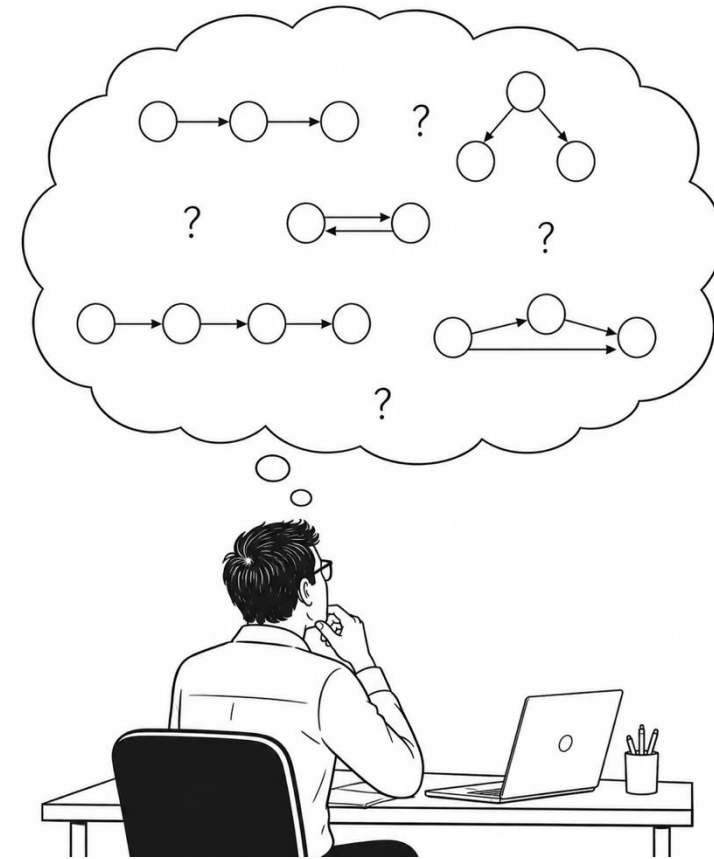


Bayes Factors for Structural Equation Models

with *bridgesampling* and *blavaan*

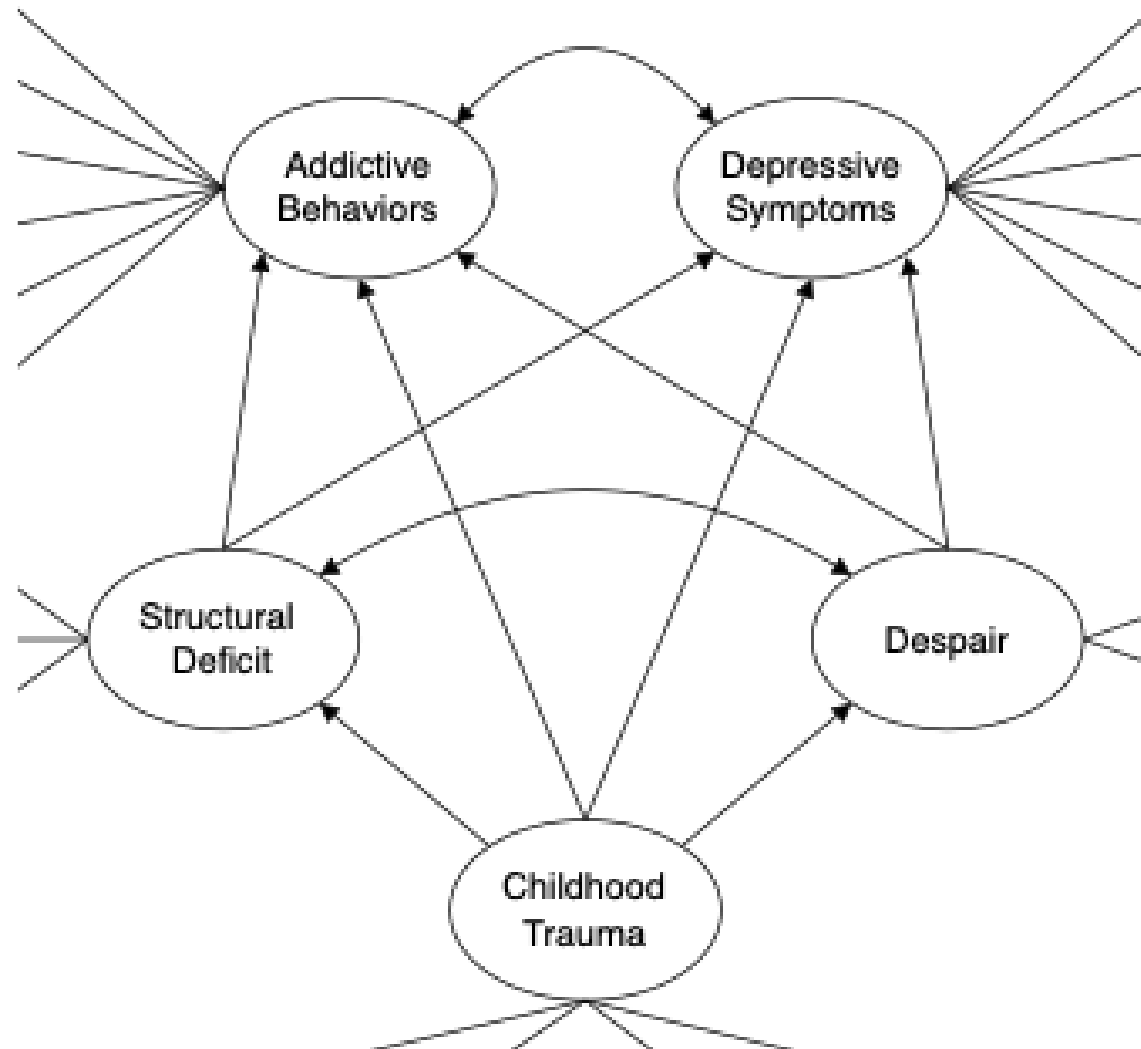


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Fuchshuber et al, 2018

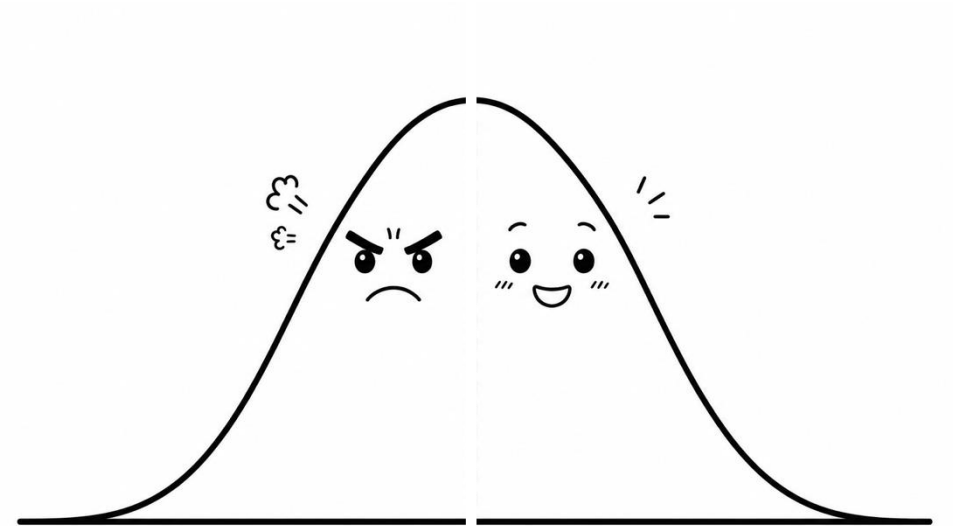
Motivation – Model comparison in SEM

We want a method that can:

- Quantify evidence
- Reward parsimony
- Consistent
- Incorporate prior information

→ *Marginal likelihoods* and their ratio,
Bayes factor:

- Why are Bayes factors rarely used in SEM?
 - Focus on estimation
 - Priors seen as the enemy (but they can be your friend)



Motivation – BIC

- Most simple method for BFs in SEM: difference of BICs (see Kaplan & Lee, 2016)
- BIC corresponds to a hidden prior: **unit-information (UI) prior**
 - Centered at the MLE
 - Spread relatively diffuse: One observation worth of information
 - Changing the prior information is almost impossible
 - Conservative against complex models
- Our goal:
 - ➔ Workflow to obtain BFs with accurate marginal likelihood estimation while incorporating prior
 - ➔ Usable software: *blavaan* and *bridgesampling*

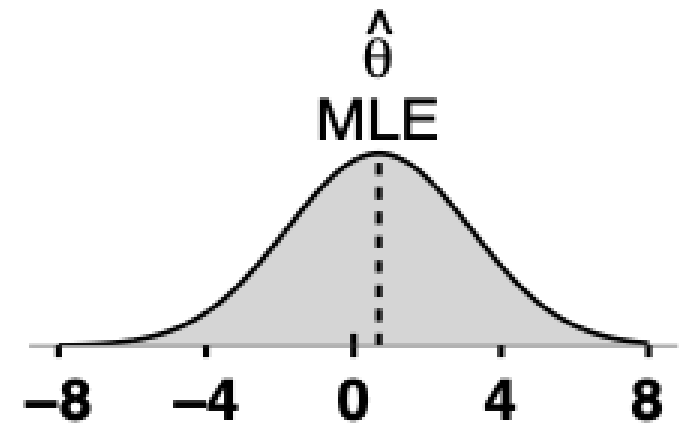
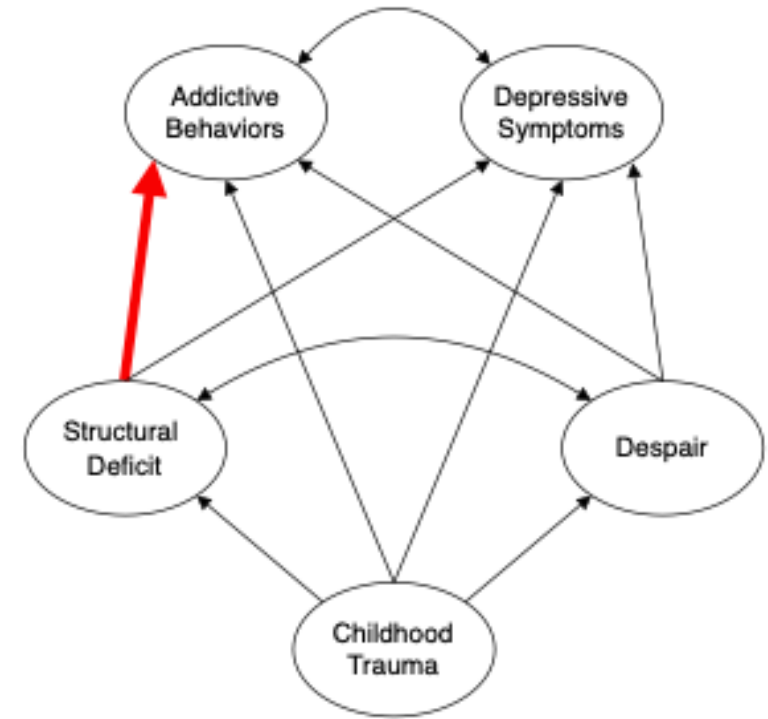
Methodology – UI Prior

Which priors for model comparison?

- UI-prior as starting point to incorporate prior information
- *blavaan*: approximate *MVN* UI-prior with a product of univariate UI-priors (Ntzoufras, 2009)

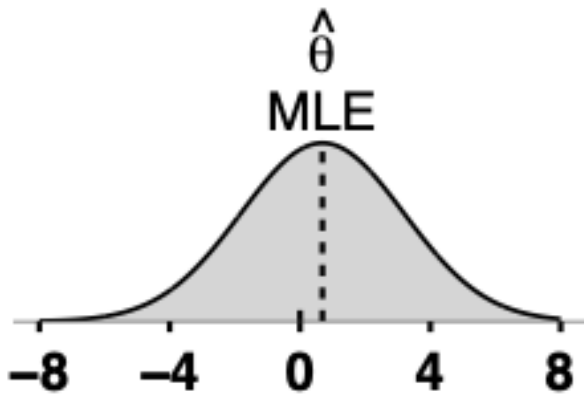
Example: UI-prior on regression path:

- Centered at the MLE, and SD as $\sqrt{N} \cdot SE$:
- $Normal(0.687, SD = 2.5)$ at a sample size of 500



Methodology – UI-type priors

UI baseline



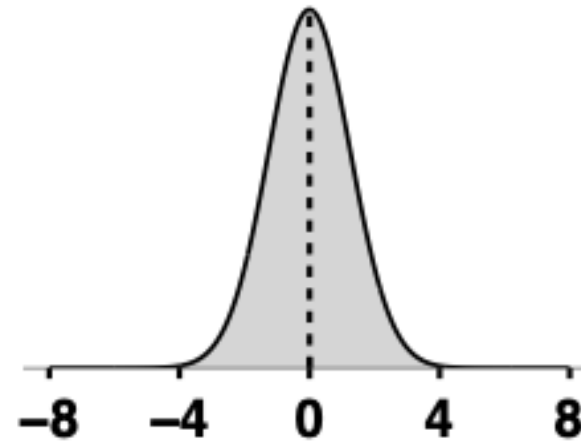
- mean at the MLE
- SD at $\sqrt{N} \cdot SE$

UI-0



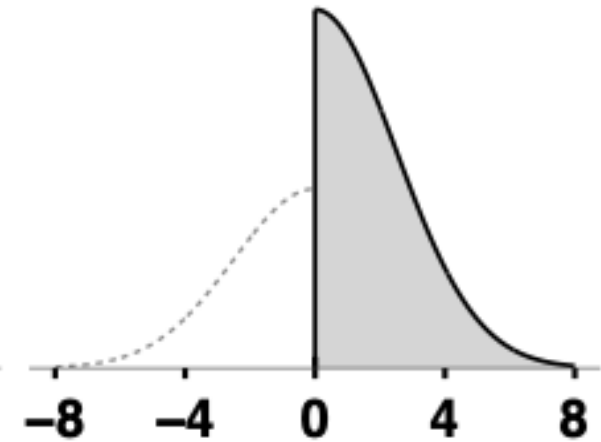
- mean at 0
- SD at $\sqrt{N} \cdot SE$

UI-0-half



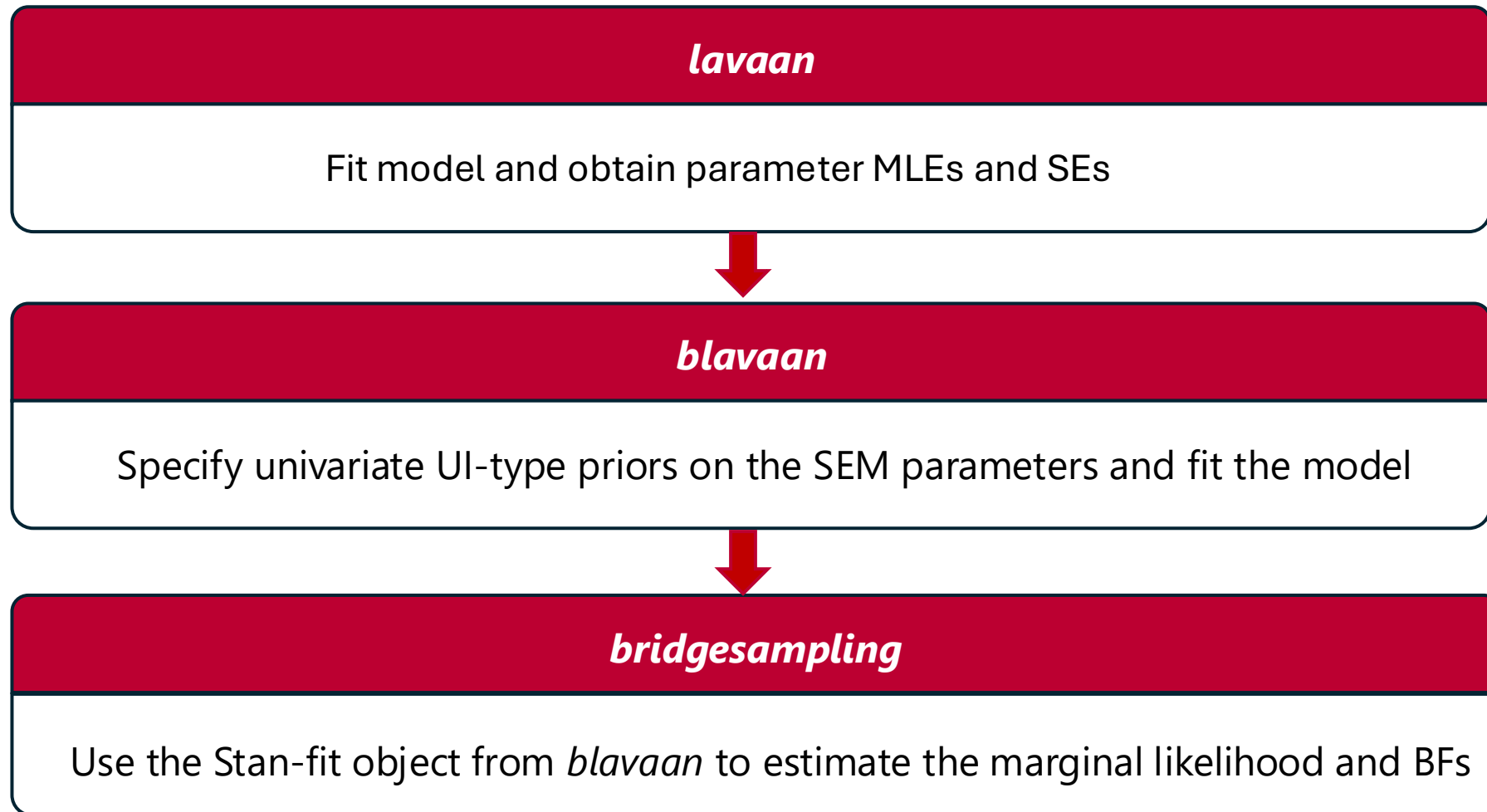
- mean at 0
- SD at $\frac{1}{2} \sqrt{N} \cdot SE$

UI-0-dir

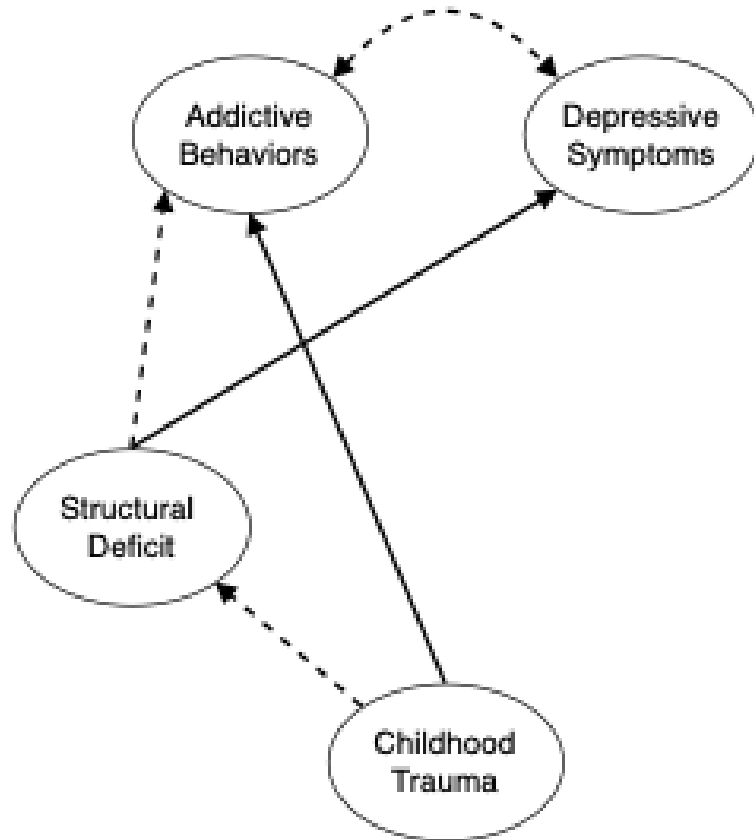


- same as UI-0, plus a positivity constraint

Methodology – in R



Small simulation – Setup



- Testing the *blavaan-bridgesampling* workflow to obtain BFs
- Generate data from M_1 (more complex) and from M_0
- Questions:
 - Do the BFs from the UI-prior baseline approximate the BIC BFs?
 - Using different priors what is the evidence in favour of the data generating model?

Small simulation – Results

- BF from univariate UI-baseline priors are close to the BIC BF
- When M_1 is true:
 - Re-centering from the MLE to zero (UI-0) changes the evidence little
 - Halving the prior spread (UI-0-half) increases the evidence for M_1
 - Adding the positivity constraint (UI-0-dir) increases it further
- When M_0 is true:
 - Every prior-variant-BF correctly favors M_0

Extensions

1. Robust mixture priors for SEM

- Compare models using multiple priors:
 - diffuse prior (e.g., UI-0)
 - informative prior (e.g., UI-0-dir)

2. Bayesian model averaging for SEM

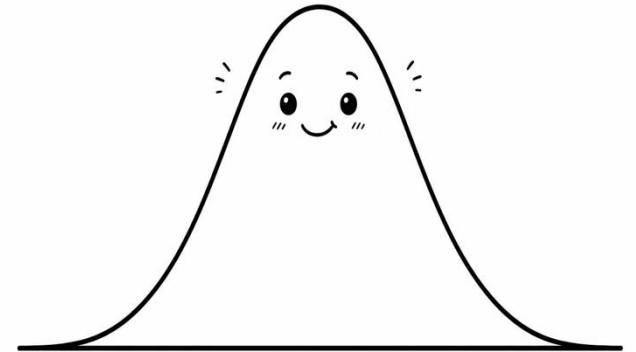
- Fit candidate models with *blavaan-bridgesampling* workflow
- Use different priors
- Average over models and priors

Conclusion

- (Unlike BIC) *bridge sampling* with *blavaan* makes the prior explicit and adjustable
- Informative priors can sharpen the evidence for the true model
- The *blavaan-bridgesampling* workflow is extendable (and usable)

Outlook:

- More validation
- More usability by implementation in JASP



Thank you

- Preprint at https://osf.io/preprints/psyarxiv/pt2bc_v1
- Code at <https://osf.io/wyuqd/>



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