Universität Zürich[UZH]

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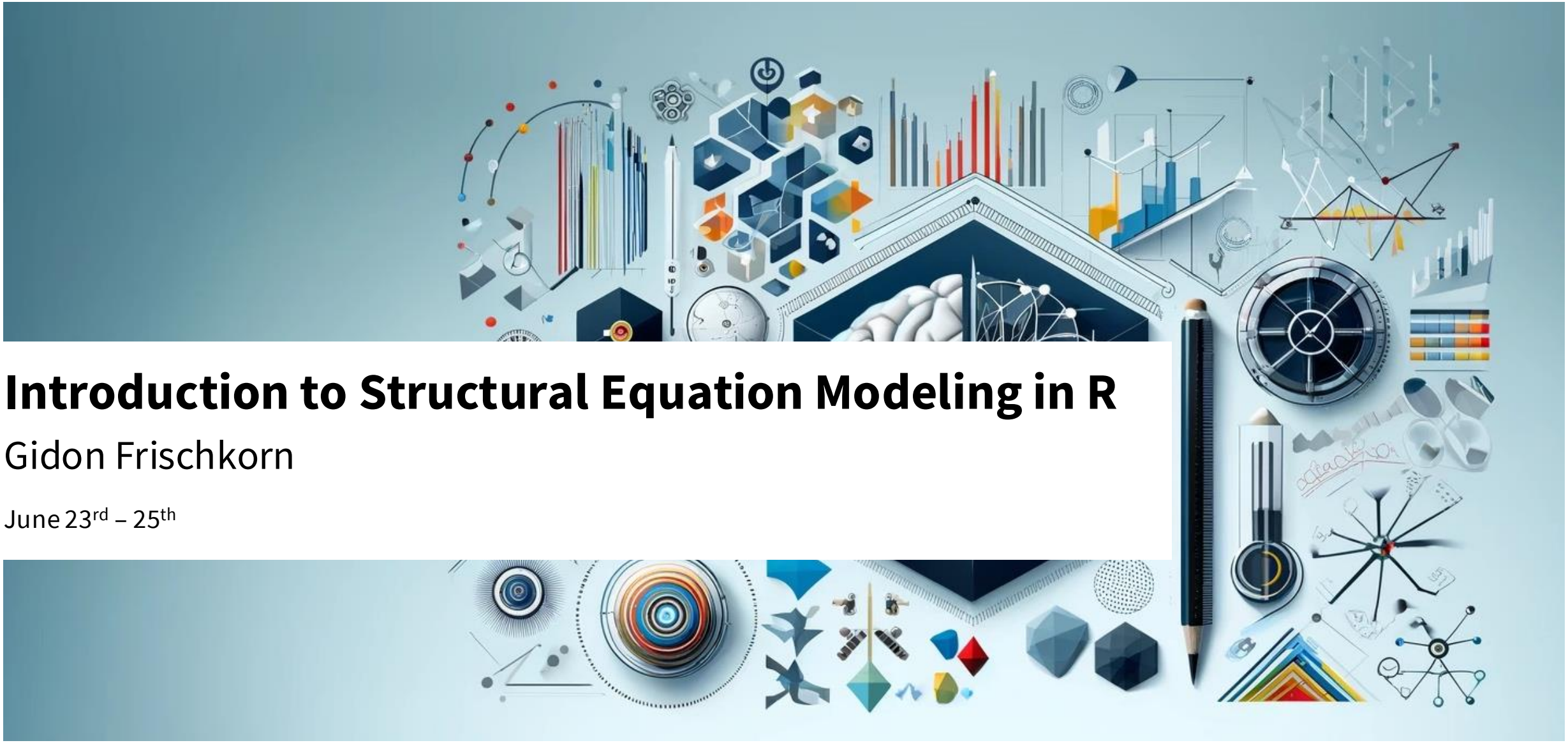
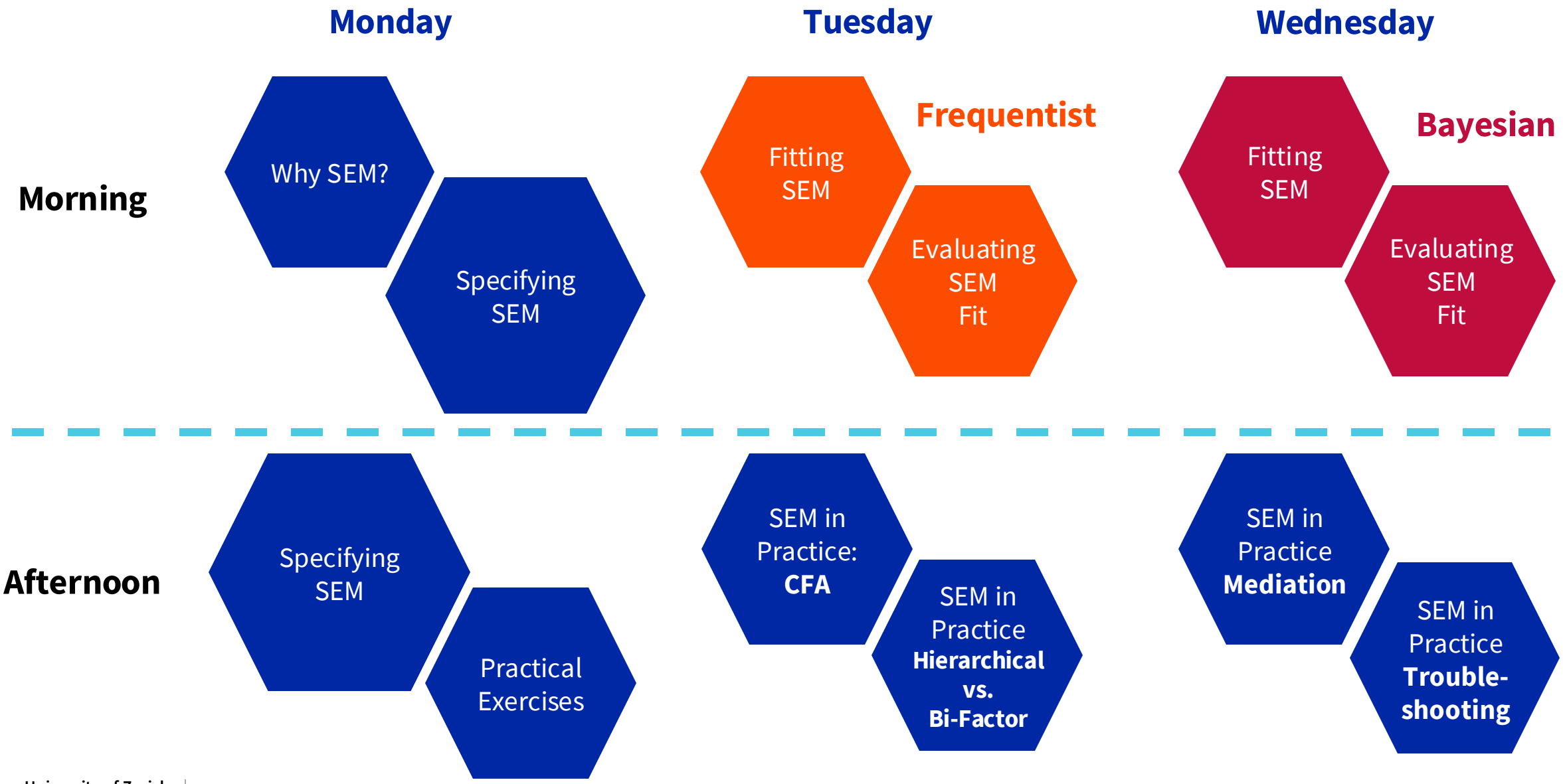


Introduction to Structural Equation Modeling in R

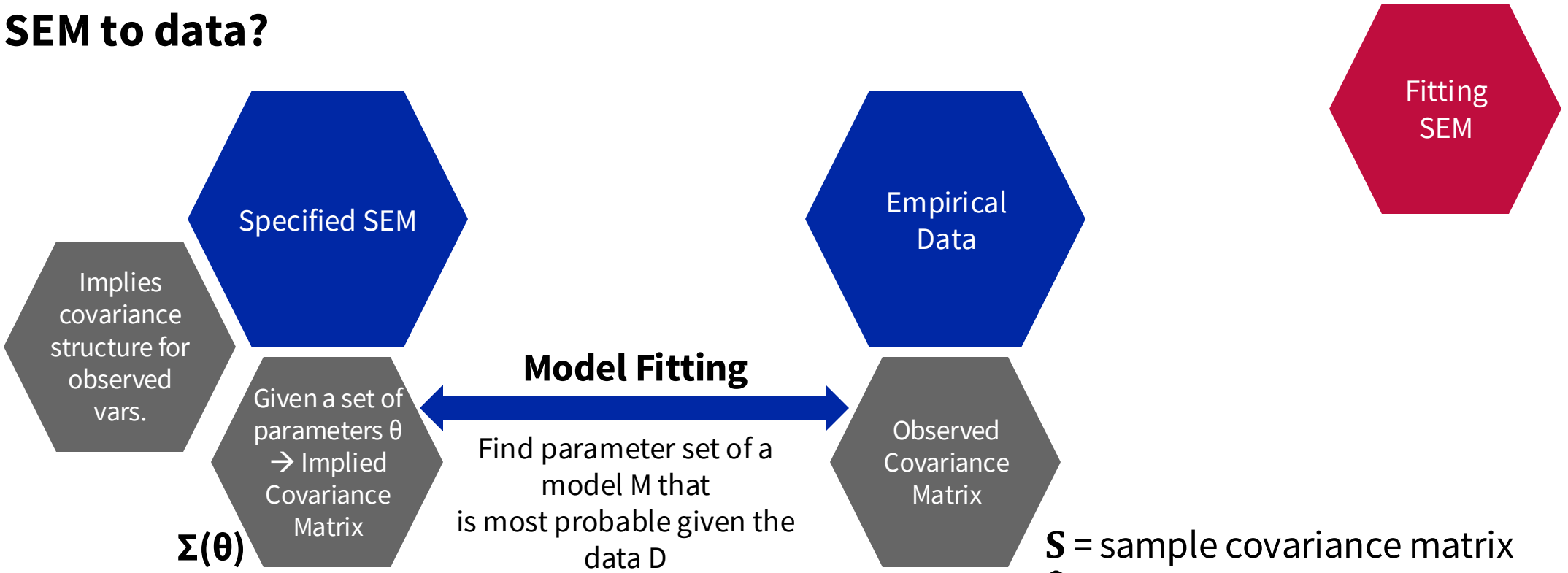
Gidon Frischkorn

June 23rd – 25th

SEM Workshop: Overview



How to fit SEM to data?



$\mathbf{S}$ = sample covariance matrix
$\hat{\boldsymbol{\Sigma}}$ = estimated population covariance matrix

Likelihood **Prior**

$$P(M|D) = \frac{P(D|M) * P(D)}{P(M)}$$

Posterior Model Probability

Marginal Likelihood

How to fit SEM to data?

Likelihood Prior

$$P(M|D) = \frac{P(D|M) * P(D)}{P(M)}$$

Posterior Model Probability

Marginal Likelihood

Fitting SEM

Specified SEM

Empirical Data

Benefits of Bayesian Estimation

Priors can restrict parameters to proper range

Posterior quantified uncertainty of model fit and parameters

Avoid negative variances & correlations larger than 1

How to fit SEM to data?

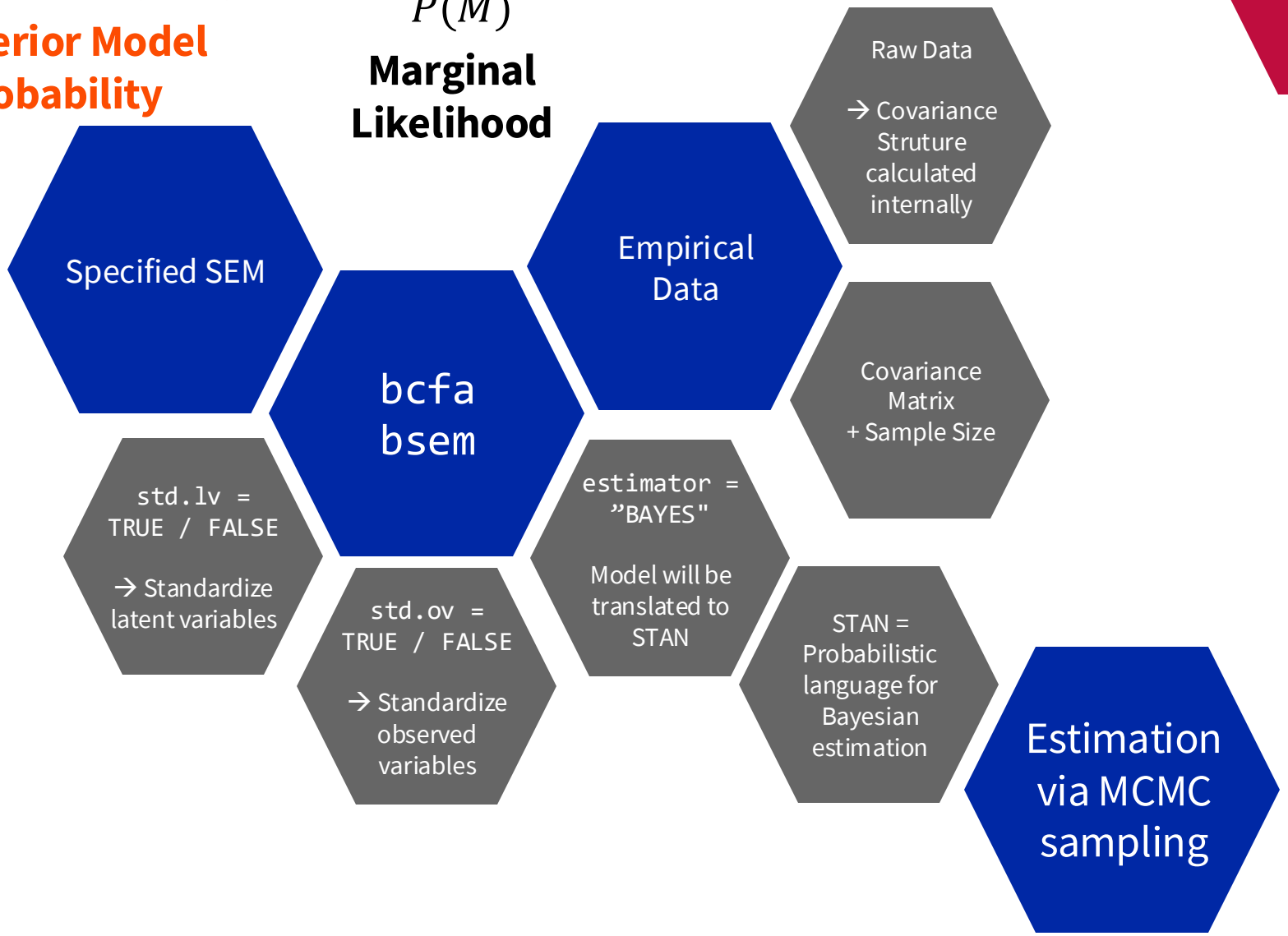
→ lavaan

Likelihood Prior

$$P(M|D) = \frac{P(D|M) * P(D)}{P(M)}$$

Posterior Model Probability

Marginal Likelihood



What are your questions so far?

How to fit SEM to data?

Fitting SEM

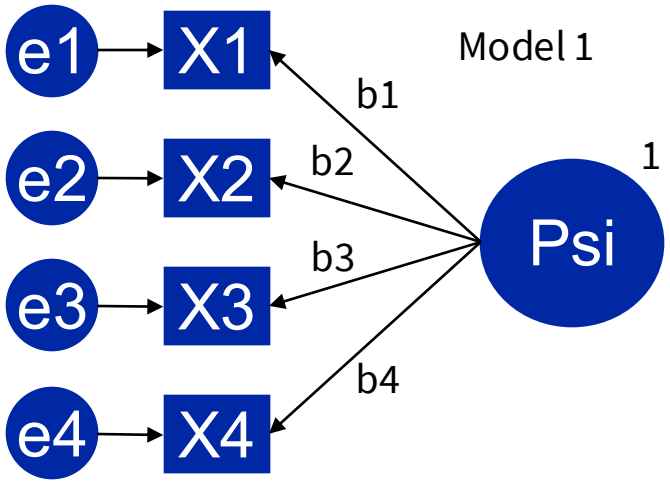
Exercise: Fit these models via Bayesian Estimation

```
# fit SEM
library(blavaan)
my_fit <- bsem(model, data)
summary(my_fit)
```

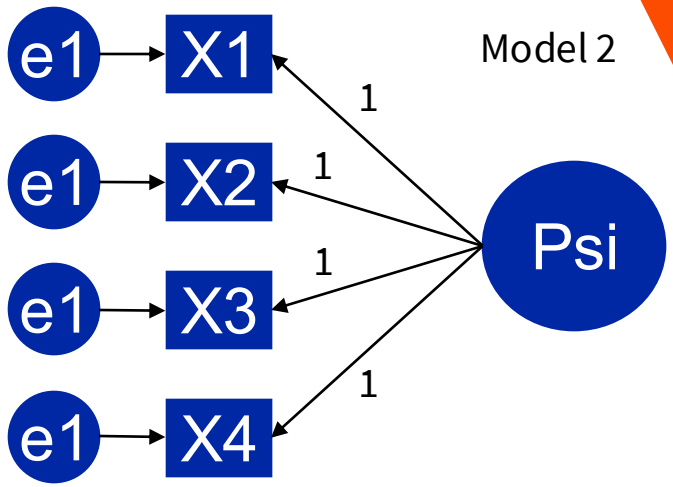
Try fitting different models to the same data

Check the summary What is different?

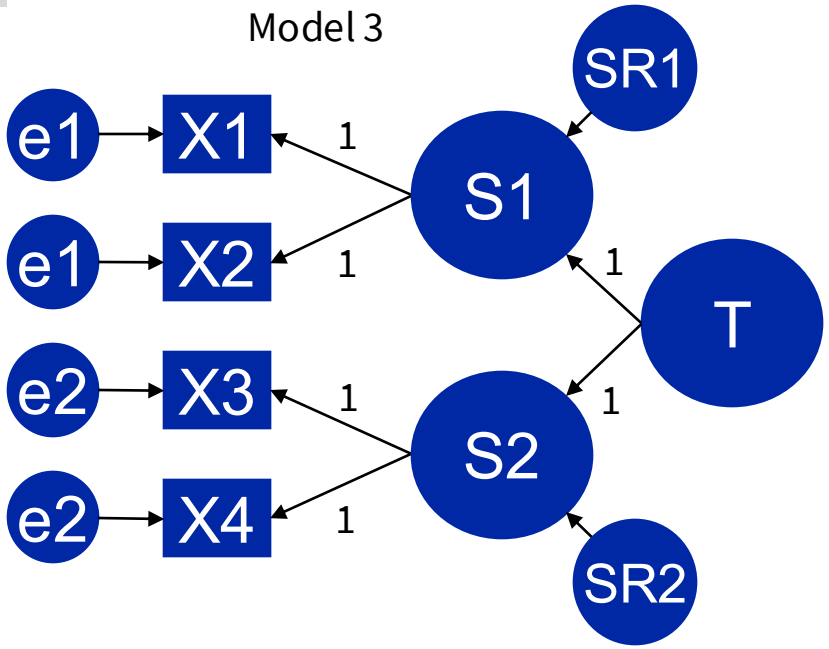
Model 1



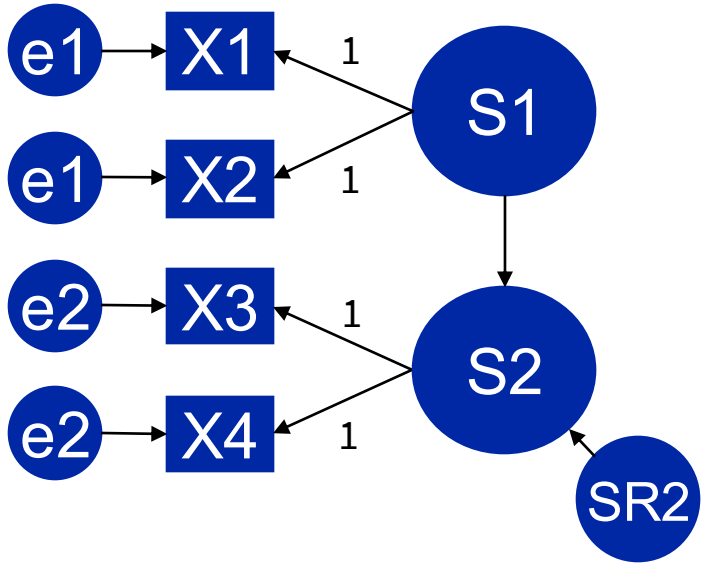
Model 2



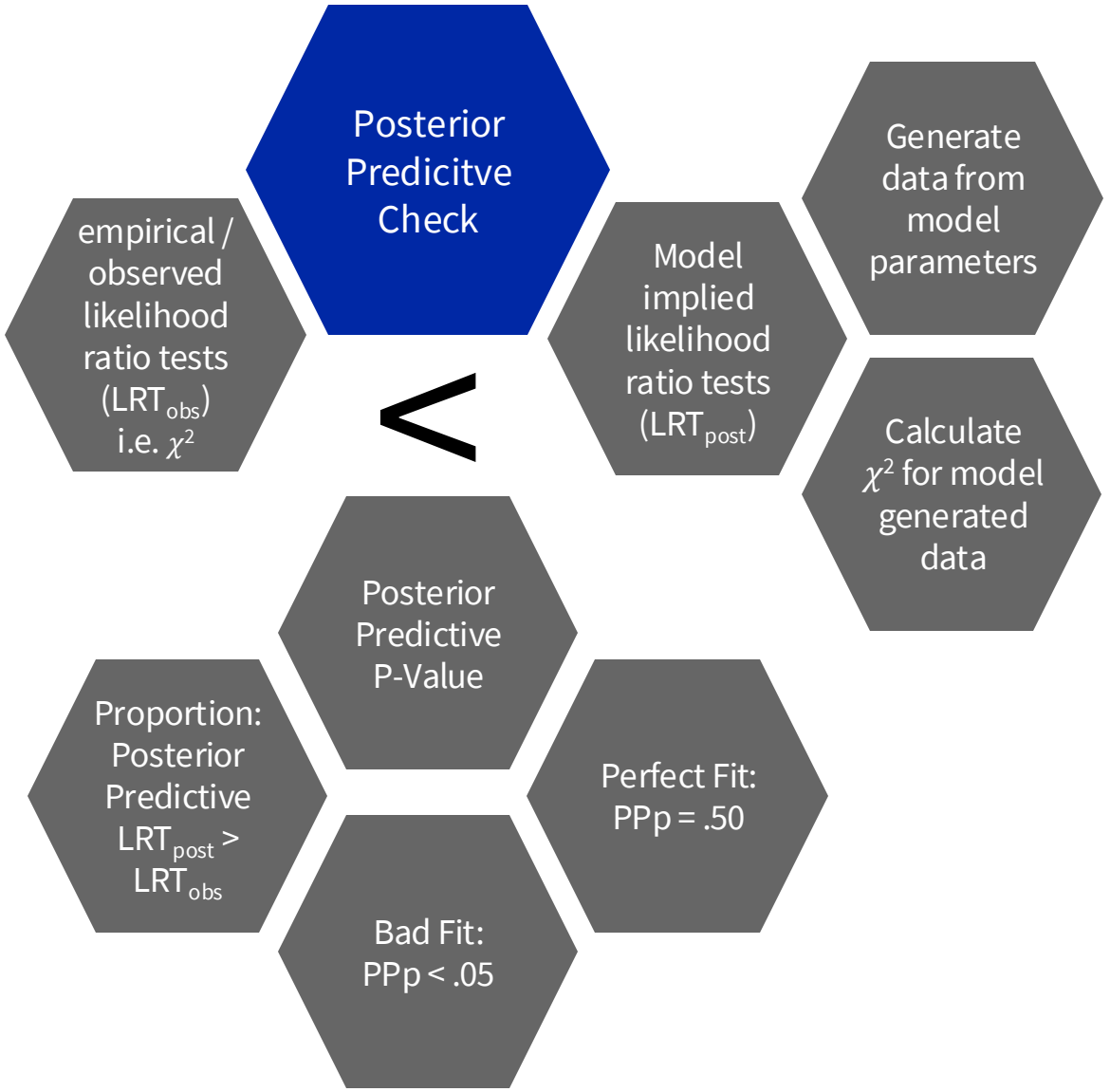
Model 3



Model 4



Evaluating SEM fit
Model test



Evaluating SEM Fit

Evaluating SEM fit
Bayesian Model Fit Indices

Evaluating SEM Fit

Goodness of Fit Indices

Null Model: All observed variables are uncorrelated

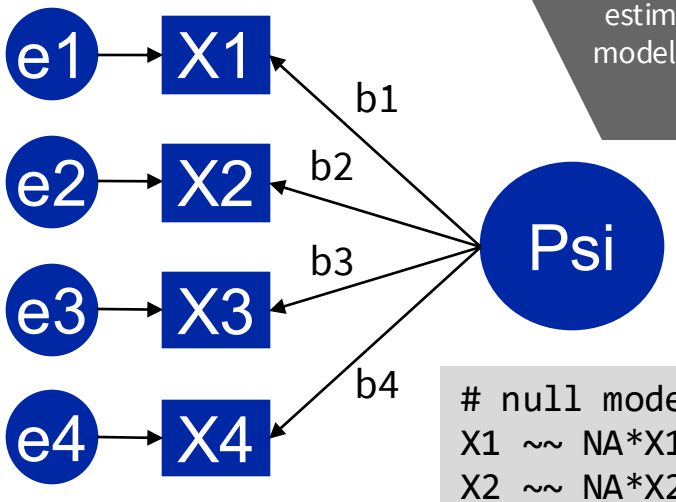
Requirement Specify and estimate null model yourself

Bayesian CFI: How does the model fare compared to null mode?

Interpretation acceptable: CFI > .90 good: CFI > .95

Bayesian Root Mean Square Error of Approximation (RMSEA)

Interpretation acceptable: RMSEA < .08 good: RMSEA < .05

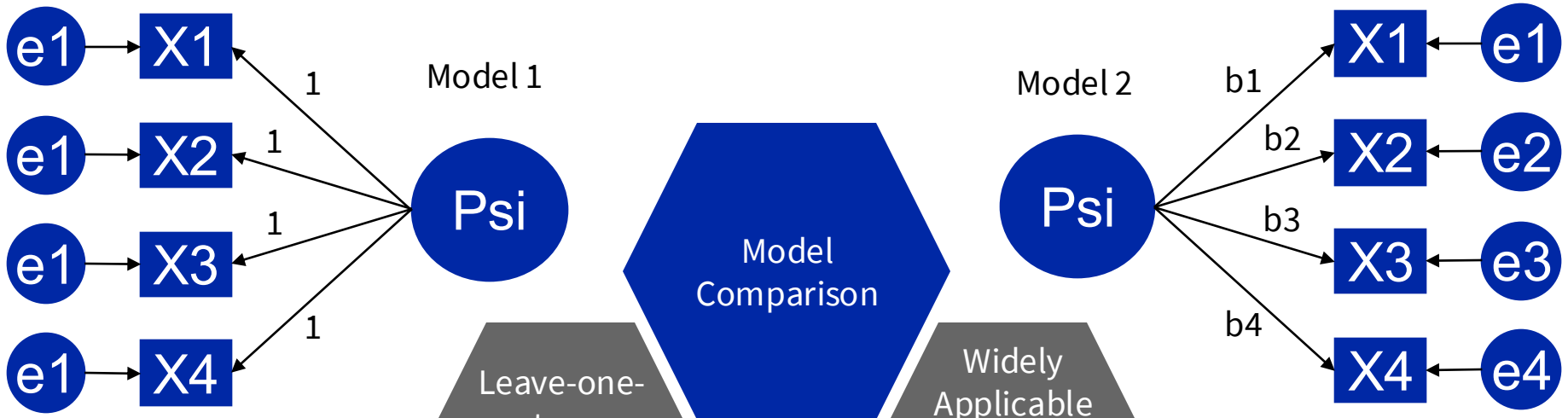



```
# null model
X1 ~~ NA*X1
X2 ~~ NA*X2
X3 ~~ NA*X3
X4 ~~ NA*X4
```

```
# get Model fit indices
my_fit <- bsem(model, data)
my_fit0 <- bsem(model0, data)
bayes_fitIdx <- blavfitIndices(my_fit,
                               baseline.model = my_fit0)
summary(bayes_fitIdx, central.tendency = “mean”,
        hpd = TRUE, prob = .95)
```

Evaluating SEM fit
Model Fit Indices

Evaluating SEM Fit



Model Comparison

Leave-one-out cross validation (LOO)

Widely Applicable Information Criterion (WAIC)

Bayesian generalization of AIC

Model with smaller values wins

Difference can be normailzed with SE

Again: CFI / RMSEA not well suited for model comparison

Bayes Factors are not recommended for model comparisons

```
# fit SEM
my_fit1 <- sem(model1, data)
my_fit2 <- sem(model2, data)

# compare models
blavCompare(my_fit1, my_fit2)
```

What are your questions so far?

Evaluating SEM fit

Exercise: Choose simulated data from one model

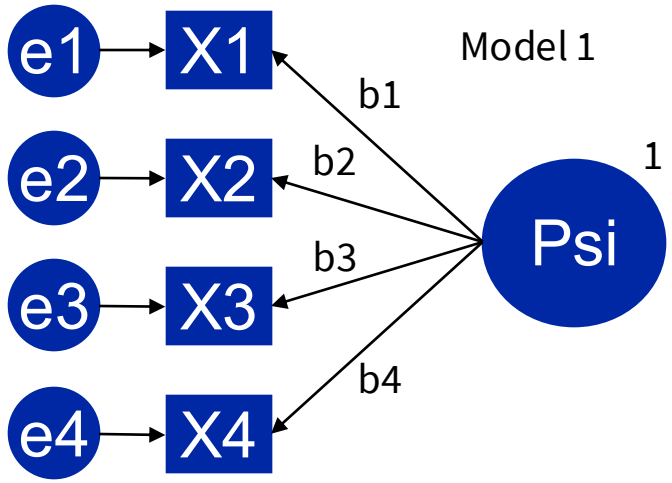
Fit all four models to the data set

Use Bayesian estimation

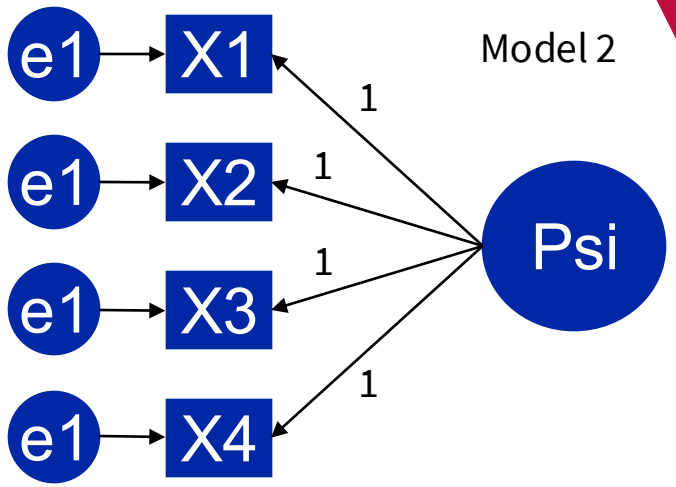
Evaluate fit of every model on its own

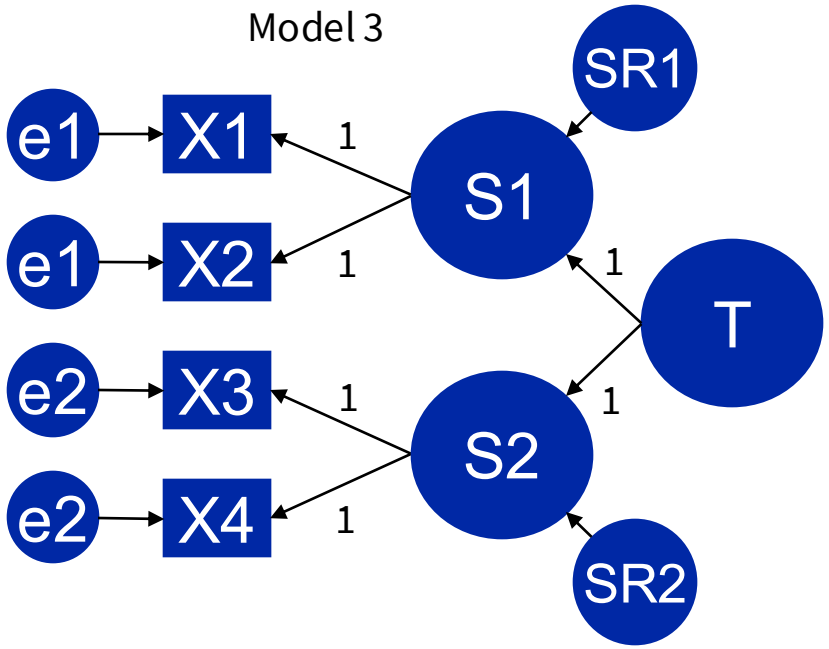
Compare the models to each other

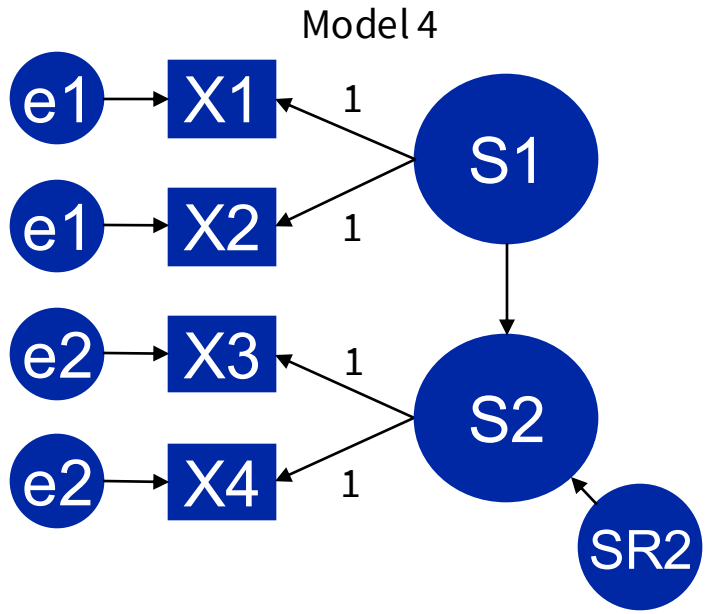
Does the correct model win?



Evaluating SEM Fit







Evaluating SEM fit
Model Fit Indices

Evaluating SEM Fit

We have a well fitting model ☺

→ Test if a model parameters *q* is credible

Evaluate 95% Highest Posterior Density Intervall (HDI)

95% HDI includes 0 ☹ Re-estimate model with parameter = 0

95% HDI excludes 0 ☺ Model parameter is not zero

```
# get Model fit indices
my_fit <- bsem(model, data)

# print model summary with fit indices
# and standardized parameter estimates
summary(my_fit,
        fit.measures = TRUE,
        standardized = TRUE)
```

Improper Solutions

Can often be avoided via informative priors

Evaluating SEM fit

Exercise: Choose simulated data from one model

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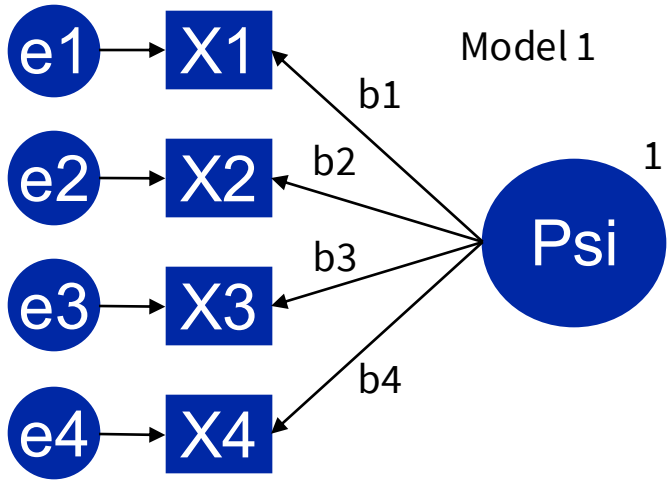
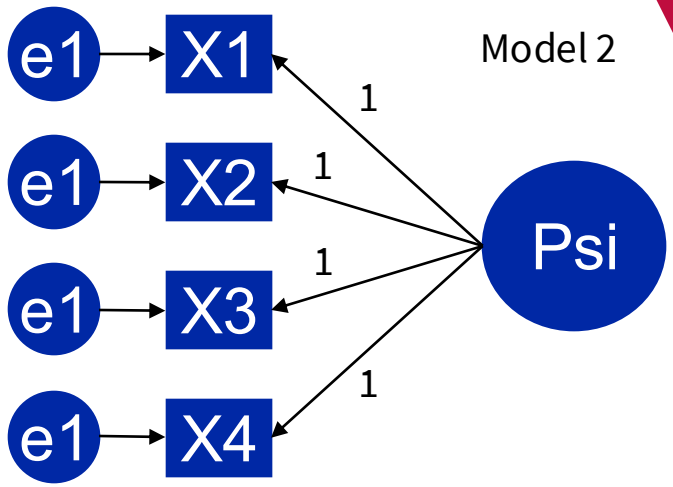
Evaluate fit of every model on its own

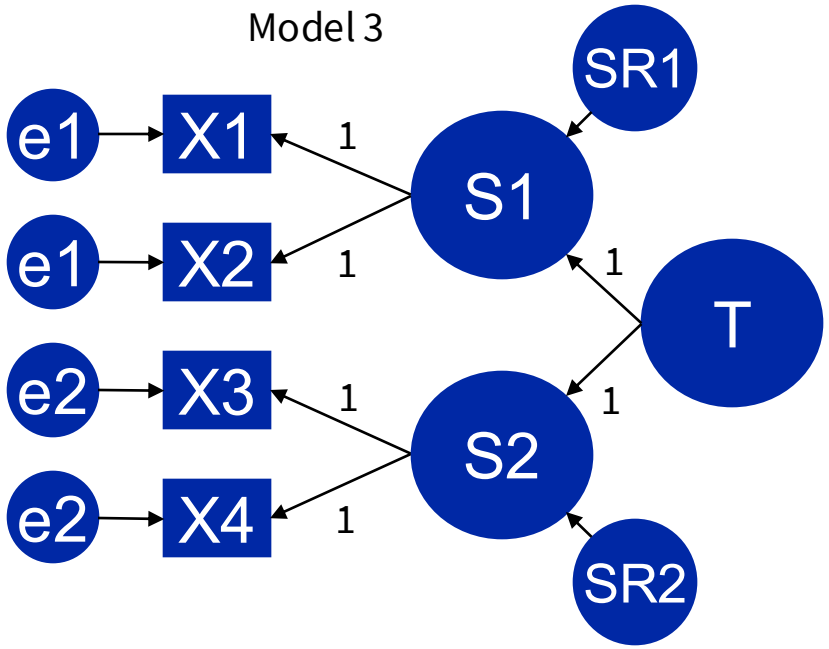
Compare the models to each other

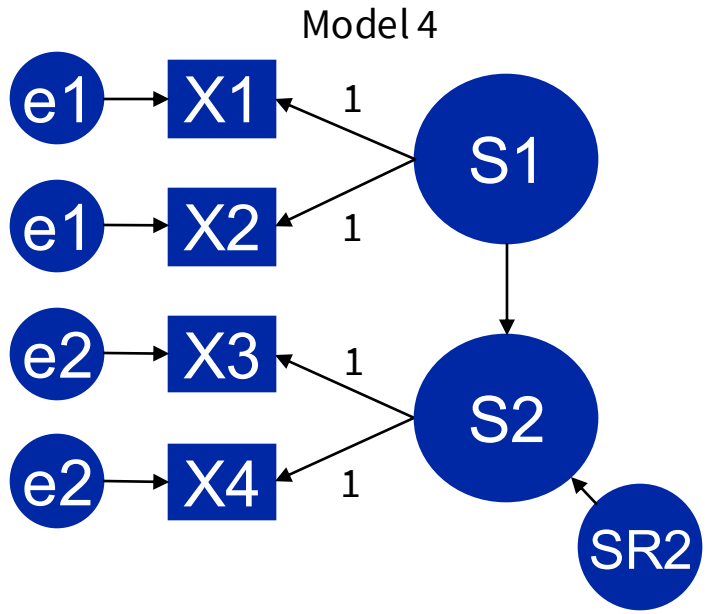
Does the correct model win?

For winning model: check if parameters are significant









Evaluating SEM Fit

What are your questions so far?