SEM in R with *lavaan*

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Loading libraries

```
library(tidyverse)
library(knitr)
library(lavaan)
library(lavaanPlot)
library(psych)
library(DiagrammeR)
library(DiagrammeRsvg)
library(rsvg)
```

Reading data from CSV

```
df <- read_csv("Reading_Header.csv", na = '999999') # specifying missing values while reading data



df <- df %>%
  mutate(across(.cols = c(starts_with('INT'), starts_with('FAM')), .fns = ~as.character(.x))) # categor



glimpse(df)
```

```
## Rows: 537
## Columns: 15
## $ SUBJECT <dbl> 2, 2, 2, 3, 3, 3, 4, 4, 4, 5, 5, 5, 6, 6, 6, 7, 7, 7, 8, 8,...
## $ TEXT    <chr> "Netz", "Wind", "Spek", "Netz", "Wind", "Spek", "Netz", "Wi...
## $ OSPAN   <dbl> 0.7523810, 0.7523810, 0.7523810, 0.7979497, 0.7979497, 0.79...
## $ SSPAN   <dbl> 0.6907937, 0.6907937, 0.6907937, 0.4099440, 0.4099440, 0.40...
## $ COM1    <dbl> 3, 1, 3, 2, 0, 2, 3, 2, 3, 3, 2, 2, 3, 3, 2, 3, 2, 3, 2, 2,...
## $ COM2    <dbl> 3, 1, 2, 2, 0, 2, 2, 1, 2, 3, 1, 1, 3, 3, 3, 3, 2, 2, 1, 0,...
## $ COM3    <dbl> 3, 2, 2, 2, 3, 1, 3, 1, 3, 3, 1, 1, 3, 1, 3, 3, 1, 3, 2, 2,...
## $ INT1    <chr> "3", "1", "1", "2", "1", "2", "2", "2", "2", "3", "1", "1",...
## $ INT2    <chr> "3", "1", "1", "2", "1", "1", "2", "1", "1", "3", "1", "0",...
## $ INT3    <chr> "3", "0", "1", "2", "1", "1", "2", "1", "1", "3", "1", "1",...
## $ FAM1    <chr> "1", "3", "0", "2", "1", "2", "0", "1", "1", "2", "1", "0",...
## $ FAM2    <chr> "2", "2", "0", "3", "0", "1", "1", "2", "2", "3", "1", "1",...
```

```
## $ FAM3    <chr> "1", "2", "0", "2", "1", "1", "1", "1", "1", "3", "1", "1",...
## $ VOL     <dbl> 0.00, 0.25, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00,...
## $ INV     <dbl> 0.2500000, 0.2500000, 0.2500000, 0.6000000, 0.8000000, 0.50...
```

```
summary(df)
```

```
##     SUBJECT          TEXT               OSPAN             SSPAN
##  Min.   :  2.0   Length:537         Min.   :0.02451   Min.   :0.06803
##  1st Qu.: 50.0   Class :character   1st Qu.:0.60915   1st Qu.:0.45971
##  Median : 97.0   Mode  :character   Median :0.74893   Median :0.57576
##  Mean   :100.6                      Mean   :0.70170   Mean   :0.56546
##  3rd Qu.:144.0                      3rd Qu.:0.84944   3rd Qu.:0.68214
##  Max.   :337.0                      Max.   :1.00000   Max.   :1.00000
##                                                       NA's   :3
##       COM1            COM2            COM3           INT1
##  Min.   :0.000   Min.   :0.000   Min.   :0.000   Length:537
##  1st Qu.:1.000   1st Qu.:1.000   1st Qu.:1.000   Class :character
##  Median :2.000   Median :2.000   Median :2.000   Mode  :character
##  Mean   :1.818   Mean   :1.611   Mean   :1.855
##  3rd Qu.:2.000   3rd Qu.:2.000   3rd Qu.:3.000
##  Max.   :3.000   Max.   :3.000   Max.   :3.000
##
##      INT2               INT3               FAM1               FAM2
##  Length:537         Length:537         Length:537         Length:537
##  Class :character   Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character   Mode  :character
##
##
##
##
##      FAM3                VOL              INV
##  Length:537         Min.   :0.0000   Min.   :0.000
##  Class :character   1st Qu.:0.0000   1st Qu.:0.000
##  Mode  :character   Median :0.0000   Median :0.250
##                     Mean   :0.1316   Mean   :0.265
##                     3rd Qu.:0.2500   3rd Qu.:0.400
##                     Max.   :1.0000   Max.   :1.000
##                     NA's   :9        NA's   :9
```

Code for producing Table-1

Results can be found in Covariances table

```
corr.lv.model <- '

# latent variable definitions

lat_COM =~ COM1 + COM2 + COM3
lat_INT =~ INT1 + INT2 + INT3
lat_FAM =~ FAM1 + FAM2 + FAM3
lat_WMC =~ OSPAN + SSPAN
```

```
# covariances

VOL ~~ INV
lat_INT ~~ lat_WMC
lat_INT ~~ lat_FAM
lat_INT ~~ lat_COM
lat_COM ~~ lat_FAM
lat_COM ~~ lat_WMC
lat_FAM ~~ lat_WMC



'




fit.lv.model <- cfa(model = corr.lv.model, data = df, cluster = 'SUBJECT', ordered = paste0(rep(c("INT"

summary(fit.lv.model, standardized=TRUE) # In covariance table std.lv includes the correlation
```

```
## lavaan 0.6-6 ended normally after 86 iterations
##
##   Estimator                                         DWLS
##   Optimization method                           NLMINB
##   Number of free parameters                         50
##
##                                                   Used       Total
##   Number of observations                           525         537
##   Number of clusters [SUBJECT]                     178
##
## Model Test User Model:
##                                               Standard      Robust
##   Test Statistic                               570.553     556.927
##   Degrees of freedom                                60          60
##   P-value (Chi-square)                           0.000       0.000
##   Scaling correction factor                                  1.073
##   Shift parameter                                           25.050
##        simple second-order correction
##
## Parameter Estimates:
##
##   Standard errors                             Robust.sem
##   Information                                   Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lat_COM =~
##     COM1              1.000                               0.457    0.507
##     COM2              1.411    0.211    6.671    0.000    0.645    0.682
##     COM3              1.312    0.215    6.102    0.000    0.600    0.626
##   lat_INT =~
```

```
##     INT1              1.000                               0.923    0.923
##     INT2              0.986    0.018   54.433    0.000    0.910    0.910
##     INT3              0.944    0.017   54.917    0.000    0.871    0.871
##   lat_FAM =~
##     FAM1              1.000                               0.893    0.893
##     FAM2              0.966    0.021   45.380    0.000    0.863    0.863
##     FAM3              1.032    0.023   45.470    0.000    0.922    0.922
##   lat_WMC =~
##     OSPAN             1.000                               0.130    0.654
##     SSPAN             0.995    0.267    3.720    0.000    0.130    0.756
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   VOL ~~
##     INV             -0.008    0.003   -2.836    0.005   -0.008   -0.145
##   lat_INT ~~
##     lat_WMC           0.005    0.007    0.702    0.482    0.039    0.039
##     lat_FAM           0.440    0.031   14.017    0.000    0.534    0.534
##   lat_COM ~~
##     lat_INT           0.196    0.035    5.636    0.000    0.465    0.465
##     lat_FAM           0.111    0.028    3.969    0.000    0.271    0.271
##     lat_WMC           0.020    0.006    3.523    0.000    0.334    0.334
##   lat_FAM ~~
##     lat_WMC           0.007    0.007    1.077    0.281    0.064    0.064
##
## Intercepts:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .COM1              1.832    0.042   44.133    0.000    1.832    2.031
##    .COM2              1.619    0.041   39.017    0.000    1.619    1.712
##    .COM3              1.867    0.045   41.479    0.000    1.867    1.947
##    .INT1              0.000                               0.000    0.000
##    .INT2              0.000                               0.000    0.000
##    .INT3              0.000                               0.000    0.000
##    .FAM1              0.000                               0.000    0.000
##    .FAM2              0.000                               0.000    0.000
##    .FAM3              0.000                               0.000    0.000
##    .OSPAN             0.707    0.012   59.905    0.000    0.707    3.545
##    .SSPAN             0.568    0.008   74.341    0.000    0.568    3.311
##     VOL               0.130    0.018    7.357    0.000    0.130    0.572
##     INV               0.264    0.012   21.320    0.000    0.264    1.091
##     lat_COM           0.000                               0.000    0.000
##     lat_INT           0.000                               0.000    0.000
##     lat_FAM           0.000                               0.000    0.000
##     lat_WMC           0.000                               0.000    0.000
##
## Thresholds:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     INT1|t1         -1.234    0.073  -16.916    0.000   -1.234   -1.234
##     INT1|t2         -0.278    0.056   -5.008    0.000   -0.278   -0.278
##     INT1|t3          0.788    0.061   12.839    0.000    0.788    0.788
##     INT2|t1         -1.102    0.069  -16.035    0.000   -1.102   -1.102
##     INT2|t2         -0.065    0.055   -1.177    0.239   -0.065   -0.065
##     INT2|t3          0.956    0.065   14.733    0.000    0.956    0.956
##     INT3|t1         -0.949    0.065  -14.657    0.000   -0.949   -0.949
```

```
##     INT3|t2           0.002    0.055    0.044    0.965    0.002    0.002
##     INT3|t3           1.224    0.073   16.859    0.000    1.224    1.224
##     FAM1|t1          -0.694    0.060  -11.602    0.000   -0.694   -0.694
##     FAM1|t2           0.229    0.055    4.139    0.000    0.229    0.229
##     FAM1|t3           1.175    0.071   16.557    0.000    1.175    1.175
##     FAM2|t1          -0.994    0.066  -15.108    0.000   -0.994   -0.994
##     FAM2|t2          -0.117    0.055   -2.136    0.033   -0.117   -0.117
##     FAM2|t3           1.010    0.066   15.256    0.000    1.010    1.010
##     FAM3|t1          -0.821    0.062  -13.243    0.000   -0.821   -0.821
##     FAM3|t2           0.219    0.055    3.965    0.000    0.219    0.219
##     FAM3|t3           1.321    0.076   17.335    0.000    1.321    1.321
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .COM1             0.605    0.052   11.555    0.000    0.605    0.743
##    .COM2             0.478    0.063    7.575    0.000    0.478    0.535
##    .COM3             0.559    0.061    9.174    0.000    0.559    0.608
##    .INT1             0.149                              0.149    0.149
##    .INT2             0.172                              0.172    0.172
##    .INT3             0.242                              0.242    0.242
##    .FAM1             0.202                              0.202    0.202
##    .FAM2             0.256                              0.256    0.256
##    .FAM3             0.149                              0.149    0.149
##    .OSPAN            0.023    0.005    4.942    0.000    0.023    0.572
##    .SSPAN            0.013    0.004    2.847    0.004    0.013    0.428
##     VOL              0.052    0.003   16.357    0.000    0.052    1.000
##     INV              0.058    0.004   15.341    0.000    0.058    1.000
##     lat_COM          0.209    0.049    4.298    0.000    1.000    1.000
##     lat_INT          0.851    0.019   44.197    0.000    1.000    1.000
##     lat_FAM          0.798    0.024   33.406    0.000    1.000    1.000
##     lat_WMC          0.017    0.005    3.441    0.001    1.000    1.000
##
## Scales y*:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     INT1             1.000                              1.000    1.000
##     INT2             1.000                              1.000    1.000
##     INT3             1.000                              1.000    1.000
##     FAM1             1.000                              1.000    1.000
##     FAM2             1.000                              1.000    1.000
##     FAM3             1.000                              1.000    1.000
```

```r
# Estimating Cronbach's alpha for Latent variable

alpha(df %>% select(starts_with("COM"))) # Estimate for Comprehension
```

```
##
## Reliability analysis
## Call: alpha(x = df %>% select(starts_with("COM")))
##
##   raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
##       0.64      0.64    0.54      0.37 1.7 0.027  1.8 0.71     0.36
##
##  lower alpha upper     95% confidence boundaries
## 0.58 0.64 0.69
```

```
##
##  Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## COM1      0.53      0.53    0.36      0.36 1.1    0.040    NA  0.36
## COM2      0.50      0.50    0.34      0.34 1.0    0.043    NA  0.34
## COM3      0.58      0.58    0.41      0.41 1.4    0.036    NA  0.41
##
##  Item statistics
##        n raw.r std.r r.cor r.drop mean   sd
## COM1 537  0.75  0.76  0.57   0.45  1.8 0.91
## COM2 537  0.78  0.77  0.59   0.47  1.6 0.94
## COM3 537  0.75  0.74  0.52   0.42  1.9 0.96
##
## Non missing response frequency for each item
##         0    1    2    3 miss
## COM1 0.09 0.25 0.42 0.25    0
## COM2 0.13 0.33 0.35 0.20    0
## COM3 0.10 0.25 0.35 0.30    0
```

```
alpha(df %>% select(starts_with("INT")) %>% mutate_all(as.numeric)) # Estimate for Interest
```

```
##
## Reliability analysis
## Call: alpha(x = df %>% select(starts_with("INT")) %>% mutate_all(as.numeric))
##
##   raw_alpha std.alpha G6(smc) average_r S/N    ase mean   sd median_r
##        0.9       0.9    0.85      0.74 8.6 0.0078  1.6 0.84     0.74
##
##  lower alpha upper     95% confidence boundaries
## 0.88 0.9 0.91
##
##  Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## INT1      0.84      0.84    0.72      0.72 5.2    0.014    NA  0.72
## INT2      0.85      0.85    0.74      0.74 5.7    0.013    NA  0.74
## INT3      0.87      0.87    0.76      0.76 6.4    0.012    NA  0.76
##
##  Item statistics
##        n raw.r std.r r.cor r.drop mean   sd
## INT1 537  0.92  0.92  0.86   0.81  1.7 0.93
## INT2 537  0.91  0.91  0.84   0.80  1.5 0.93
## INT3 537  0.90  0.90  0.82   0.78  1.4 0.90
##
## Non missing response frequency for each item
##         0    1    2    3 miss
## INT1 0.11 0.28 0.39 0.21    0
## INT2 0.14 0.34 0.36 0.17    0
## INT3 0.18 0.33 0.39 0.11    0
```

```
alpha(df %>% select(starts_with("FAM")) %>% mutate_all(as.numeric)) # Estimate for Familarity
```

```
##
## Reliability analysis
```

```
## Call: alpha(x = df %>% select(starts_with("FAM")) %>% mutate_all(as.numeric))
##
##   raw_alpha std.alpha G6(smc) average_r S/N    ase mean   sd median_r
##       0.88      0.88    0.84      0.71 7.5 0.0089  1.4 0.84     0.69
##
##  lower alpha upper     95% confidence boundaries
## 0.86 0.88 0.9
##
##  Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## FAM1      0.82      0.82    0.69      0.69 4.6    0.016    NA  0.69
## FAM2      0.87      0.87    0.77      0.77 6.6    0.011    NA  0.77
## FAM3      0.81      0.81    0.68      0.68 4.3    0.016    NA  0.68
##
##  Item statistics
##        n raw.r std.r r.cor r.drop mean   sd
## FAM1 537  0.91  0.91  0.84   0.78  1.3 0.96
## FAM2 537  0.88  0.88  0.77   0.73  1.5 0.94
## FAM3 537  0.91  0.91  0.85   0.80  1.3 0.90
##
## Non missing response frequency for each item
##         0    1    2    3 miss
## FAM1 0.25 0.34 0.29 0.12    0
## FAM2 0.16 0.29 0.39 0.15    0
## FAM3 0.21 0.38 0.32 0.09    0
```

```
alpha(df %>% select(ends_with("PAN")))  # Estimate for WMC
```

```
##
## Reliability analysis
## Call: alpha(x = df %>% select(ends_with("PAN")))
##
##   raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
##       0.66      0.67     0.5       0.5   2 0.029 0.63 0.16      0.5
##
##  lower alpha upper     95% confidence boundaries
## 0.61 0.66 0.72
##
##  Reliability if an item is dropped:
##       raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
## OSPAN      0.50       0.5    0.25       0.5  NA       NA  0.50   0.5
## SSPAN      0.25       0.5      NA        NA  NA       NA  0.25   0.5
##
##  Item statistics
##         n raw.r std.r r.cor r.drop mean   sd
## OSPAN 537  0.89  0.87  0.61    0.5 0.70 0.20
## SSPAN 534  0.84  0.87  0.61    0.5 0.57 0.17
```

Code for producing Table-2 and Tbale-3

In the regression table Std.all includes the estimates in Table-2 and Std.lv includes estimate for Table-3. I am not clear why the sign is opposite with respect to the sign in the paper in Table-3.

```
myModel <- readLines("model.lav")


cat(myModel, fill = TRUE)
```

```
##  # latent variable definitions   lat_COM =~ COM1 + COM2 + COM3
## lat_INT =~ INT1 + INT2 + INT3 lat_FAM =~ FAM1 + FAM2 + FAM3
## lat_WMC =~ OSPAN + SSPAN    # regressions
## lat_COM ~ a * lat_WMC + b * lat_INT + c * lat_FAM + VOL + INV
## VOL ~ d * lat_WMC + e * lat_INT + f * lat_FAM
## INV ~ g * lat_WMC + h * lat_INT + i * lat_FAM     # variances and covariances
## VOL ~~ INV lat_INT ~~ lat_WMC lat_FAM ~~ lat_WMC lat_INT ~~ lat_FAM
```

```
fit <- sem(model = myModel, data = df, cluster = 'SUBJECT', ordered = paste0(rep(c("INT", "FAM"), each =

summary(fit, standardized=TRUE)
```

```
## lavaan 0.6-6 ended normally after 102 iterations
##
##   Estimator                                         DWLS
##   Optimization method                           NLMINB
##   Number of free parameters                         58
##
##                                                   Used       Total
##   Number of observations                           525         537
##   Number of clusters [SUBJECT]                     178
##
## Model Test User Model:
##                                               Standard      Robust
##   Test Statistic                                59.776     127.152
##   Degrees of freedom                                52          52
##   P-value (Chi-square)                           0.214       0.000
##   Scaling correction factor                                  0.523
##   Shift parameter                                           12.880
##        simple second-order correction
##
## Parameter Estimates:
##
##   Standard errors                             Robust.sem
##   Information                                   Expected
##   Information saturated (h1) model          Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lat_COM =~
##     COM1              1.000                               0.465    0.515
##     COM2              1.357    0.193    7.043    0.000    0.631    0.667
##     COM3              1.307    0.205    6.373    0.000    0.607    0.633
##   lat_INT =~
##     INT1              1.000                               0.925    0.925
##     INT2              0.981    0.018   54.248    0.000    0.908    0.908
##     INT3              0.940    0.017   54.999    0.000    0.870    0.870
```

```
##   lat_FAM =~
##     FAM1              1.000                                    0.893    0.893
##     FAM2              0.968    0.022   44.710    0.000    0.864    0.864
##     FAM3              1.032    0.023   45.099    0.000    0.922    0.922
##   lat_WMC =~
##     OSPAN             1.000                                    0.131    0.656
##     SSPAN             0.989    0.240    4.122    0.000    0.129    0.754
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   lat_COM ~
##     lat_WMC    (a)    0.895    0.252    3.552    0.000    0.252    0.252
##     lat_INT    (b)    0.146    0.039    3.752    0.000    0.290    0.290
##     lat_FAM    (c)    0.008    0.032    0.263    0.792    0.016    0.016
##     VOL              -0.559    0.130   -4.283    0.000   -1.203   -0.274
##     INV              -0.454    0.118   -3.840    0.000   -0.976   -0.236
##   VOL ~
##     lat_WMC    (d)   -0.209    0.082   -2.537    0.011   -0.027   -0.120
##     lat_INT    (e)   -0.081    0.010   -8.320    0.000   -0.075   -0.329
##     lat_FAM    (f)    0.008    0.010    0.758    0.448    0.007    0.031
##   INV ~
##     lat_WMC    (g)   -0.249    0.093   -2.687    0.007   -0.033   -0.134
##     lat_INT    (h)   -0.073    0.013   -5.417    0.000   -0.068   -0.280
##     lat_FAM    (i)   -0.006    0.014   -0.397    0.691   -0.005   -0.021
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##  .VOL ~~
##    .INV              -0.014    0.003   -4.941    0.000   -0.014   -0.286
##   lat_INT ~~
##     lat_WMC            0.005    0.007    0.707    0.479    0.040    0.040
##   lat_FAM ~~
##     lat_WMC            0.007    0.007    1.079    0.281    0.064    0.064
##   lat_INT ~~
##     lat_FAM            0.441    0.031   14.020    0.000    0.534    0.534
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .COM1              2.025    0.064   31.510    0.000    2.025    2.245
##    .COM2              1.880    0.073   25.758    0.000    1.880    1.988
##    .COM3              2.118    0.078   27.114    0.000    2.118    2.209
##    .INT1              0.000                              0.000    0.000
##    .INT2              0.000                              0.000    0.000
##    .INT3              0.000                              0.000    0.000
##    .FAM1              0.000                              0.000    0.000
##    .FAM2              0.000                              0.000    0.000
##    .FAM3              0.000                              0.000    0.000
##    .OSPAN             0.707    0.012   59.905    0.000    0.707    3.545
##    .SSPAN             0.568    0.008   74.341    0.000    0.568    3.311
##    .VOL               0.130    0.018    7.357    0.000    0.130    0.572
##    .INV               0.264    0.012   21.320    0.000    0.264    1.091
##    .lat_COM           0.000                              0.000    0.000
##     lat_INT           0.000                              0.000    0.000
##     lat_FAM           0.000                              0.000    0.000
```

```
##     lat_WMC           0.000                             0.000    0.000
##
## Thresholds:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     INT1|t1         -1.234    0.073  -16.916    0.000   -1.234   -1.234
##     INT1|t2         -0.278    0.056   -5.008    0.000   -0.278   -0.278
##     INT1|t3          0.788    0.061   12.839    0.000    0.788    0.788
##     INT2|t1         -1.102    0.069  -16.035    0.000   -1.102   -1.102
##     INT2|t2         -0.065    0.055   -1.177    0.239   -0.065   -0.065
##     INT2|t3          0.956    0.065   14.733    0.000    0.956    0.956
##     INT3|t1         -0.949    0.065  -14.657    0.000   -0.949   -0.949
##     INT3|t2          0.002    0.055    0.044    0.965    0.002    0.002
##     INT3|t3          1.224    0.073   16.859    0.000    1.224    1.224
##     FAM1|t1         -0.694    0.060  -11.602    0.000   -0.694   -0.694
##     FAM1|t2          0.229    0.055    4.139    0.000    0.229    0.229
##     FAM1|t3          1.175    0.071   16.557    0.000    1.175    1.175
##     FAM2|t1         -0.994    0.066  -15.108    0.000   -0.994   -0.994
##     FAM2|t2         -0.117    0.055   -2.136    0.033   -0.117   -0.117
##     FAM2|t3          1.010    0.066   15.256    0.000    1.010    1.010
##     FAM3|t1         -0.821    0.062  -13.243    0.000   -0.821   -0.821
##     FAM3|t2          0.219    0.055    3.965    0.000    0.219    0.219
##     FAM3|t3          1.321    0.076   17.335    0.000    1.321    1.321
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .COM1             0.598    0.050   11.860    0.000    0.598    0.735
##    .COM2             0.497    0.058    8.506    0.000    0.497    0.555
##    .COM3             0.551    0.058    9.443    0.000    0.551    0.599
##    .INT1             0.144                              0.144    0.144
##    .INT2             0.176                              0.176    0.176
##    .INT3             0.243                              0.243    0.243
##    .FAM1             0.202                              0.202    0.202
##    .FAM2             0.253                              0.253    0.253
##    .FAM3             0.151                              0.151    0.151
##    .OSPAN            0.023    0.004    5.469    0.000    0.023    0.570
##    .SSPAN            0.013    0.004    3.210    0.001    0.013    0.431
##    .VOL              0.046    0.003   16.545    0.000    0.046    0.884
##    .INV              0.052    0.003   15.540    0.000    0.052    0.894
##    .lat_COM          0.129    0.030    4.345    0.000    0.599    0.599
##     lat_INT          0.856    0.019   44.492    0.000    1.000    1.000
##     lat_FAM          0.798    0.024   33.133    0.000    1.000    1.000
##     lat_WMC          0.017    0.005    3.770    0.000    1.000    1.000
##
## Scales y*:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     INT1             1.000                              1.000    1.000
##     INT2             1.000                              1.000    1.000
##     INT3             1.000                              1.000    1.000
##     FAM1             1.000                              1.000    1.000
##     FAM2             1.000                              1.000    1.000
##     FAM3             1.000                              1.000    1.000
```

Code for producing Figure-2

```
labels = list(lat_INT = "Interest", lat_FAM = "Familarity", lat_WMC = "WMC", lat_COM = "Reading", VOL =


grph <- lavaanPlot(model = fit, stand = TRUE,
           labels = labels, node_options = list(shape = "box", fontname = "Helvetica"),
           edge_options = list(color = "grey"), coef = TRUE)


tmp<-capture.output(rsvg_png(charToRaw(export_svg(grph)),'SEM.png'))

cat('![Structural equation model with estimated standardized coefficients.](SEM.png){#fig:SEM}\n\n')
```

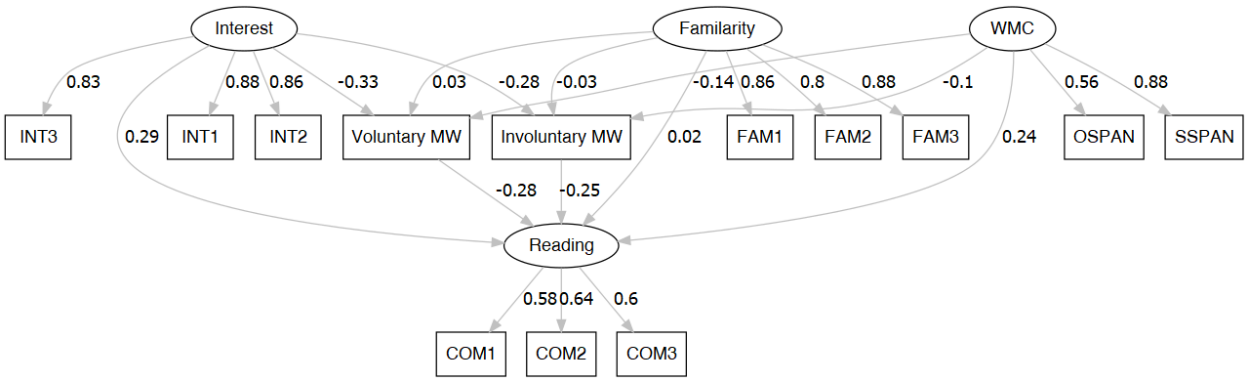

Figure 1: Structural equation model with estimated standardized coefficients.

Code for producing Table-4

```
df %>% select(-SUBJECT, -TEXT) %>% lowerCor(digits = 2)
```

```
##       OSPAN SSPAN COM1  COM2  COM3  INT1  INT2  INT3  FAM1  FAM2  FAM3
## OSPAN  1.00
## SSPAN  0.50  1.00
## COM1   0.11  0.21  1.00
## COM2   0.14  0.14  0.41  1.00
## COM3   0.15  0.15  0.34  0.36  1.00
## INT1   0.11  0.05  0.22  0.29  0.29  1.00
## INT2   0.08 -0.03  0.18  0.28  0.24  0.76  1.00
## INT3   0.05 -0.05  0.18  0.26  0.27  0.74  0.72  1.00
## FAM1   0.01  0.00  0.05  0.13  0.10  0.34  0.37  0.32  1.00
## FAM2   0.11  0.07  0.11  0.21  0.20  0.41  0.48  0.40  0.68  1.00
## FAM3   0.03  0.06  0.11  0.17  0.15  0.36  0.40  0.34  0.77  0.69  1.00
## VOL   -0.05 -0.13 -0.24 -0.21 -0.24 -0.30 -0.27 -0.25 -0.08 -0.17 -0.12
## INV   -0.13 -0.08 -0.15 -0.21 -0.22 -0.28 -0.21 -0.24 -0.17 -0.14 -0.13
##      VOL   INV
## VOL  1.00
## INV -0.15  1.00
```

```
describe(df %>% select(-SUBJECT, -TEXT)) %>% rownames_to_column() %>% kable(digits = 2)
```

rowname	vars	n	mean	sd	median	trimmed	mad	min	max	range	skew	kurtosis	se
OSPAN	1	537	0.70	0.20	0.75	0.73	0.16	0.02	1	0.98	-1.17	1.07	0.01
SSPAN	2	534	0.57	0.17	0.58	0.57	0.16	0.07	1	0.93	-0.28	0.05	0.01
COM1	3	537	1.82	0.91	2.00	1.88	1.48	0.00	3	3.00	-0.35	-0.67	0.04
COM2	4	537	1.61	0.94	2.00	1.64	1.48	0.00	3	3.00	-0.08	-0.91	0.04
COM3	5	537	1.85	0.96	2.00	1.94	1.48	0.00	3	3.00	-0.38	-0.87	0.04
INT1	6	537	1.70	0.93	2.00	1.75	1.48	0.00	3	3.00	-0.23	-0.81	0.04
INT2	7	537	1.55	0.93	2.00	1.56	1.48	0.00	3	3.00	-0.05	-0.86	0.04
INT3	8	537	1.43	0.90	1.00	1.41	1.48	0.00	3	3.00	-0.07	-0.83	0.04
FAM1	9	537	1.28	0.96	1.00	1.23	1.48	0.00	3	3.00	0.20	-0.96	0.04
FAM2	10	537	1.53	0.94	2.00	1.54	1.48	0.00	3	3.00	-0.13	-0.88	0.04
FAM3	11	537	1.30	0.90	1.00	1.26	1.48	0.00	3	3.00	0.14	-0.80	0.04
VOL	12	528	0.13	0.23	0.00	0.08	0.00	0.00	1	1.00	2.10	4.40	0.01
INV	13	528	0.27	0.24	0.25	0.24	0.37	0.00	1	1.00	0.81	0.40	0.01