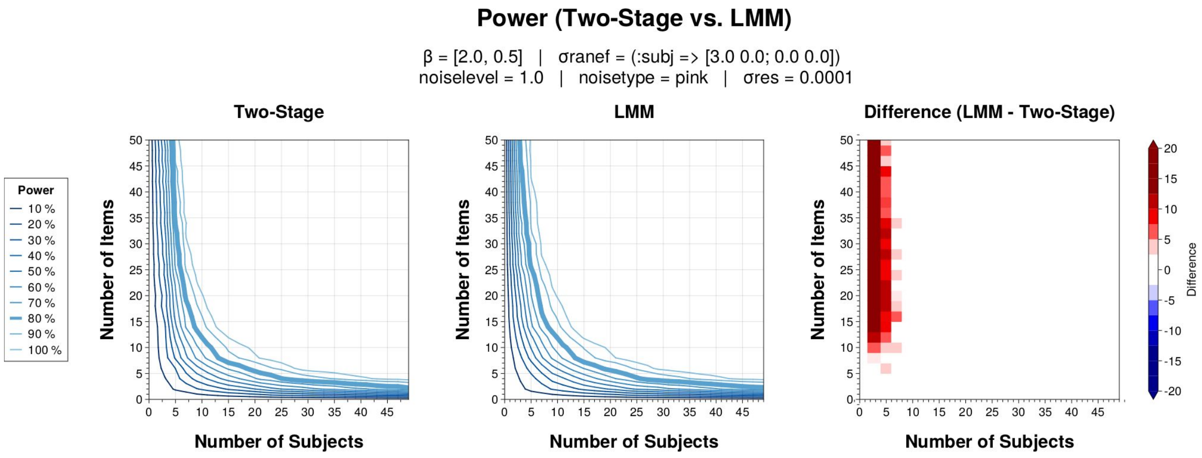
Varying subject intercept variance



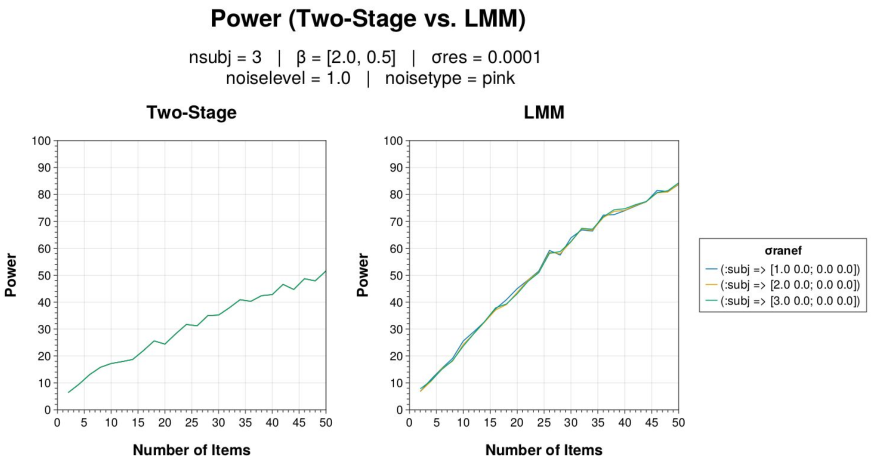
Varying subject intercept variance

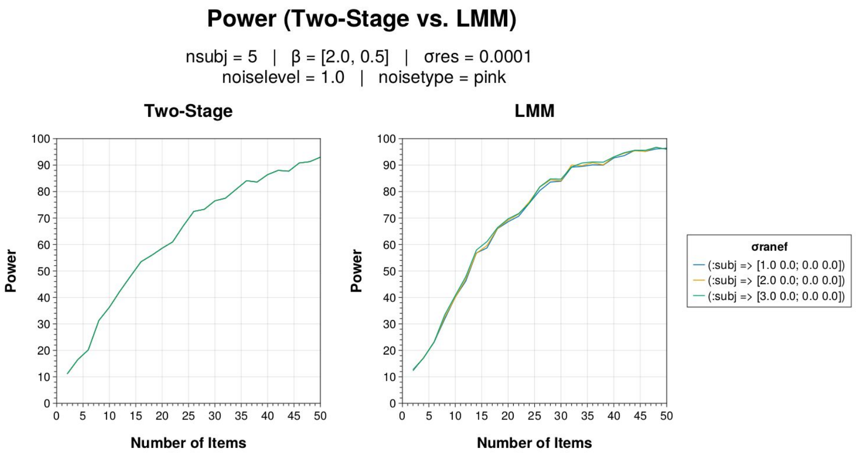


Varying subject intercept variance

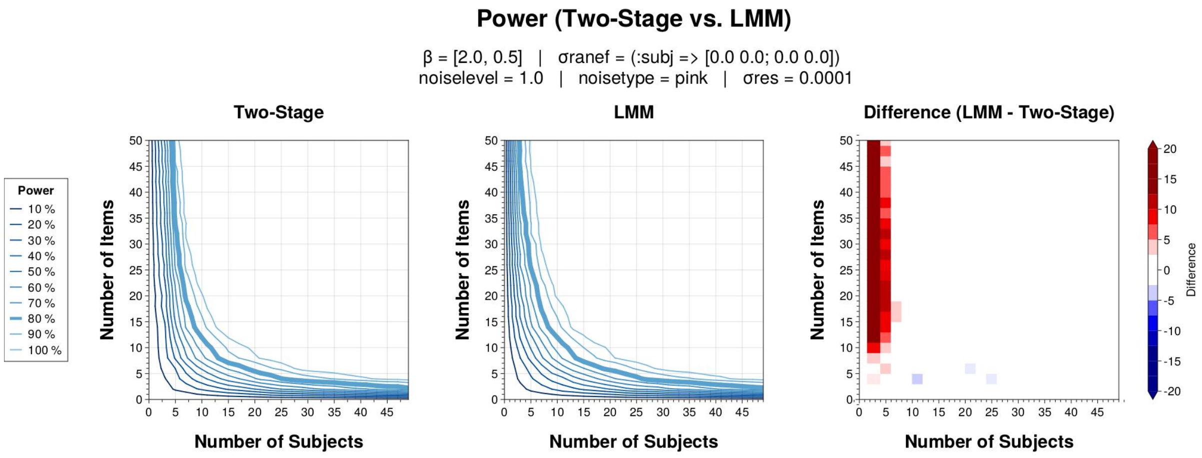


Varying subject intercept variance

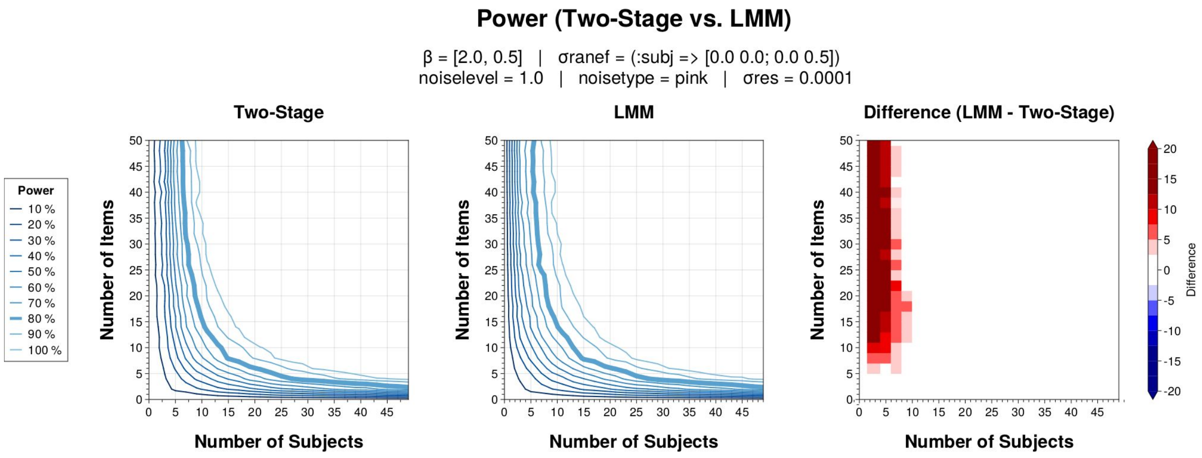




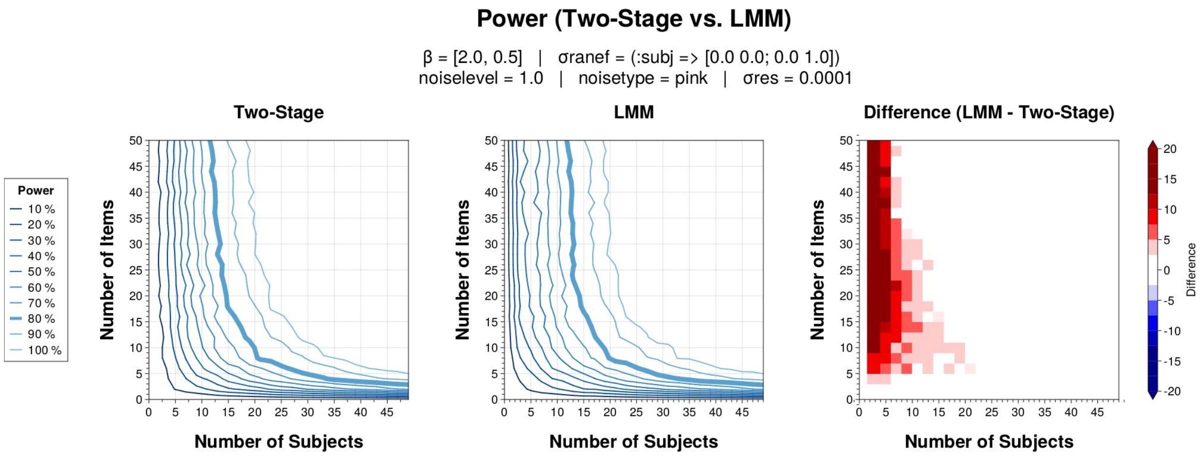
Varying subject slope variance



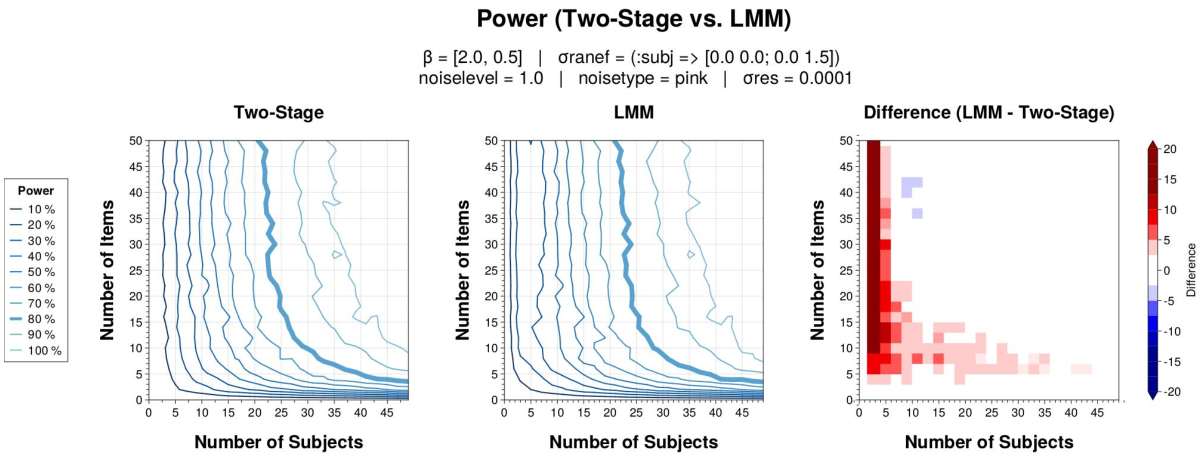
Varying subject slope variance



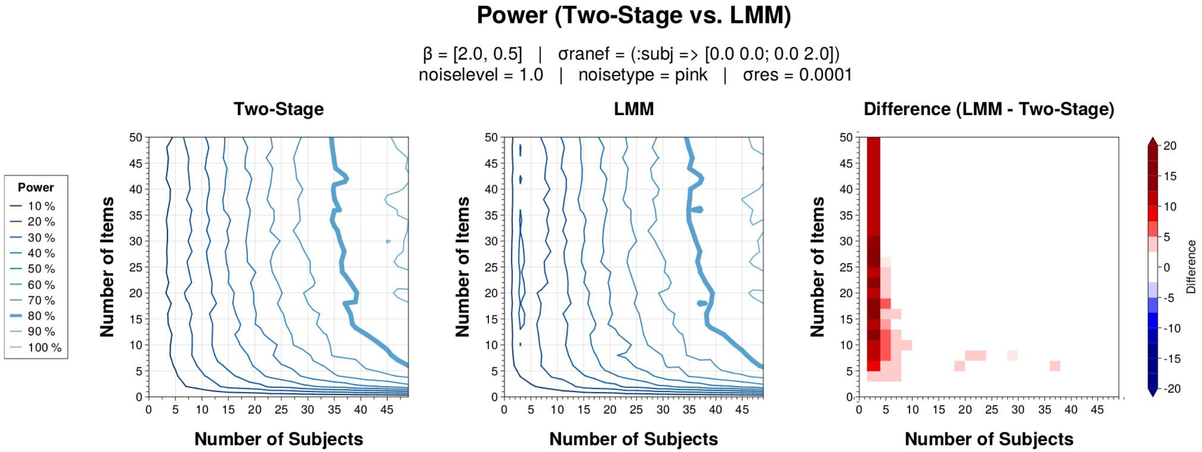
Varying subject slope variance



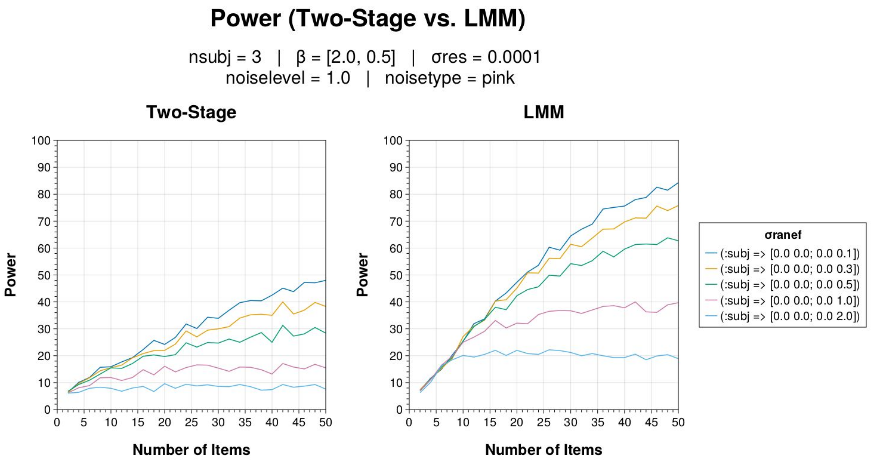
Varying subject slope variance

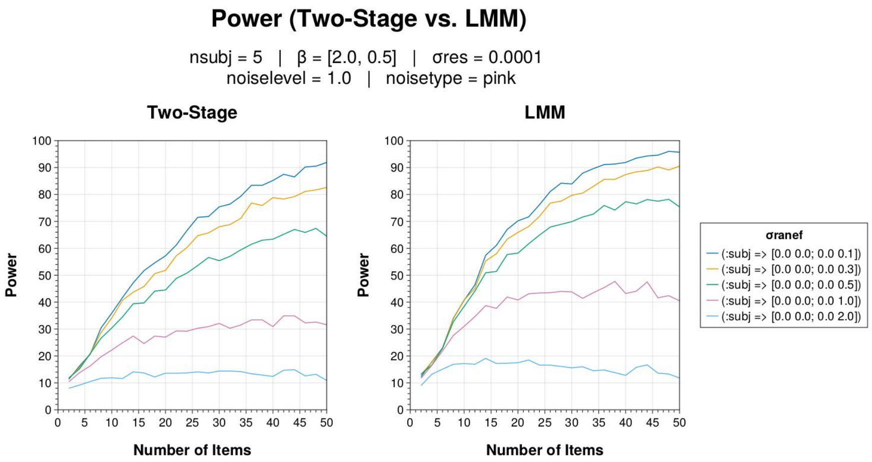


Varying subject slope variance



Varying subject slope variance





Limitations

Simulated data

Small parameter space

Increased type 1 error for LMMs

Conclusion

Observed results did NOT show an advantage of the LMMs over the two-stage approach

Different scenarios / parameters need to be investigated for a more founded conclusion

UnfoldSim.jl good starting point for further investigation

Discussion

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