

# Structural Equation Modeling

## P.08 - MIMIC Models and Instrumental Variables

November 15, 2022 (15:25:56)

---

### Lab Description

For this practical you will need the following packages: `lavaan` and `semPlot`. You can install and load these packages using the following code:

```
# Install packages.
install.packages(c("lavaan", "semPlot", "mvtnorm", "GGally"))

# Load the packages.
library(lavaan)
library(semPlot)
```

### Exercise 1

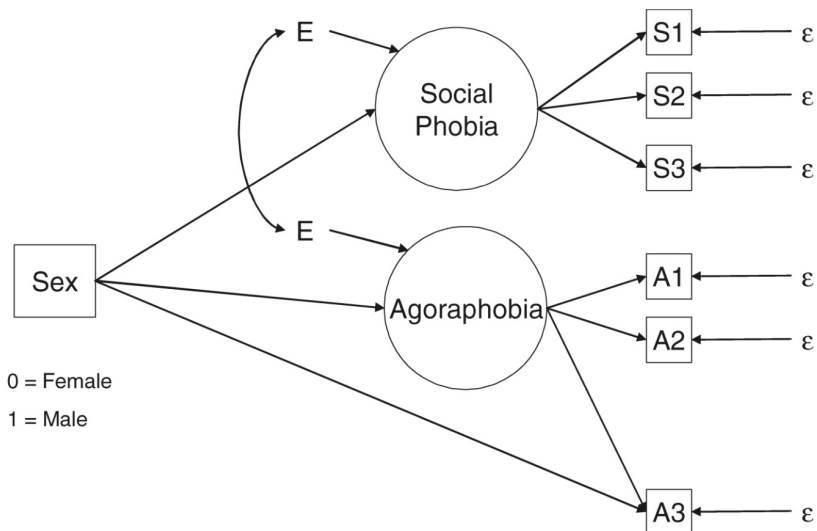
Estimate the model in *Figure 1* in `lavaan` and examine if there is evidence of Differential Item Functioning (DIF) in the measurement instruments. To help you get started, you are provided with the code that contains the correlations and standard deviations corresponding to the model depicted in *Figure 1*.

Standard deviations and correlations.

```
# Standard deviations.
sd <- "2.26 2.73 2.11 2.32 2.61 2.44 0.50"

# Correlations.
cor <- "
  1.000
  0.705 1.000
  0.724 0.646 1.000
  0.213 0.195 0.190 1.000
  0.149 0.142 0.128 0.521 1.000
  0.155 0.162 0.135 0.557 0.479 1.000
  -0.019 -0.024 -0.029 -0.110 -0.074 -0.291 1.000
"

# Get covariances.
cov <- getCov(cor, sds = sd, names = c("S1", "S2", "S3", "A1", "A2", "A3", "sex"))
```



Sample Correlations and Standard Deviations (SDs);  $N = 730$  (365 males, 365 females)

	S1	S2	S3	A1	A2	A3	Sex
S1	1.000						
S2	0.705	1.000					
S3	0.724	0.646	1.000				
A1	0.213	0.195	0.190	1.000			
A2	0.149	0.142	0.128	0.521	1.000		
A3	0.155	0.162	0.135	0.557	0.479	1.000	
Sex	-0.019	-0.024	-0.029	-0.110	-0.074	-0.291	1.000
SD:	2.260	2.730	2.110	2.320	2.610	2.440	0.500

**FIGURE 7.5.** MIMIC model of Social Phobia and Agoraphobia. S1, giving a speech; S2, meeting strangers; S3, talking to people; A1, going long distances from home; A2, entering a crowded mall; A3, walking alone in isolated areas. (All questionnaire items rated on 0–8 scales, where 0 = no fear and 8 = extreme fear.)

Figure 1: Reproduction of Figure 7.5 from Brown (2014, p. 275)

We start by specifying the syntax for the *MIMIC* model.

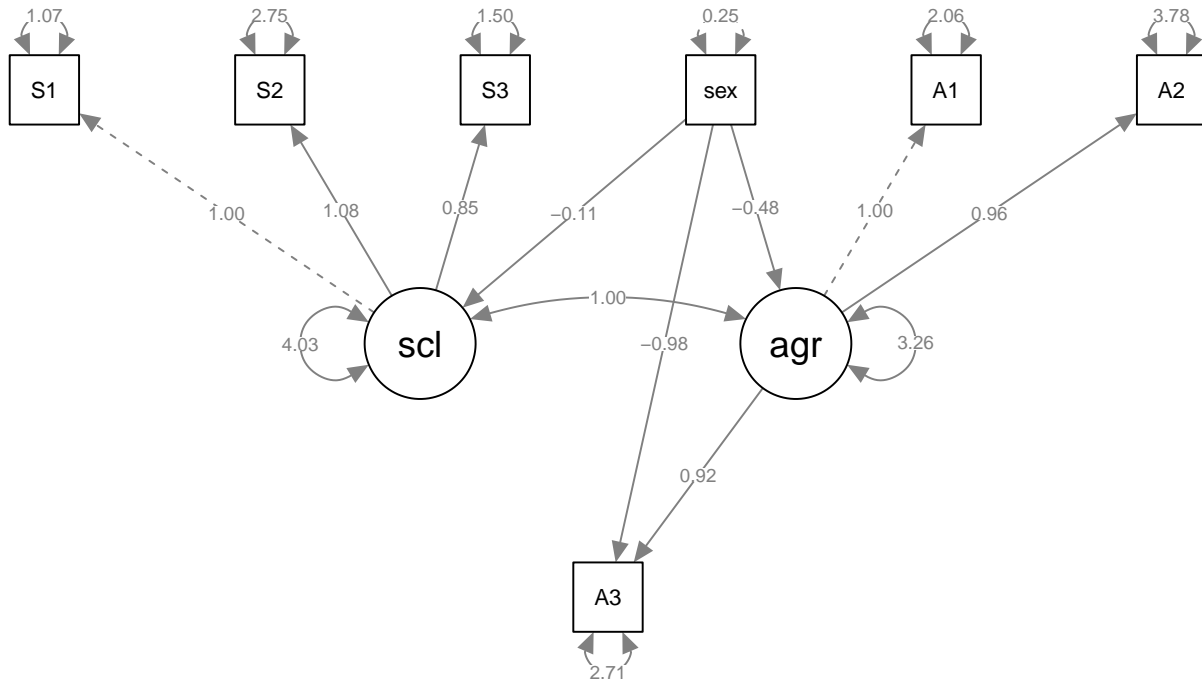
```
# Model syntax.
model_ex_1 <- "
  # Measurement part.
  social =~ S1 + S2 + S3
  agoraph =~ A1 + A2 + A3

  # Regression equations.
  social ~ sex
  agoraph ~ sex
  A3 ~ sex

  # Covariances.
  social ~~ agoraph
"

# Fit the model.
model_ex_1_fit <- cfa(model_ex_1, sample.cov = cov, sample.nobs = 730)

# Visualize the model.
semPaths(model_ex_1_fit, what = "paths", whatLabels = "est")
```



```
# Model summary.
summary(model_ex_1_fit, fit.measures = TRUE, standardized = TRUE, modindices = TRUE)
```

```
## lavaan 0.6-12 ended normally after 52 iterations
```

```
##
```

```
## Estimator ML
```

```
## Optimization method NLMINB
```

```
## Number of model parameters 16
```

```
##
```

```

##      Number of observations                730
##
## Model Test User Model:
##
##      Test statistic                        3.797
##      Degrees of freedom                    11
##      P-value (Chi-square)                 0.975
##
## Model Test Baseline Model:
##
##      Test statistic                        1771.017
##      Degrees of freedom                    21
##      P-value                              0.000
##
## User Model versus Baseline Model:
##
##      Comparative Fit Index (CFI)          1.000
##      Tucker-Lewis Index (TLI)            1.008
##
## Loglikelihood and Information Criteria:
##
##      Loglikelihood user model (H0)        -9167.606
##      Loglikelihood unrestricted model (H1) -9165.707
##
##      Akaike (AIC)                        18367.212
##      Bayesian (BIC)                      18440.701
##      Sample-size adjusted Bayesian (BIC)  18389.896
##
## Root Mean Square Error of Approximation:
##
##      RMSEA                               0.000
##      90 Percent confidence interval - lower 0.000
##      90 Percent confidence interval - upper 0.000
##      P-value RMSEA <= 0.05                1.000
##
## Standardized Root Mean Square Residual:
##
##      SRMR                                0.011
##
## Parameter Estimates:
##
##      Standard errors                      Standard
##      Information                          Expected
##      Information saturated (h1) model      Structured
##
## Latent Variables:
##
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      social =~
##      S1         1.000          2.007  0.889
##      S2         1.079    0.045  23.967  0.000  2.166  0.794
##      S3         0.855    0.035  24.534  0.000  1.716  0.814

```

```

##   agoraph =~
##       A1           1.000           1.820   0.785
##       A2           0.956   0.066   14.388   0.000   1.739   0.667
##       A3           0.917   0.063   14.495   0.000   1.669   0.684
##
## Regressions:
##           Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##   social ~
##       sex       -0.109   0.158   -0.689   0.491   -0.054   -0.027
##   agoraph ~
##       sex       -0.475   0.160   -2.973   0.003   -0.261   -0.130
##   A3 ~
##       sex       -0.985   0.148   -6.654   0.000   -0.985   -0.202
##
## Covariances:
##           Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##   .social ~~
##   .agoraph      0.999   0.171   5.857   0.000   0.276   0.276
##
## Variances:
##           Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##   .S1           1.072   0.126   8.533   0.000   1.072   0.210
##   .S2           2.750   0.195  14.087   0.000   2.750   0.370
##   .S3           1.501   0.114  13.169   0.000   1.501   0.338
##   .A1           2.062   0.217   9.498   0.000   2.062   0.384
##   .A2           3.777   0.264  14.302   0.000   3.777   0.555
##   .A3           2.705   0.214  12.642   0.000   2.705   0.455
##   .social       4.026   0.284  14.175   0.000   0.999   0.999
##   .agoraph      3.257   0.317  10.269   0.000   0.983   0.983
##
## Modification Indices:
##
##       lhs op      rhs   mi    epc sepc.lv sepc.all sepc.nox
## 1      sex ==    sex 0.000 0.000 0.000 0.000 0.000
## 2    social =~   A1 1.779 0.056 0.113 0.049 0.049
## 3    social =~   A2 0.505 -0.033 -0.067 -0.026 -0.026
## 4  agoraph =~   S1 0.010 -0.004 -0.007 -0.003 -0.003
## 5  agoraph =~   S2 0.461 0.031 0.057 0.021 0.021
## 6  agoraph =~   S3 0.286 -0.019 -0.034 -0.016 -0.016
## 7      S1 ==    S2 0.305 -0.298 -0.298 -0.174 -0.174
## 8      S1 ==    S3 0.459 0.303 0.303 0.239 0.239
## 9      S1 ==    A1 0.322 0.053 0.053 0.036 0.036
## 10     S1 ==    A2 0.018 -0.015 -0.015 -0.007 -0.007
## 11     S1 ==    A3 0.310 -0.054 -0.054 -0.032 -0.032
## 12     S2 ==    S3 0.007 -0.035 -0.035 -0.017 -0.017
## 13     S2 ==    A1 0.025 -0.020 -0.020 -0.008 -0.008
## 14     S2 ==    A2 0.000 -0.002 -0.002 -0.001 -0.001
## 15     S2 ==    A3 0.734 0.110 0.110 0.040 0.040
## 16     S3 ==    A1 0.171 0.039 0.039 0.022 0.022
## 17     S3 ==    A2 0.135 -0.041 -0.041 -0.017 -0.017
## 18     S3 ==    A3 0.531 -0.071 -0.071 -0.035 -0.035

```

```

## 19      A1 ~~      A2 0.599 -0.409 -0.409 -0.147 -0.147
## 20      A1 ~~      A3 0.819 -0.451 -0.451 -0.191 -0.191
## 21      A2 ~~      A3 2.184 0.625 0.625 0.195 0.195
## 22  social ~      A3 0.599 -0.044 -0.022 -0.054 -0.054
## 23 agoraph ~      A3 0.599 0.145 0.080 0.194 0.194
## 24      sex ~ social 0.000 0.990 1.987 3.977 3.977
## 25      sex ~ agoraph 0.000 0.044 0.080 0.160 0.160
## 26      sex ~      A3 0.000 0.018 0.018 0.086 0.086

```

The *MIMIC* model provides a good fit to the data, with a  $\chi^2(11) = 3.80$ ,  $p\text{-value} = .98$ ,  $RMSEA = 0.00$ , and  $CFI = 1.00$ .

Regarding the evidence for DIF, the following paragraph from Brown (2014, p. 280) is relevant:

Consistent with the researcher's predictions, the results of the *MIMIC* model show that the A3 indicator is not invariant for males and females (akin to intercept non-invariance in multiple-groups CFA). This is reflected by the significant direct effect of **sex** on the A3 indicator ( $z = 6.65$ ,  $p < .001$ ) that is not mediated by **agoraphobia**. In other words, when the latent variable of **agoraphobia** is held constant, there is a significant direct effect of **sex** on the A3 indicator. Thus, at any given value of the factor, women score significantly higher on the A3 indicator than men (by .985 units, or nearly a full point on the 0–8 scale). This is evidence of *differential item functioning*; that is, the item behaves differently as an indicator of **agoraphobia** in men and women.

## References

Brown, T. A. (2014). *Confirmatory factor analysis for applied research*. Guilford Publications.