

Factor analysis workflow:

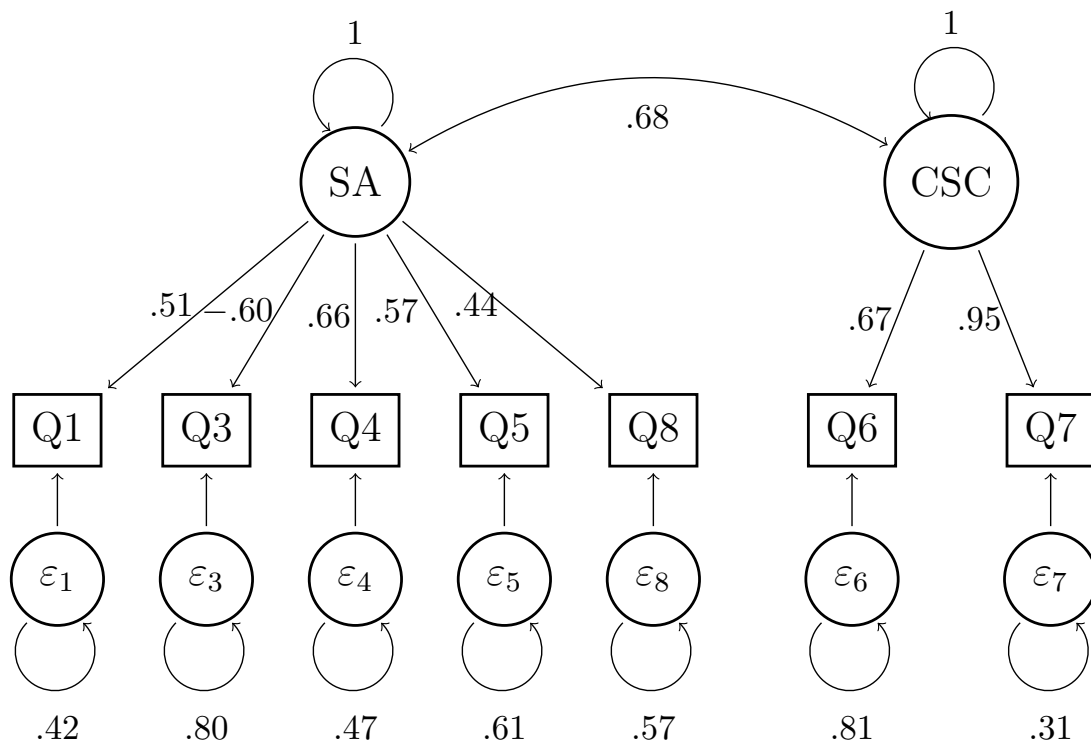
- use *exploratory factor analysis* to find a potential measurement model (latent factor structures) for a given set of data
 - how many factors/dimensions?
 - which items load onto the different factors?
- use *confirmatory factor analysis* to **test** these models and estimate its components
 - test of *exact fit* – χ^2 test (\mathcal{H}_0 : model fits data exactly) – compares to *saturated model* – want $p > 0.05$!
 - test of *absolute fit* – is RMSEA < 0.05 ?

In this lecture, we will discuss how to build and compare **competing** measurement models

- use the SEM module in JASP
- explore ways to improve model fit (compute *modification indices*)
- compare model fits using *Bayesian information criterion* (BIC)
- how to turn this into a thesis!

SAQ-8 items:

1. Statistics makes me cry
2. My friends will think I'm stupid for not being able to use statistical software
3. Standard deviations excite me
4. I dream that Pearson is attacking me with correlation coefficients
5. I don't understand statistics
6. I have little experience with computers
7. All computers hate me
8. I have never been good at mathematics



- $\chi^2(13) = 66.8$, $p < 0.001$ (model *not* a good fit, but X^2 performs badly with large N)
- RMSEA = 0.040, 95% CI = (0.031, 0.050) (model IS a good fit)

Questions for today:

1. Can we get a *better* model structure?
2. How much better?

Answers:

1. Can we get a *better* model structure?
 - build a "structural equation model" in JASP
 - compute "modification indices" (MIs)
 - build new model, adding components with large MI
2. How much better?
 - compare two models using Bayesian information criterion (BIC)
 - lower is better
 - convert difference in BIC to Bayes factor – directly compare likelihood of data under the two competing models

Structural equation modeling in JASP

- uses "SEM" module
- requires `lavaan` syntax
 - `lavaan` is an R package for doing SEM

Let's demonstrate in JASP

Modification indices

- what happens to model fit when additional components are added?
- MI = change (decrease) in χ^2 statistic when adding that component

In JASP, do the following:

- select "Modification indices" from the "Statistics" menu
- choose ONE modification to make to your model (usually the one with the largest MI)
- go to "Advanced" and change model name (i.e., "Model 2")
- modify the `lavaan` code and re-fit the model

How much better does Model 2 fit?

- use BIC – smaller is better
- BIC for Model 1 = 46,711.672
- BIC for Model 2 = 46,684.084 – better fit!

How much better does Model 2 fit?

- convert BIC to a *Bayes factor* (Kass & Raftery, 1995; Wagenmakers, 2007; Faulkenberry, 2018)
- Bayes factor = how much more likely is the data under Model 2 compared to Model 1?
- Computing Bayes factor:

$$\text{BF} = \exp\left(\frac{\Delta\text{BIC}}{2}\right)$$

- for our models, we have:

$$\begin{aligned}\text{BF} &= \exp\left(\frac{46711.672 - 46684.084}{2}\right) \\ &= \exp\left(\frac{27.588}{2}\right) \\ &= \exp(13.794) \\ &= 978719.1\end{aligned}$$

Interpretation: our data are approximately 979,000 times more likely under Model 2 than Model 1.

Summary – how to turn this into a thesis

- construct an interpretable measurement model (exploratory factor analysis)
 - SAQ-8 seems to consist of two factors: SA and CSC
- estimate and validate the model (confirmatory factor analysis)
 - report χ^2 test and RMSEA
- use structural equation modeling (SEM) to explore potentially *better* factor structures
 - compute modification indices – add some components, but remember to keep it simple
- compare model fits
 - lower BIC is better
 - how much better? Translate BIC to Bayes factor
- next step – collect NEW data and confirm new model on this data (use CFA)