

# **semPlot:** Unified visualizations of Structural Equation Models

Sacha Epskamp

University of Amsterdam  
Department of Psychological Methods

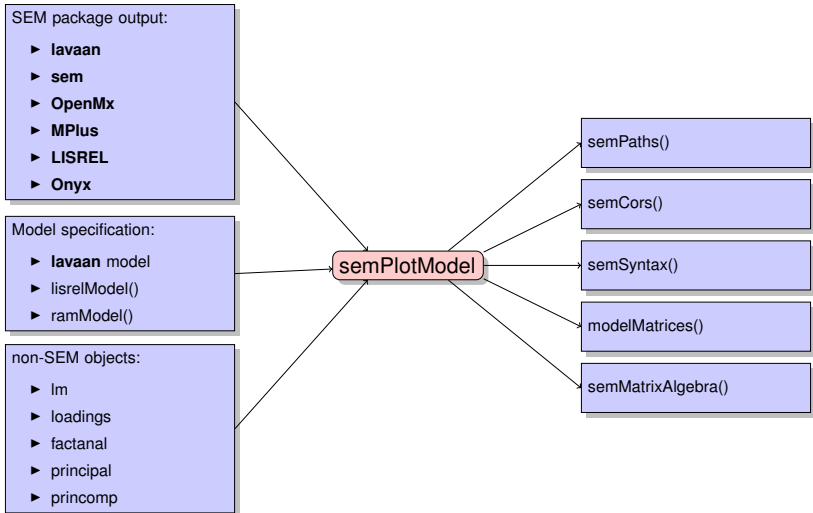
M3 2014  
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# semPlot

- ▶ **R** package dedicated to visualizing structural equation models (SEM)
- ▶ fills the gap between advanced, but time-consuming, graphical software and the limited graphics produced automatically by SEM software
- ▶ Also unifies different SEM software packages and model frameworks in **R**
  - ▶ General framework for extracting parameters from different SEM software packages to different SEM modeling frameworks
- ▶ Sister package and extension to **qgraph** (Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012)

# Supported input

- ▶ **R** (R Core Team, 2013) objects:
  - ▶ `lm`
  - ▶ `loadings`
  - ▶ `factanal`
  - ▶ `princomp`
  - ▶ `principal` (Revelle, 2010)
- ▶ **R** package output:
  - ▶ **lavaan** (Rosseel, 2012)
    - ▶ Output and model
  - ▶ **sem** (Fox, Nie, & Byrnes, 2013)
  - ▶ **OpenMx** (Boker et al., 2011)
    - ▶ Path specification only
- ▶ String indication output file of:
  - ▶ **MPlus** (L. K. Muthén & B. O. Muthén, 1998–2012)
    - ▶ Via **MplusAutomation** (Hallquist & Wiley, 2013)
  - ▶ **LISREL** (Jöreskog & Sörbom, 1996)
    - ▶ Via **lisrelToR** (Epskamp, 2013)



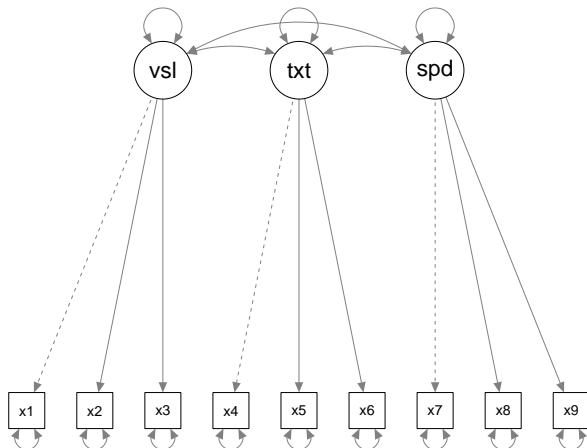


```
library("lavaan")  
## The famous Holzinger and Swineford (1939) example  
HS.model <- ' visual  =~ x1 + x2 + x3  
               textual =~ x4 + x5 + x6  
               speed   =~ x7 + x8 + x9 '  
  
fit <- cfa(HS.model, data=HolzingerSwineford1939)
```

# semPaths

`semPaths()` can be used to plot a path diagram:

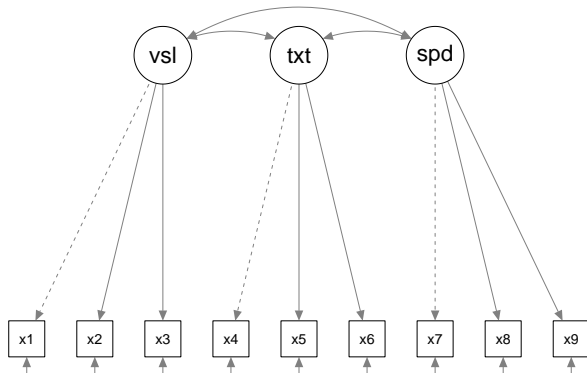
```
semPaths(fit)
```



# semPaths

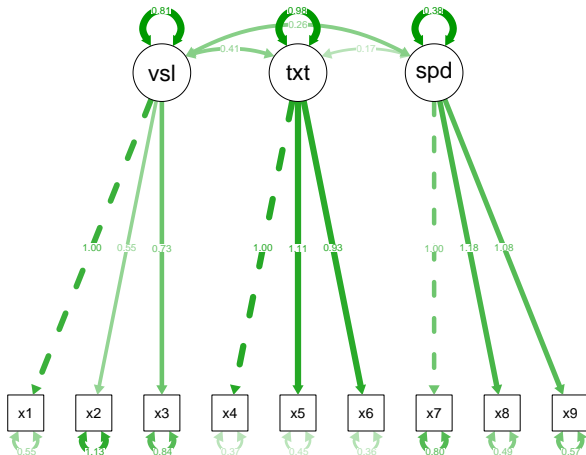
`semPaths()` can be used to plot a path diagram:

```
semPaths(fit, style = "lisrel")
```





```
semPaths(fit, "Standardized", "Estimates")
```



# semPaths

`semPaths` has quite a lot of arguments:

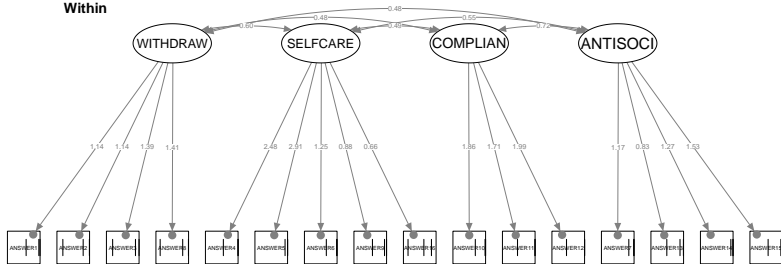
*style, layout, intercepts, residuals, thresholds, rotation, curve, curvature, nCharNodes, nCharEdges, sizeMan, sizeLat, sizeInt, sizeMan2, sizeLat2, sizeInt2, shapeMan, shapeLat, shapeInt, ask, mar, title, title.color, title.adj, title.line, title.cex, include, combineGroups, manifests, latents, groups, color, residScale, gui, allVars, edge.color, reorder, structural, ThreshAtSide, thresholdColor, thresholdSize, fixedStyle, freeStyle, as.expression, optimizeLatRes, inheritColor, levels, nodeLabels, edgeLabels, pastel, rainbowStart, intAtSide, springLevels, nDigits, exoVar, exoCov, centerLevels, panelGroups, layoutSplit, measurementLayout, subScale, subScale2, subRes, subLinks, modelOpts, curveAdjacent, edge.label.cex, cardinal, equalizeManifests, covAtResiduals, bifactor, optimPoints*

# semPaths

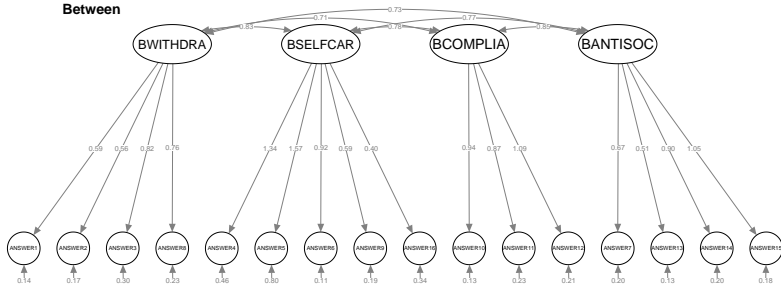
And even more via the `qgraph` backend:

*edge.width, node.width, node.height, esize, asize,  
minimum, maximum, cut, details, mar, filetype,  
filename, width, height, normalize, DoNotPlot, plot,  
rescale, label.cex, label.color, borders, border.color,  
border.width, polygonList, vTrans, label.prop,  
label.norm, label.scale, label.font, posCol, negCol,  
unCol, colFactor, trans, fade, loop,  
curvePivot, curvePivotShape, edge.label.bg,  
edge.label.position, edge.label.font, layout.par, bg,  
bgcontrol, bgres, pty, font, arrows, arrowAngle, asize,  
open, weighted, XKCD, ...*

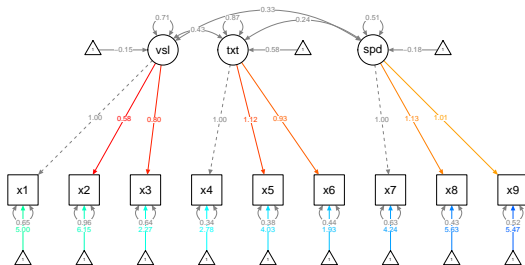
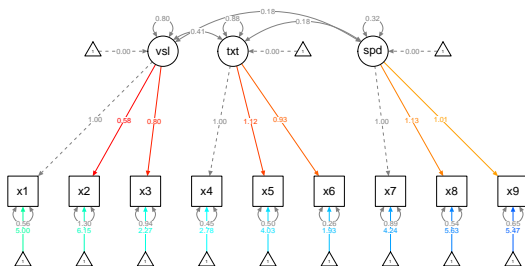
# Within



# Between



# Constraints

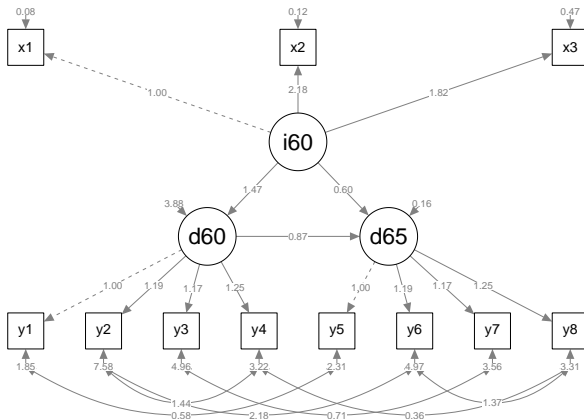


# Structural Models

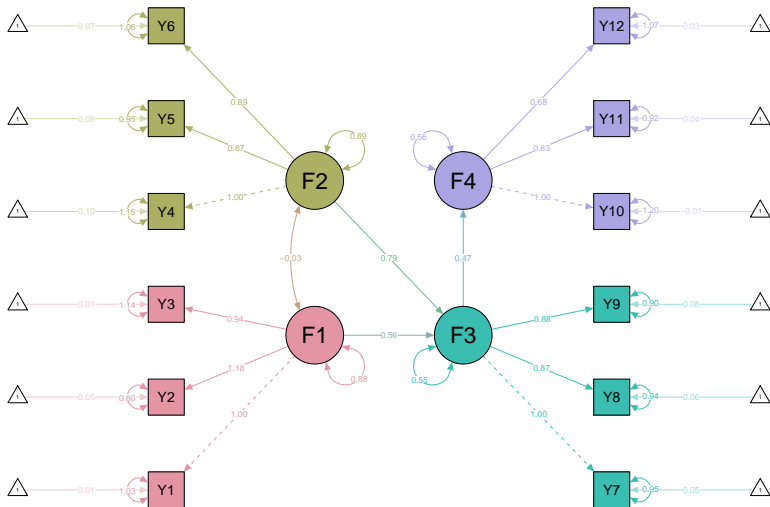
```
# lavaan sem example:
```

```
example(sem)
```

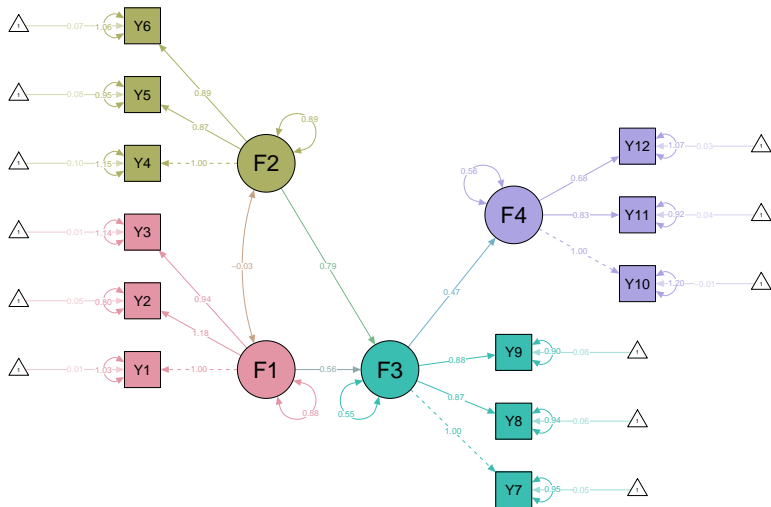
```
semPaths(fit, "model", "est", style = "lisrel")
```



# LISREL style layout

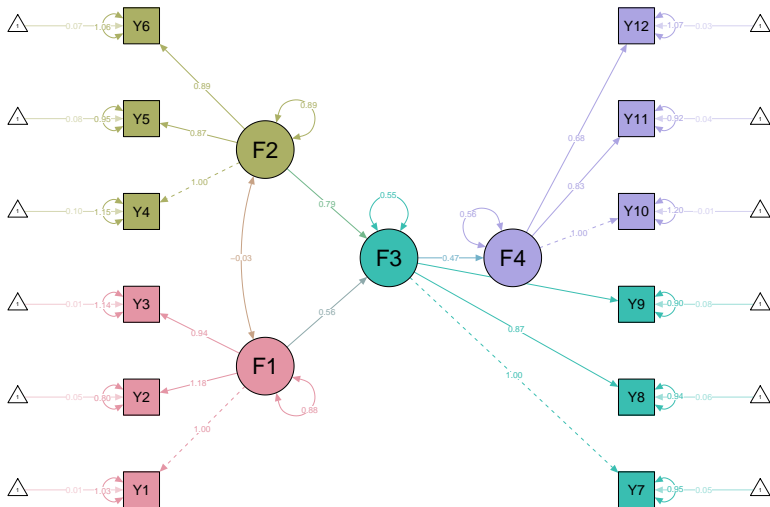


# Reingold-Tilford based layout

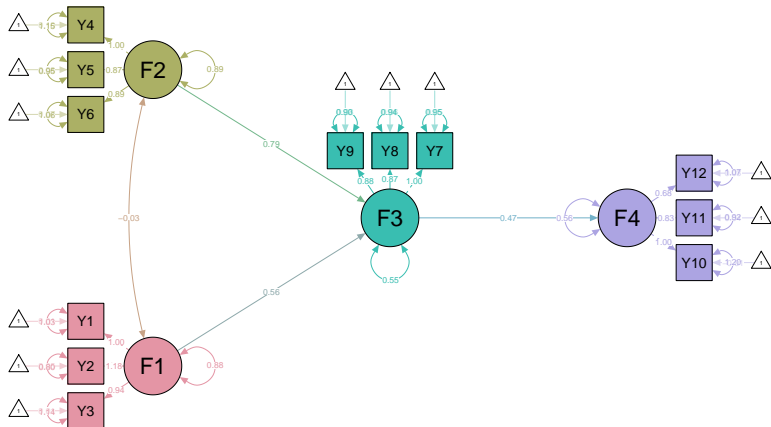




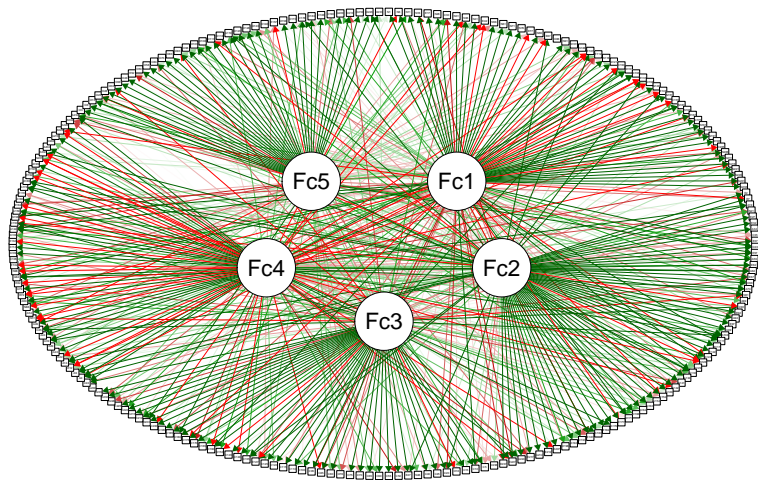
# Boker-McArdle-Neale based layout



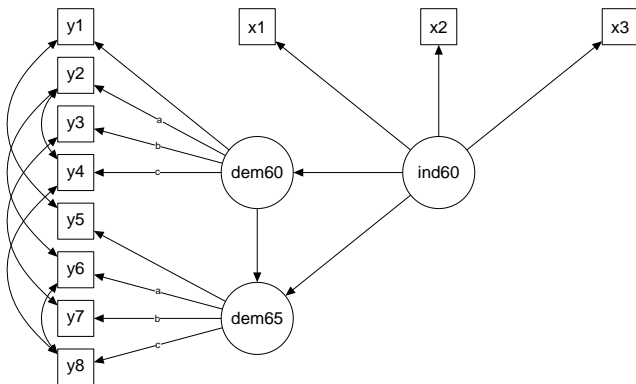
# Split measurement and structural models



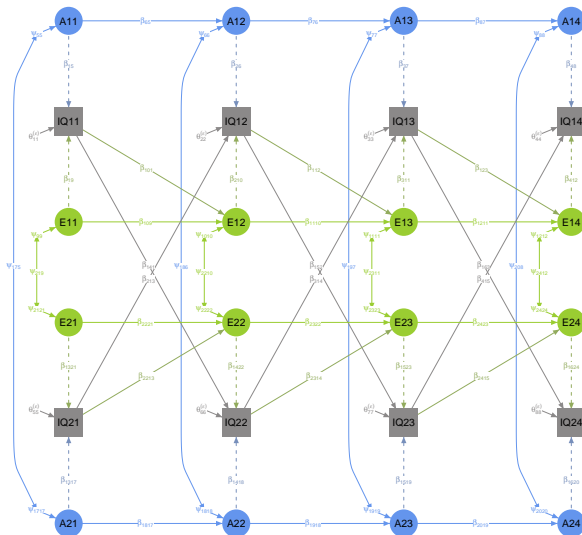
# Circular layout



# Manual Specification



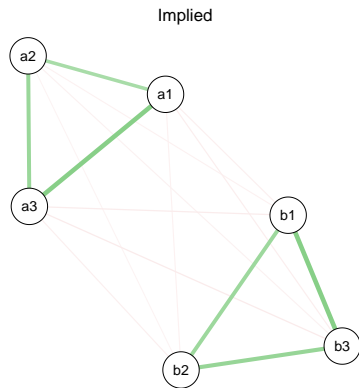
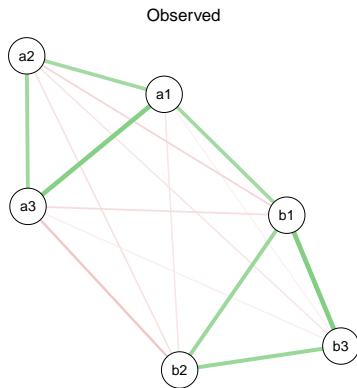
# Model by Janneke de Kort

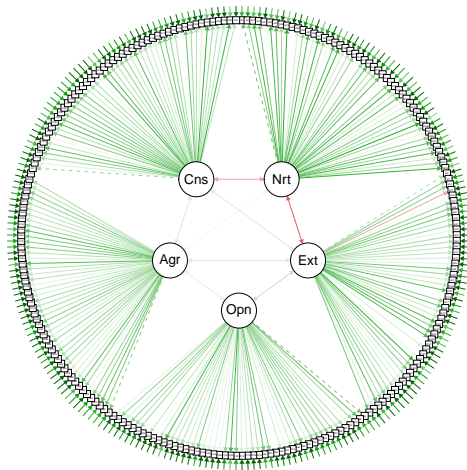


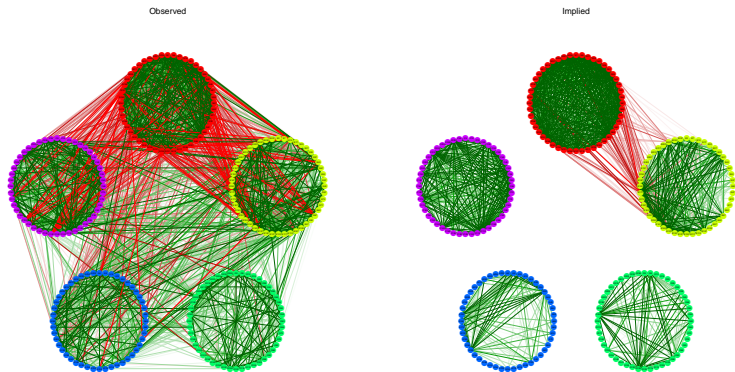
# Visual correlation analysis

`semCovs()` can be used to plot implied and observed covariances using the **qgraph** framework (Epskamp et al., 2012).

```
semCovs(fit, layout = "spring", titles = TRUE)
```







See also See also (Epskamp et al., 2012)



`modelMatrices()` can be used to obtain a list of all matrices in one of three modeling frameworks:

```
names(modelMatrices(fit, "ram"))
```

```
## [1] "A" "S" "F"
```

```
names(modelMatrices(fit, "lisrel"))
```

```
## [1] "LY" "TE" "PS" "BE" "LX" "TD"
```

```
## [7] "PH" "GA" "TY" "TX" "AL" "KA"
```

```
names(modelMatrices(fit, "mplus"))
```

```
## [1] "Nu" "Lambda" "Theta"
```

```
## [4] "Kappa" "Alpha" "Beta"
```

```
## [7] "Gamma" "Psi"
```

The `semMatrixAlgebra()` function makes extracting matrices easier:

```
semMatrixAlgebra(fit, A)

## model set to 'ram'

##      a1 a2 a3 b1 b2 b3      A      B
## a1  0  0  0  0  0  0  1.0000  0.000
## a2  0  0  0  0  0  0  0.7335  0.000
## a3  0  0  0  0  0  0  1.0390  0.000
## b1  0  0  0  0  0  0  0.0000  1.000
## b2  0  0  0  0  0  0  0.0000  0.765
## b3  0  0  0  0  0  0  0.0000  1.012
## A   0  0  0  0  0  0  0.0000  0.000
## B   0  0  0  0  0  0  0.0000  0.000
```

Note how using the term `A` caused the function to automatically identify we were interested in the RAM model.

`semMatrixAlgebra()` can also be used to easily perform algebraic computations:

```
semMatrixAlgebra(fit, Lambda %*% Psi %*% t(Lambda) + Theta)

## model set to 'mplus'

##           a1           a2           a3           b1           b2           b3
## a1  2.02879  0.60113  0.85151 -0.12520 -0.09578 -0.12674
## a2  0.60113  1.52291  0.62456 -0.09183 -0.07025 -0.09296
## a3  0.85151  0.62456  1.63260 -0.13008 -0.09951 -0.13168
## b1 -0.12520 -0.09183 -0.13008  1.95964  0.66839  0.88447
## b2 -0.09578 -0.07025 -0.09951  0.66839  1.53194  0.67661
## b3 -0.12674 -0.09296 -0.13168  0.88447  0.67661  1.78813
```

`semSyntax` can be used to translate any input to `semPlot` into **lavaan** codes. This has two advantages:

- ▶ Easily fit a model based on an output file in **lavaan**
- ▶ Simulate data based on an estimated model using **lavaan's** `simulateData`

Translating **lavaan** syntax to **MPlus** syntax can be attempted using `lavaan:::lav2mplus`. **sem** is also supported but a bit bugged at the moment. Mail me for a **lavaan** to **OpenMx** translator.

## Translate **MPlus** to **lavaan**:

```
l <- "http://www.statmodel.com/usersguide/chap5/ex5.1.out"  
download.file(l, modfile <- tempfile(fileext = ".out"))  
Model <- semPlotModel(modfile)  
lavMod <- semSyntax(Model)
```

```
## Reading model:  ex5.1.out  
##  
## Model <- '  
## F1 =~ 1*Y1  
## F1 =~ Y2  
## F1 =~ Y3  
## F2 =~ 1*Y4  
## F2 =~ Y5  
## F2 =~ Y6  
## F2 ~~ F1  
## Y1 ~ 1  
## Y2 ~ 1  
## Y3 ~ 1  
## Y4 ~ 1  
## Y5 ~ 1  
## Y6 ~ 1  
## F1 ~~ F1  
## F2 ~~ F2
```

Simulate data:

```
l <- "http://www.statmodel.com/usersguide/chap5/ex5.1.out"  
download.file(l, modfile <- tempfile(fileext = ".out"))  
Model <- semPlotModel(modfile)  
lavMod <- semSyntax(Model, allFixed = TRUE)
```

## Simulate data:

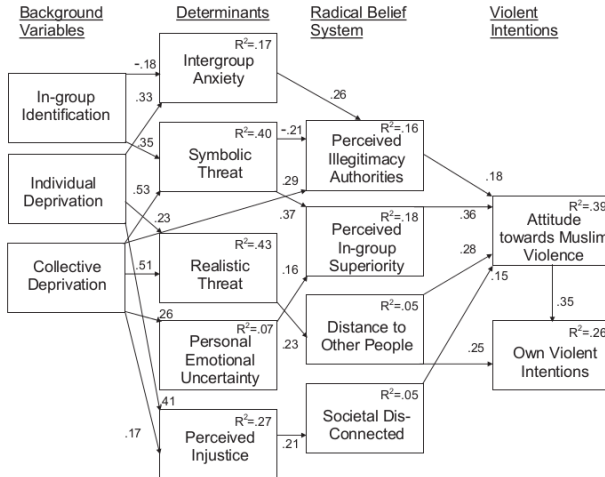
```
library("lavaan")  
head(simulateData(lavMod))
```

##		Y1	Y2	Y3	Y4	Y5	Y6
## 1		-0.1812	-0.86023	-0.26249	0.8436	1.3738	-0.2065
## 2		0.4026	-1.42322	-0.03974	0.6176	0.5889	0.6993
## 3		1.2055	0.37841	1.44397	0.7376	0.9466	-0.8903
## 4		2.1490	-0.67511	0.07165	0.1718	-0.4993	-2.1682
## 5		0.3397	-0.09025	-0.06618	-1.2264	0.0610	-1.2726
## 6		-1.5069	-0.81482	-1.58714	1.1065	-0.4947	0.2997

# Future directions

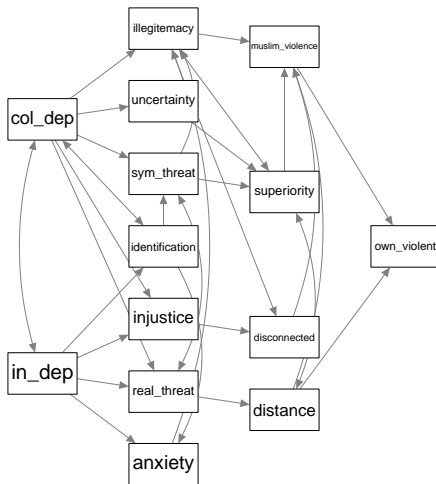
- ▶ (Better) support for:
  - ▶ **Onyx**
  - ▶ **Amos**
  - ▶ **EQS**
  - ▶ **lava**
  - ▶ **xxM**
- ▶ Extension to different models:
  - ▶ LKA
  - ▶ IRT
  - ▶ Bayesian models
- ▶ Equivalent model sampler
- ▶ Partial correlation matrices



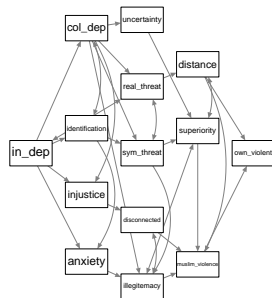
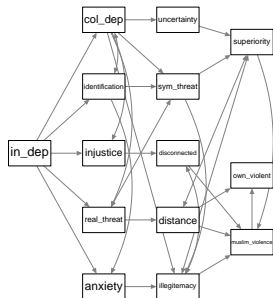


Doosje, B., Loseman, A., & Bos, K. (2013). Determinants of radicalization of islamic youth in the netherlands: personal uncertainty, perceived injustice, and perceived group threat. *Journal of Social Issues*, 69(3), 586–604

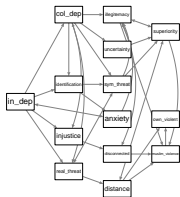
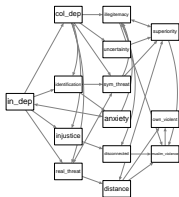
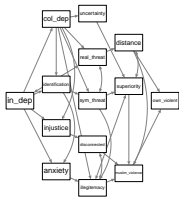
# Equivalent model



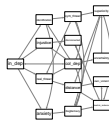
# Equivalent models



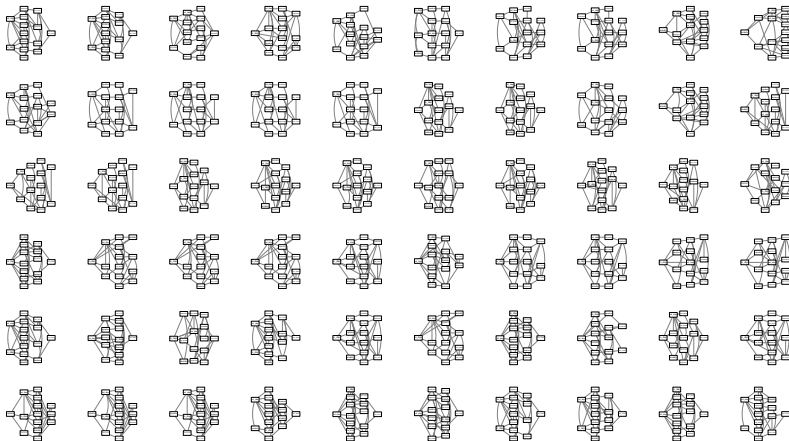
# Equivalent models



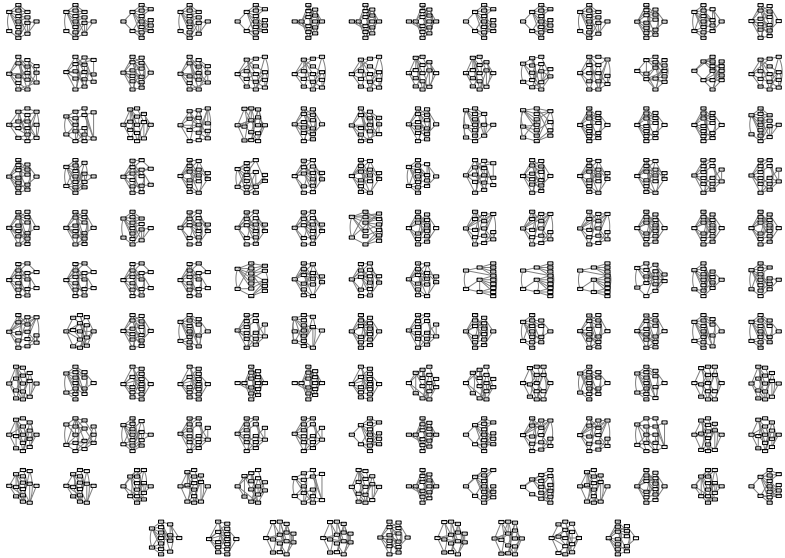
## Equivalent models



# Equivalent models



# Equivalent models



# Partial correlation matrices

SEM models the (latent) covariance matrix:

$$\text{Var}(\boldsymbol{\eta}) = (\mathbf{I} - \mathbf{B})^{-1} \boldsymbol{\Psi} (\mathbf{I} - \mathbf{B})^{-1\top}$$

But also the precision matrix:

$$\text{Var}^{-1}(\boldsymbol{\eta}) = (\mathbf{I} - \mathbf{B})^{\top} \boldsymbol{\Psi}^{-1} (\mathbf{I} - \mathbf{B})$$

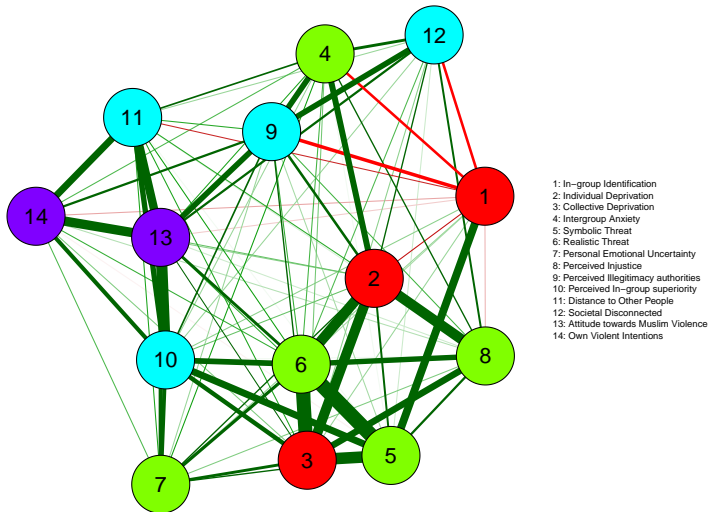
The precision matrix directly corresponds to *partial correlations*:

$$\rho_{i,j} = \begin{cases} -\frac{\omega_{i,j}}{\sqrt{\omega_{i,i}\omega_{j,j}}} & \text{if } i \neq j \\ 1 & \text{otherwise} \end{cases}$$

$\rho_{i,j} = 0$  indicates that  $i$  and  $j$  are independent given all other variables.



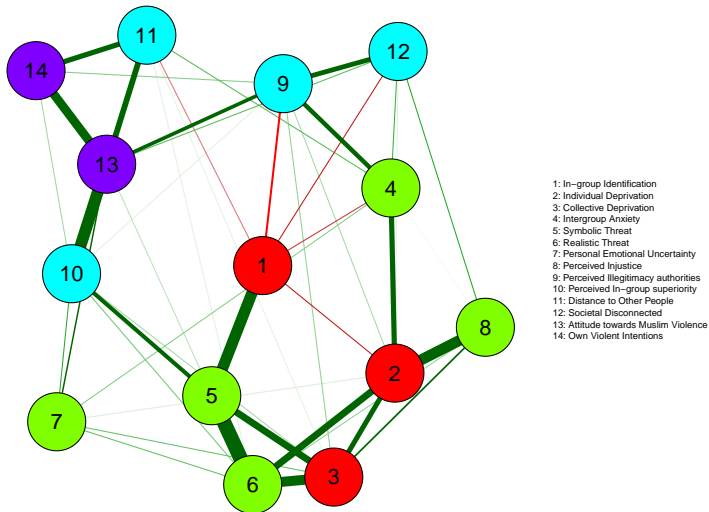
# Correlation network









# Partial correlation network

After glasso (Friedman, Hastie, & Tibshirani, 2011):








Thank you for your attention!

# References I

-  Boker, S. M., Neale, M., Maes, H., Wilde, M., Spiegel, M., Brick, T., . . . Fox, J. (2011). OpenMx: an open source extended structural equation modeling framework. *Psychometrika*, 76(2), 306–317.
-  Doosje, B., Loseman, A., & Bos, K. (2013). Determinants of radicalization of islamic youth in the netherlands: personal uncertainty, perceived injustice, and perceived group threat. *Journal of Social Issues*, 69(3), 586–604.
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## References II

-  Fox, J., Nie, Z., & Byrnes, J. (2013). *sem: structural equation models*. R package version 3.1-1. Retrieved from <http://CRAN.R-project.org/package=sem>
-  Friedman, J., Hastie, T., & Tibshirani, R. (2011). *Glasso: graphical lasso- estimation of gaussian graphical models*. R package version 1.7. Retrieved from <http://CRAN.R-project.org/package=glasso>
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# References III



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Revelle, W. (2010). PSYCH: procedures for psychological, psychometric, and personality research. R package version 1.0-93. Northwestern University. Evanston, Illinois. Retrieved from <http://personality-project.org/r/psych.manual.pdf>



Rosseel, Y. (2012). lavaan: an R package for structural equation modeling. *Journal of Statistical Software*, 48(2), 1–36. Retrieved from <http://www.jstatsoft.org/v48/i02/>