

MCFA_GBPNS-PE Scale

DS

15 Januar 2020

MCFA and reliability analysis, 11 items: R4 excluded

Load Packages

```
library(lavaan)
library(tidyverse)
library(Matrix)
library(psych)
```

```
# Load dataset AKS_U_Skala
AKS_PE <- read.csv2(file.choose())

##### Delete R4.
AKS_PE <- AKS_PE[, -c(9)]

# Delete empty cases.
maxNA <- 7
AKS_PE <- AKS_PE[!(base::rowSums(is.na(AKS_PE)) > maxNA), ]
```

Daten

Zur Veranschaulichung des Datensatzes

```
## 'data.frame':   481 obs. of  12 variables:
##  $ Gruppe           : int  5 5 5 5 5 5 5 5 5 5 ...
##  $ Autonomy_PE_1    : int  2 1 4 3 2 1 2 3 3 3 ...
##  $ Autonomy_PE_2    : int  2 2 3 3 3 1 3 2 4 2 ...
##  $ Autonomy_PE_3    : int  4 2 3 3 5 1 3 5 3 3 ...
##  $ Autonomy_PE_4    : int  4 2 4 4 4 1 3 2 4 3 ...
##  $ Relatedness_PE_1: int  5 5 5 5 5 5 4 5 3 3 ...
##  $ Relatedness_PE_2: int  2 5 5 4 5 5 4 5 3 3 ...
##  $ Relatedness_PE_3: int  2 5 5 3 5 5 4 5 3 3 ...
##  $ Competence_PE_1 : int  4 5 5 5 5 1 4 5 2 3 ...
##  $ Competence_PE_2 : int  3 4 4 4 5 1 2 3 2 3 ...
##  $ Competence_PE_3 : int  1 5 3 4 5 1 4 5 2 3 ...
##  $ Competence_PE_4 : int  5 4 1 4 5 1 4 4 3 2 ...
```

```
##      Gruppe      Autonomy_PE_1  Autonomy_PE_2  Autonomy_PE_3
##  Min.      : 1.00    Min.      :1.000    Min.      :1.000    Min.      :1.000
## 1st Qu.: 9.00    1st Qu.:2.000    1st Qu.:2.000    1st Qu.:3.000
## Median :17.00    Median :3.000    Median :3.000    Median :3.000
## Mean   :17.05    Mean   :3.015    Mean   :3.057    Mean   :3.546
## 3rd Qu.:25.00    3rd Qu.:3.000    3rd Qu.:4.000    3rd Qu.:5.000
## Max.   :33.00    Max.   :5.000    Max.   :5.000    Max.   :5.000
##      NA's      :5      NA's      :7      NA's      :5
## Autonomy_PE_4  Relatedness_PE_1 Relatedness_PE_2 Relatedness_PE_3
##  Min.      :1.000    Min.      :1.000    Min.      :1.000    Min.      :1.00
## 1st Qu.:3.000    1st Qu.:3.000    1st Qu.:3.000    1st Qu.:3.00
## Median :3.000    Median :4.000    Median :4.000    Median :4.00
## Mean   :3.279    Mean   :4.038    Mean   :3.878    Mean   :3.96
## 3rd Qu.:4.000    3rd Qu.:5.000    3rd Qu.:5.000    3rd Qu.:5.00
## Max.   :5.000    Max.   :5.000    Max.   :5.000    Max.   :5.00
## NA's    :11      NA's     :9      NA's     :7      NA's     :10
## Competence_PE_1 Competence_PE_2 Competence_PE_3 Competence_PE_4
##  Min.      :1.000    Min.      :1.000    Min.      :1.000    Min.      :1.000
## 1st Qu.:3.000    1st Qu.:3.000    1st Qu.:3.000    1st Qu.:3.000
## Median :4.000    Median :3.000    Median :4.000    Median :4.000
## Mean   :3.859    Mean   :3.279    Mean   :3.684    Mean   :3.656
## 3rd Qu.:5.000    3rd Qu.:4.000    3rd Qu.:4.000    3rd Qu.:4.000
## Max.   :5.000    Max.   :5.000    Max.   :5.000    Max.   :5.000
## NA's    :12      NA's     :8      NA's    :12      NA's     :7
```

MCFA

```
print(AKS_PE %>%
  group_by(Gruppe) %>%
  summarise(obs_per_class = n()) , n = Inf)
```

```
## # A tibble: 33 x 2
##   Gruppe obs_per_class
##   <int>         <int>
##  1         1          22
##  2         2          12
##  3         3          22
##  4         4          23
##  5         5          14
##  6         6           4
##  7         7           4
##  8         8          18
##  9         9           8
## 10        10           5
## 11        11          13
## 12        12          18
## 13        13           9
## 14        14          24
## 15        15          20
## 16        16          11
## 17        17          15
## 18        18           9
## 19        19          23
## 20        20          19
## 21        21          16
## 22        22          14
## 23        23          12
## 24        24          19
## 25        25           7
## 26        26          13
## 27        27          26
## 28        28          11
## 29        29          11
## 30        30          11
## 31        31          13
## 32        32          19
## 33        33          16
```

```
print(AKS_PE %>%
  group_by(Gruppe) %>%
  summarise_all(funs(mean = mean(., na.rm = T))) , width = Inf, n = Inf)
```

```
## # A tibble: 33 x 12
```

```
##   Gruppe Autonomy_PE_1_mean Autonomy_PE_2_mean Autonomy_PE_3_mean
##   <int>          <dbl>          <dbl>          <dbl>
## 1     1           3.09           3.09           3.59
## 2     2           3.42           3.5            3.83
## 3     3           2.68           3             3.32
## 4     4           3.91           3.39           3.74
## 5     5           2.5            2.57           3.5
## 6     6           2.25           2.5            3.75
## 7     7           4             3.25           4.25
## 8     8           3.06           2.89           3.67
## 9     9           3.38           3.38           4.12
## 10    10          2.6            3             3.4
## 11    11          2.69           3.46           3.77
## 12    12          3.33           2.94           3.44
## 13    13          3.89           3.44           3.44
## 14    14          2.74           2.67           3.25
## 15    15          2.65           3.2            3.58
## 16    16          3.6            2.73           3.64
## 17    17          3.71           3.43           4.21
## 18    18          3.33           2.88           3.78
## 19    19          3.05           3.23           3.65
## 20    20          1.61           2.11           2.53
## 21    21          3.19           2.79           3.33
## 22    22          3.29           3.43           3.93
## 23    23          3.42           3.67           4.5
## 24    24          2.47           2.53           2.53
## 25    25          4             3.86           4
## 26    26          2.77           2.92           3.17
## 27    27          3.15           3.16           3.76
## 28    28          2.55           3.18           3.45
## 29    29          2.82           3.1            3.91
## 30    30          4             3.73           3.91
## 31    31          2.85           3             3.23
## 32    32          2.42           3.11           3.47
## 33    33          2.81           2.81           3.44
```

```
##   Autonomy_PE_4_mean Relatedness_PE_1_mean Relatedness_PE_2_mean
##   <dbl>          <dbl>          <dbl>
## 1           3.55           3.64           3.55
## 2           3.75           3.5            3.75
## 3           3.32           4.05           3.73
## 4           3.61           4.26           3.83
## 5           3.14           4.36           4
## 6           3             4             4.5
## 7           3.25           3.5            3.75
## 8           3.39           4.39           4.17
## 9           3.88           3.88           3.75
## 10          2.8            4             3.8
## 11          3.54           4.38           3.69
## 12          3.06           4.28           4
## 13          3.44           3.89           3.89
## 14          3.18           3.75           3.79
## 15          3.22           4.05           4.16
## 16          3.09           3.91           3.82
## 17          3.86           4.07           3.87
## 18          3.33           3.78           3.67
## 19          3.43           4.36           4.05
## 20          2.11           4.06           3.95
## 21          2.43           3.75           3.6
## 22          3.64           3.71           3.93
```

## 23	3.83	4.25	4.27
## 24	2.74	3.84	3.53
## 25	4.14	4.57	4
## 26	2.83	3.77	3.54
## 27	3.32	4.31	4.04
## 28	3.36	4.3	4.3
## 29	3.36	3.91	4
## 30	4.18	4.36	3.91
## 31	3.08	3.46	3.69
## 32	3.21	4.42	4.26
## 33	2.94	3.87	3.53
##	Relatedness_PE_3_mean	Competence_PE_1_mean	Competence_PE_2_mean
##	<dbl>	<dbl>	<dbl>
## 1	3.9	3.64	3.05
## 2	3.92	4	3.58
## 3	3.91	3.95	3.23
## 4	3.83	4	3.10
## 5	3.93	3.86	3.36
## 6	3.5	3.75	3.25
## 7	4	3.5	3.75
## 8	4.22	3.61	2.72
## 9	4	4.38	3.88
## 10	4	4	3.8
## 11	3.77	4	3.46
## 12	3.89	4.24	3.67
## 13	3.89	3.88	3
## 14	3.83	3.79	3.25
## 15	4	3.9	3.32
## 16	3.91	3.91	2.9
## 17	4.2	4.08	4
## 18	3.88	4.11	3.38
## 19	4.38	4.09	3.68
## 20	4.16	3.5	2.79
## 21	3.81	3.94	3
## 22	4.07	3.43	3.14
## 23	4.08	4.33	4
## 24	3.63	3.32	2.89
## 25	4.29	3.43	3.29
## 26	3.67	3.83	3.38
## 27	4.08	4.12	3.19
## 28	4.2	3.82	3.09
## 29	3.91	3.64	3.09
## 30	3.73	3.55	3.18
## 31	3.83	3.92	3.38
## 32	4.21	4.11	3.42
## 33	3.69	3.62	3.25
##	Competence_PE_3_mean	Competence_PE_4_mean	
##	<dbl>	<dbl>	
## 1	3.41	3.45	
## 2	3.67	3.83	
## 3	3.5	3.59	
## 4	3.83	3.52	
## 5	3.64	3.5	
## 6	4	3.5	
## 7	3.67	3.5	
## 8	3.89	3.44	
## 9	4	4	
## 10	3.8	3.6	
## 11	4.15	4.08	
## 12	3.72	4.11	

```
## 13      4.11      3.33
## 14      3.46      3.79
## 15      4        3.8
## 16      3.7      3.64
## 17      3.93      4
## 18      3.67      4.22
## 19      4.05      3.86
## 20      3.39      3.26
## 21      3.07      3.21
## 22      3.5      3.79
## 23      4        3.91
## 24      3.26      3.32
## 25      4.14      3.14
## 26      3.54      3.85
## 27      3.8      3.65
## 28      3.6      3.82
## 29      4.09      3.91
## 30      3.55      3.27
## 31      3.23      3.23
## 32      4        3.84
## 33      3.19      3.6
```

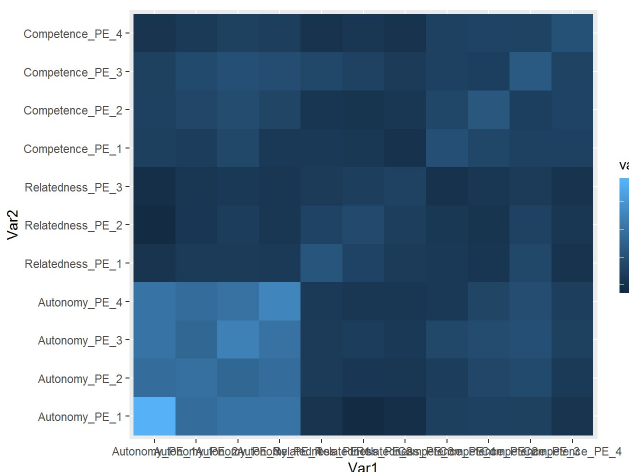
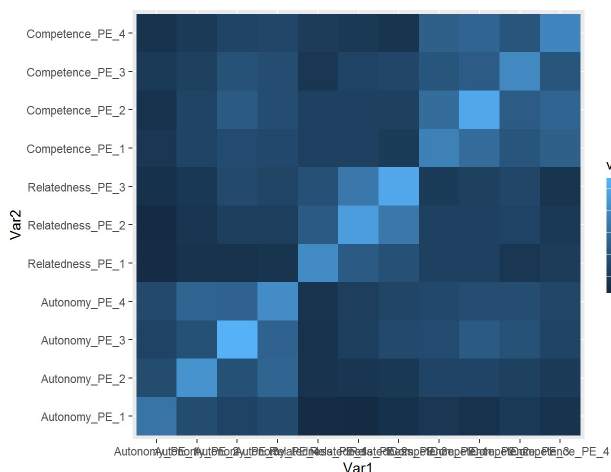
Define functions for MCFA

```
# Execute function mcfa.input with grouping variable and save to object x
x <- mcfa_input("Gruppe", AKS_PE)
```

```
# Graphical representation of the pure within and between covariance matrix
melted_pw.cov <- reshape2::melt(x$pw.cov)
melted_b.cov <- reshape2::melt(x$b.cov)

ggplot(data = melted_pw.cov, aes(x=Var1, y=Var2, fill=value)) +
  geom_tile()

ggplot(data = melted_b.cov, aes(x=Var1, y=Var2, fill=value)) +
  geom_tile()
```



Indicates three factors at individual level but maybe only one factor at group level.

```
str(x)
```

```
## List of 10
## $ b.cov : num [1:11, 1:11] 3.747 1.863 2.039 2.045 0.112 ...
## .. attr(*, "dimnames")=List of 2
## .. ..$ : chr [1:11] "Autonomy_PE_1" "Autonomy_PE_2" "Autonomy_PE_3" "Autonomy_PE_4" ...
## .. ..$ : chr [1:11] "Autonomy_PE_1" "Autonomy_PE_2" "Autonomy_PE_3" "Autonomy_PE_4" ...
## $ pw.cov: num [1:11, 1:11] 0.805 0.428 0.344 0.41 0.106 ...
## .. attr(*, "dimnames")=List of 2
## .. ..$ : chr [1:11] "Autonomy_PE_1" "Autonomy_PE_2" "Autonomy_PE_3" "Autonomy_PE_4" ...
## .. ..$ : chr [1:11] "Autonomy_PE_1" "Autonomy_PE_2" "Autonomy_PE_3" "Autonomy_PE_4" ...
## $ ab.cov: num [1:11, 1:11] 0.225466 0.110042 0.129883 0.125318 0.000456 ...
## .. attr(*, "dimnames")=List of 2
## .. ..$ : chr [1:11] "Autonomy_PE_1" "Autonomy_PE_2" "Autonomy_PE_3" "Autonomy_PE_4" ...
## .. ..$ : chr [1:11] "Autonomy_PE_1" "Autonomy_PE_2" "Autonomy_PE_3" "Autonomy_PE_4" ...
## $ n : int 433
## $ G : int 33
## $ c. : num 13
## $ sqc : num 3.61
## $ icc : Named num [1:11] 0.219 0.059 0.06 0.103 0.011 -0.023 -0.043 0.004 -0.002 0.023 ...
## .. attr(*, "names")= chr [1:11] "Autonomy_PE_1" "Autonomy_PE_2" "Autonomy_PE_3" "Autonomy_PE_4" ...
## $ dfw : int 400
## $ dfb : int 33
```

Calculate ICCs as indicator for the variance, which can be attributed to the the groups.

```
x$icc
```

```
## Autonomy_PE_1 Autonomy_PE_2 Autonomy_PE_3 Autonomy_PE_4
## 0.219 0.059 0.060 0.103
## Relatedness_PE_1 Relatedness_PE_2 Relatedness_PE_3 Competence_PE_1
## 0.011 -0.023 -0.043 0.004
## Competence_PE_2 Competence_PE_3 Competence_PE_4
## -0.002 0.023 0.006
```

ICCs vary heavily.

```
max(x$icc)
```

```
## [1] 0.219
```

minimal

```
min(x$icc)
```

```
## [1] -0.043
```

```
mean(c(0.219,0.059,0.060,0.103,0.011,0,0,0.004,0,0.023,0.006))
```

```
## [1] 0.04409091
```

```
median(c(0.219,0.059,0.060,0.103,0.011,0,0,0.004,0,0.023,0.006))
```

```
## [1] 0.011
```

```
sd(c(0.219,0.059,0.060,0.103,0.011,0,0,0.004,0,0.023,0.006))
```

```
## [1] 0.06705886
```

Note negative ICCs. Three negative ICCs were set to zero, since the ICC

$$\rho = (\Sigma_B^2 + \Sigma_W^2)^{-1} * \Sigma_B^2$$

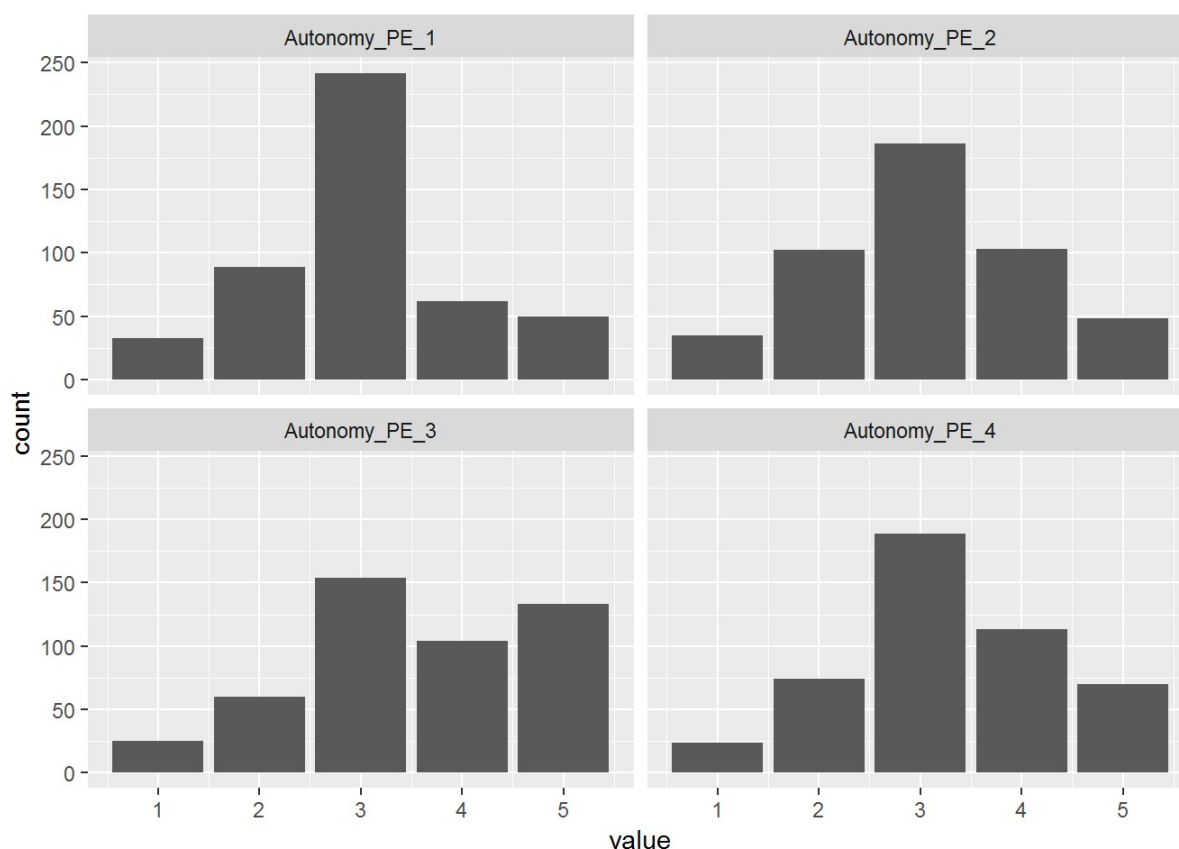
should vary between 0 and 1 by definition. Due to the fact that the between group variance Σ_B^2 is estimated by a scaled difference between two diagonal entries of two empirical covariance matrices (the empirical within and between covariance matrices), it does not have to be positive for any sample size. Here, the estimated within-variance is larger than the estimated between-variance and led to negative ICCs.

Graphical analysis

```
AKS_PE_aut <- AKS_PE %>%
  select(starts_with("Auto"))

ggplot(gather(AKS_PE_aut), aes(x = value)) + geom_bar() + facet_wrap(~ key)
```

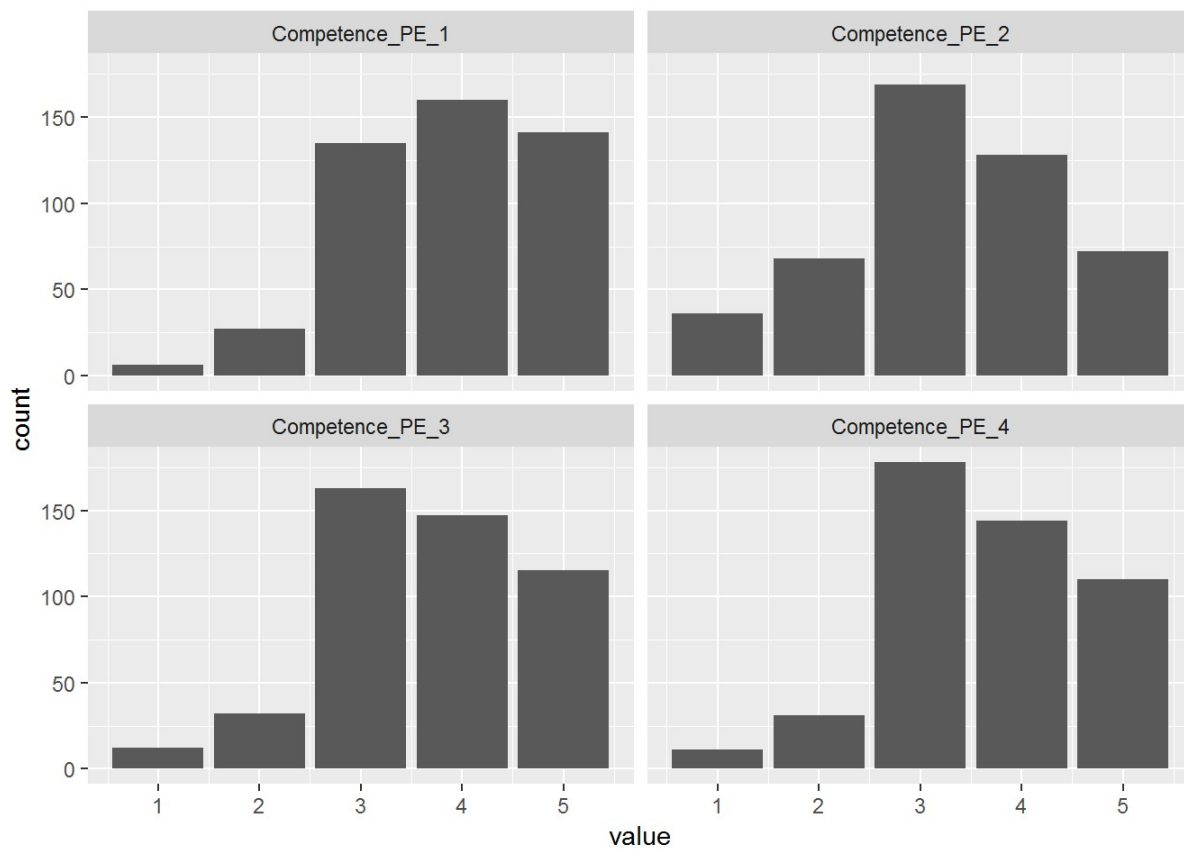
```
## Warning: Removed 28 rows containing non-finite values (stat_count).
```



```
AKS_PE_comp <- AKS_PE %>%
  select(starts_with("Comp"))

ggplot(gather(AKS_PE_comp), aes(x = value)) + geom_bar() + facet_wrap(~ key)
```

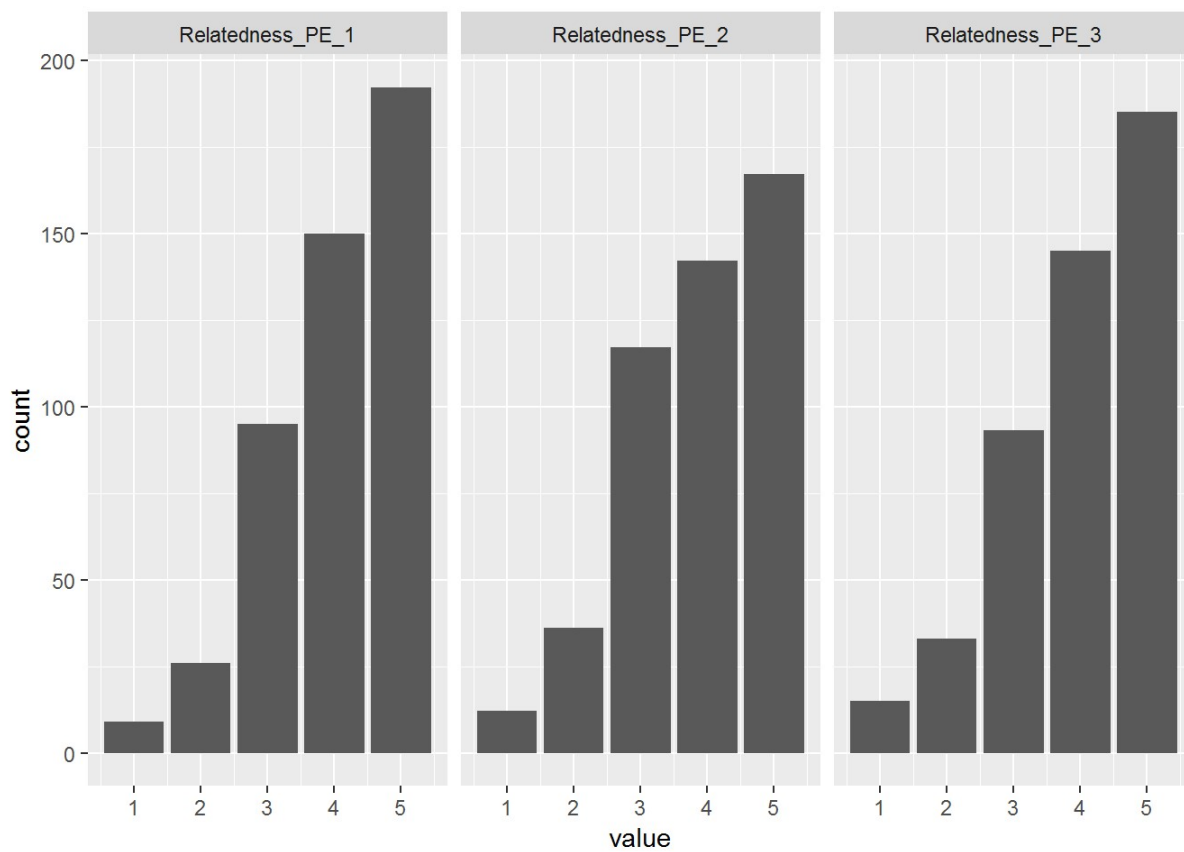
```
## Warning: Removed 39 rows containing non-finite values (stat_count).
```

```
AKS_PE_related <- AKS_PE %>%
  select(starts_with("Related"))

ggplot(gather(AKS_PE_related), aes(x = value)) + geom_bar() + facet_wrap(~ key)
```

```
## Warning: Removed 26 rows containing non-finite values (stat_count).
```



The data is clearly unbalanced. Hence \mathbf{S}_{Bd} is an estimator of

$$\Sigma_W + c_d \Sigma_B$$

for each distinct group of size n_d .

This means that one gets a different covariance decomposition for each different group size, which makes estimating these models a very complex task. Therefore Muthen (1989,1990) suggested to ignore the unbalance and compute a single \mathbf{S}_B using the estimator c . of the average group size. Hence we get

$$\widehat{\Sigma_W + c \cdot \Sigma_B} := \mathbf{S}_B.$$

The scaling factor c . for the given data is

```
x$c
```

```
## [1] 13.04835
```

which is smaller then the average group size

```
mean(table(AKS_PE$Gruppe))
```

```
## [1] 14.57576
```

due to the fact that the data contains a few groups with rather few observations.

Estimation algorithm

Step 1: The level one model

Check if one or three factors at level 1.

specify models, one factor und three factor model

```
onefactor <- 'f1 =~ Autonomy_PE_1 + Relatedness_PE_1 + Competence_PE_1 + Autonomy_PE_2 + Relatedness_PE_2 + Competence_PE_2 + Autonomy_PE_3 + Relatedness_PE_3 + Competence_PE_3 + Autonomy_PE_4 + Competence_PE_4';
threefactor <- 'f1 =~ Autonomy_PE_1 + Autonomy_PE_2 + Autonomy_PE_3 + Autonomy_PE_4;
f2 =~ Relatedness_PE_1 + Relatedness_PE_2 + Relatedness_PE_3 ;
f3 =~ Competence_PE_1 + Competence_PE_2 + Competence_PE_3 + Competence_PE_4'
```

- fit models using the pooled within group variance matrix as input; output saved into an object called results1
- first argument is model object containing model definition
- second argument is source and type of data to be analyzed
- third argument is effective number of observations

```
# fit models using the pooled within group variance matrix as input; output saved into an object called results1
# first argument is model object containing model definition
# second argument is source and type of data to be analyzed
# third argument is effective number of observations

models$mod_one_fac <- cfa(onefactor, sample.cov = x$pw.cov, sample.nobs = x$n - x$G)
models$mod_three_fac <- cfa(threefactor, sample.cov = x$pw.cov, sample.nobs = x$n - x$G)
```

Providing measures of model fit and factor loadings in standardized form

```
# Providing measures of model fit and factor loadings in standardized form  
sapply(models[1:2], function(X) summary(X, fit.measures = T, standardized = T))
```

```

## lavaan 0.6-3 ended normally after 36 iterations
##
## Optimization method NLMINB
## Number of free parameters 22
##
## Number of observations 400
##
## Estimator ML
## Model Fit Test Statistic 650.536
## Degrees of freedom 44
## P-value (Chi-square) 0.000
##
## Model test baseline model:
##
## Minimum Function Test Statistic 1878.559
## Degrees of freedom 55
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.667
## Tucker-Lewis Index (TLI) 0.584
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5748.719
## Loglikelihood unrestricted model (H1) -5423.451
##
## Number of free parameters 22
## Akaike (AIC) 11541.438
## Bayesian (BIC) 11629.251
## Sample-size adjusted Bayesian (BIC) 11559.443
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.186
## 90 Percent Confidence Interval 0.173 0.198
## P-value RMSEA <= 0.05 0.000
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.117
##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
## Latent Variables:
## Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 =~
## Autonomy_PE_1 1.000 0.345 0.385
## Relatdnss_PE_1 1.183 0.207 5.704 0.000 0.409 0.408
## Competenc_PE_1 2.187 0.296 7.397 0.000 0.755 0.789
## Autonomy_PE_2 1.538 0.241 6.395 0.000 0.531 0.513
## Relatdnss_PE_2 1.394 0.233 5.987 0.000 0.482 0.446
## Competenc_PE_2 2.444 0.334 7.320 0.000 0.844 0.756
## Autonomy_PE_3 1.946 0.289 6.738 0.000 0.672 0.583
## Relatdnss_PE_3 1.403 0.238 5.901 0.000 0.484 0.434

```

```

##      Competenc_PE_3      2.010      0.281      7.164      0.000      0.694      0.699
##      Autonomy_PE_4      1.850      0.266      6.950      0.000      0.639      0.635
##      Competenc_PE_4      1.998      0.278      7.182      0.000      0.690      0.705
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Autonomy_PE_1      0.684      0.050     13.805      0.000      0.684      0.852
##      .Relatdnss_PE_1      0.838      0.061     13.756      0.000      0.838      0.834
##      .Competenc_PE_1      0.347      0.032     10.919      0.000      0.347      0.378
##      .Autonomy_PE_2      0.790      0.059     13.450      0.000      0.790      0.737
##      .Relatdnss_PE_2      0.931      0.068     13.660      0.000      0.931      0.801
##      .Competenc_PE_2      0.534      0.046     11.526      0.000      0.534      0.428
##      .Autonomy_PE_3      0.879      0.067     13.144      0.000      0.879      0.661
##      .Relatdnss_PE_3      1.010      0.074     13.692      0.000      1.010      0.811
##      .Competenc_PE_3      0.504      0.041     12.274      0.000      0.504      0.511
##      .Autonomy_PE_4      0.603      0.047     12.825      0.000      0.603      0.597
##      .Competenc_PE_4      0.481      0.039     12.207      0.000      0.481      0.502
##      f1                    0.119      0.032      3.767      0.000      1.000      1.000
##
## lavaan 0.6-3 ended normally after 33 iterations
##
##      Optimization method              NLMINB
##      Number of free parameters              25
##
##      Number of observations              400
##
##      Estimator              ML
##      Model Fit Test Statistic          124.159
##      Degrees of freedom              41
##      P-value (Chi-square)              0.000
##
## Model test baseline model:
##
##      Minimum Function Test Statistic          1878.559
##      Degrees of freedom              55
##      P-value              0.000
##
## User model versus baseline model:
##
##      Comparative Fit Index (CFI)              0.954
##      Tucker-Lewis Index (TLI)              0.939
##
## Loglikelihood and Information Criteria:
##
##      Loglikelihood user model (H0)          -5485.531
##      Loglikelihood unrestricted model (H1)    -5423.451
##
##      Number of free parameters              25
##      Akaike (AIC)              11021.062
##      Bayesian (BIC)              11120.848
##      Sample-size adjusted Bayesian (BIC)      11041.522
##
## Root Mean Square Error of Approximation:
##
##      RMSEA              0.071
##      90 Percent Confidence Interval          0.057  0.086
##      P-value RMSEA <= 0.05              0.008
##
## Standardized Root Mean Square Residual:
##

```

```

##      SRMR                                0.054
##
## Parameter Estimates:
##
##      Information                                Expected
##      Information saturated (h1) model          Structured
##      Standard Errors                          Standard
##
## Latent Variables:
##      Estimate   Std.Err   z-value   P(>|z|)   Std.lv   Std.all
##      f1 =~
##      Autonomy_PE_1      1.000
##      Autonomy_PE_2      1.545      0.157      9.842      0.000      0.482      0.538
##      Autonomy_PE_3      1.514      0.165      9.155      0.000      0.745      0.720
##      Autonomy_PE_4      1.514      0.165      9.155      0.000      0.730      0.633
##      Autonomy_PE_4      1.815      0.174     10.446      0.000      0.876      0.871
##      f2 =~
##      Relatdnss_PE_1      1.000
##      Relatdnss_PE_2      1.642      0.148     11.120      0.000      0.589      0.587
##      Relatdnss_PE_3      1.466      0.130     11.258      0.000      0.966      0.896
##      Relatdnss_PE_3      1.466      0.130     11.258      0.000      0.863      0.773
##      f3 =~
##      Competenc_PE_1      1.000
##      Competenc_PE_2      1.102      0.063     17.612      0.000      0.811      0.847
##      Competenc_PE_2      1.102      0.063     17.612      0.000      0.894      0.801
##      Competenc_PE_3      0.829      0.058     14.299      0.000      0.672      0.677
##      Competenc_PE_3      0.829      0.058     14.299      0.000      0.672      0.677
##      Competenc_PE_4      0.922      0.055     16.662      0.000      0.748      0.765
##      Competenc_PE_4      0.922      0.055     16.662      0.000      0.748      0.765
##
## Covariances:
##      Estimate   Std.Err   z-value   P(>|z|)   Std.lv   Std.all
##      f1 ~~
##      f2           0.104      0.021      4.924      0.000      0.366      0.366
##      f3           0.233      0.033      7.057      0.000      0.595      0.595
##      f2 ~~
##      f3           0.199      0.034      5.923      0.000      0.416      0.416
##
## Variances:
##      Estimate   Std.Err   z-value   P(>|z|)   Std.lv   Std.all
##      .Autonomy_PE_1      0.570      0.044     13.090      0.000      0.570      0.710
##      .Autonomy_PE_2      0.517      0.047     11.079      0.000      0.517      0.482
##      .Autonomy_PE_3      0.797      0.065     12.352      0.000      0.797      0.599
##      .Autonomy_PE_4      0.244      0.040      6.091      0.000      0.244      0.242
##      .Relatdnss_PE_1      0.658      0.052     12.736      0.000      0.658      0.655
##      .Relatdnss_PE_2      0.229      0.057      4.049      0.000      0.229      0.197
##      .Relatdnss_PE_3      0.500      0.056      8.879      0.000      0.500      0.402
##      .Competenc_PE_1      0.259      0.029      8.850      0.000      0.259      0.283
##      .Competenc_PE_2      0.446      0.043     10.376      0.000      0.446      0.358
##      .Competenc_PE_3      0.534      0.043     12.416      0.000      0.534      0.541
##      .Competenc_PE_3      0.534      0.043     12.416      0.000      0.534      0.541
##      .Competenc_PE_4      0.397      0.035     11.213      0.000      0.397      0.415
##      .Competenc_PE_4      0.397      0.035     11.213      0.000      0.397      0.415
##      f1           0.233      0.043      5.383      0.000      1.000      1.000
##      f2           0.346      0.058      5.955      0.000      1.000      1.000
##      f3           0.658      0.066      9.928      0.000      1.000      1.000

```

```

## $mod_one_fac
## NULL
##
## $mod_three_fac
## NULL

```

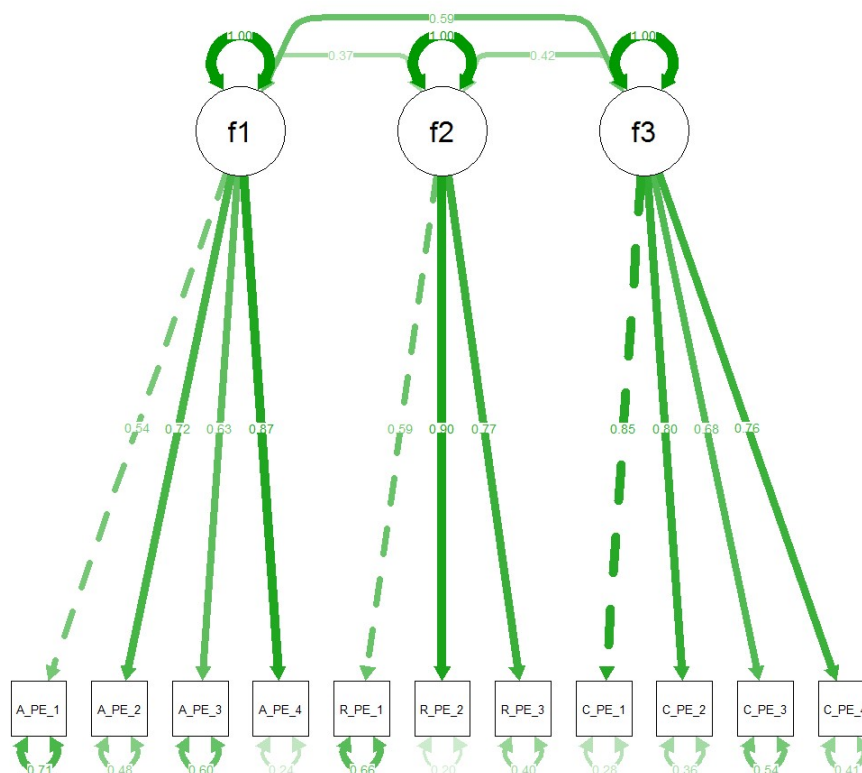
Fit measures

Hox: Simulation research shows that all these indices still depend on sample size and estimation method (e.g., ML or GLS), with the CFI and the TLI/NNFI showing the best overall performance (Chou & Bentler, 1995; Kaplan, 1995). If the

model fits perfectly, these fit indices should have the value **1**. Usually, a value of at least **.90** is required to accept a model, while a value of at least **.95** is required to judge the model fit as good. However, these are just rules of thumb. A different approach to model fit is to accept that models are only approximations, and that a perfect fit may be too much to ask for. Instead, the problem is to assess how well a given model approximates the true model. This view led to the development of an index called RMSEA, for root mean square error of approximation (Browne & Cudeck, 1992). If the approximation is good, the RMSEA should be small. Typically, an RMSEA of less than .08 is required (Kline, 2004), and an RMSEA of less than .05 is required to judge the model fit as good. Statistical tests or confidence intervals can be computed to test if the RMSEA is significantly larger than this lower bound. Given the many possible goodness-of-fit indices, the customary advice is to assess fit by inspecting several fit indices that derive from different principles. **Therefore, for the confirmatory factor model for the family data, I have reported the chi-square test, and the fit indices CFI and RMSEA.**

Path diagramm

```
semPlot::semPaths(models$mod_three_fac,"std",edge.label.cex=0.5, curvePivot = TRUE)
```



threefactor model fits better than onefactor model!

If an adequate fit is not found, there is little point in proceeding and researchers should revisit their theory behind their CFA (Huang, 2017).

Step 2: The null model

Assumption to be checked: 2 levels, 3 factors each, no variance between levels regarding factor loadings, variances and covariances

Store multiple input covariances (PW and B) and sample sizes for each in a list object

```
combined.cov <- list(within = x$pw.cov, between = x$b.cov)
combined.n <- list(within = x$n - x$G, between = x$G)
```

Specify model imposing equality constraints for within and between models (in this case for both levels)

```

nullmodel <- '
f1 =~ Autonomy_PE_1 + c(a,a)*Autonomy_PE_2 + c(b,b)*Autonomy_PE_3 + c(c,c)*Autonomy_PE_4
f2 =~ Relatedness_PE_1 + c(d,d)*Relatedness_PE_2 + c(e,e)*Relatedness_PE_3
f3 =~ Competence_PE_1 + c(g,g)*Competence_PE_2 + c(h,h)*Competence_PE_3 + c(i,i)*Competence_
PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(k,k)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(l,l)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(v,v)*f1
f2 ~~ c(w,w)*f2
f3 ~~ c(x,x)*f3
f1 ~~ c(y,y)*f2
f1 ~~ c(z,z)*f3
f2 ~~ c(aa,aa)*f3
'

# Fit null model
models$nullmodel_fit <- cfa(nullmodel, sample.cov = combined.cov, sample.nobs = combined.n)

# viewing summary statistics (in standardisierter Form)
fitMeasures(models$nullmodel_fit)

```

```

##                npar                fmin                chisq
##                25.000                0.316                273.515
##                df                pvalue                baseline.chisq
##                107.000                0.000                2130.224
##                baseline.df                baseline.pvalue                cfi
##                110.000                0.000                0.918
##                tli                nnfi                rfi
##                0.915                0.915                0.868
##                nfi                pnfi                ifi
##                0.872                0.848                0.918
##                rni                logl                unrestricted.logl
##                0.918                -6004.124                -5867.367
##                aic                bic                ntotal
##                12058.249                12160.017                433.000
##                bic2                rmsea                rmsea.ci.lower
##                12080.681                0.085                0.072
##                rmsea.ci.upper                rmsea.pvalue                rmr
##                0.097                0.000                0.116
##                rmr_nomean                srmr                srmr_bentler
##                0.116                0.091                0.091
##                srmr_bentler_nomean                crmr                crmr_nomean
##                0.091                0.069                0.069
##                srmr_mplus                srmr_mplus_nomean                cn_05
##                0.081                0.081                210.197
##                cn_01                gfi                agfi
##                228.870                0.910                0.889
##                pgfi                mfi
##                0.738                0.825

```

Fits indicate there might be a variance between levels. At this stage Multilevel validation is justified.

Step 3: The independence model

Assumption to be checked: 2 levels, 3 factors each, no variance between levels regarding factor loadings, variances and covariances and there are latent factors at level 2, every manifest variable is composed by pooled-within and between variance.

Here, we use the scaling factor c , which is calculated by `mcfa.input()`.

```
x$c
```

```
## [1] 13.04835
```

```
x$sqc
```

```
## [1] 3.612251
```

Now, we start to estimate the between variance of the model by estimation of 11 new group-level "factors".

Every group-level factor has a specific loading of

```
x$sqc
```

```
## [1] 3.612251
```

on its manifest variable (Autonomy_PE_1 bis Competence_PE_4).

Autonomy_PE_1b etc. is the name of the level 2 factor and the 0 as first argument in brackets, denies the estimation of Autonomy_PE_1b at the first level (within level).

This model is called independence model, because by using "orthogonal = T" we deny that the new latent group level factors covary with each other.

```

independence <- '
f1 =~ Autonomy_PE_1 + c(a,a)*Autonomy_PE_2 + c(b,b)*Autonomy_PE_3 + c(c,c)*Autonomy_PE_4
f2 =~ Relatedness_PE_1 + c(d,d)*Relatedness_PE_2 + c(e,e)*Relatedness_PE_3
f3 =~ Competence_PE_1 + c(g,g)*Competence_PE_2 + c(h,h)*Competence_PE_3 + c(i,i)*Competence_
PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(k,k)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(l,l)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(v,v)*f1
f2 ~~ c(w,w)*f2
f3 ~~ c(x,x)*f3
f1 ~~ c(y,y)*f2
f1 ~~ c(z,z)*f3
f2 ~~ c(aa,aa)*f3
Autonomy_PE_1b =~ c(0,x$scq)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$scq)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$scq)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$scq)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$scq)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$scq)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$scq)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$scq)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$scq)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$scq)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$scq)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
'

# Fit measures
models$mod_ind_fit <- cfa(independence, sample.cov = combined.cov, sample.nobs = combined.n,
orthogonal = T)

```

```

## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative

```

```

# Summary
fitMeasures(models$mod_ind_fit)

```

```
##          npar          fmin          chisq
##          35.000          0.282          244.328
##          df          pvalue    baseline.chisq
##          97.000          0.000          2130.224
##    baseline.df    baseline.pvalue          cfi
##          110.000          0.000          0.927
##          tli          nnfi          rfi
##          0.917          0.917          0.870
##          nfi          pnfi          ifi
##          0.885          0.781          0.928
##          rni          logl    unrestricted.logl
##          0.927          -5989.530          -5867.367
##          aic          bic          ntotal
##          12049.061          12191.537          433.000
##          bic2          rmsea    rmsea.ci.lower
##          12080.466          0.084          0.071
##    rmsea.ci.upper    rmsea.pvalue          rmr
##          0.097          0.000          0.157
##          rmr_nomean          srmr    srmr_bentler
##          0.157          0.136          0.136
##    srmr_bentler_nomean          crmr    crmr_nomean
##          0.136          0.077          0.077
##          srmr_mplus    srmr_mplus_nomean    cn_05
##          0.099          0.099          215.419
##          cn_01          gfi          agfi
##          235.479          0.915          0.884
##          pgfi          mfi
##          0.672          0.844
```

If the independence model fit well, the conclusion would be that there is substantial group-level variance but there is no substantively interesting structural model (Hox 2002). If the independence model did not fit well, that suggests that there is some kind of structural model at the group level that should be modeled (Huang, 2017).

Step 4: The saturated model

Now, we allow the introduced latent group level factors to covary.

Since we have 11 latent variables we need to estimate 55 covariances. $(k*(k-1))/2$, k = number of variables.

Keep the argument orthogonal = T.

```

saturated <- '
f1 =~ Autonomy_PE_1 + c(a,a)*Autonomy_PE_2 + c(b,b)*Autonomy_PE_3 + c(c,c)*Autonomy_PE_4
f2 =~ Relatedness_PE_1 + c(d,d)*Relatedness_PE_2 + c(e,e)*Relatedness_PE_3
f3 =~ Competence_PE_1 + c(g,g)*Competence_PE_2 + c(h,h)*Competence_PE_3 + c(i,i)*Competence_
PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(k,k)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(l,l)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(v,v)*f1
f2 ~~ c(w,w)*f2
f3 ~~ c(x,x)*f3
f1 ~~ c(y,y)*f2
f1 ~~ c(z,z)*f3
f2 ~~ c(aa,aa)*f3
Autonomy_PE_1b =~ c(0,x$scq)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$scq)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$scq)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$scq)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$scq)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$scq)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$scq)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$scq)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$scq)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$scq)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$scq)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b

Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b +
c(0,NA)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b + c(0,NA)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_4b + c(0,NA)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

Autonomy_PE_4b ~~ c(0,NA)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

```

```

(0,NA)*Competence_PE_4b

Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

Relatedness_PE_3b ~~ c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

Competence_PE_1b ~~ c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

Competence_PE_2b ~~ c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b

Competence_PE_3b ~~ c(0,NA)*Competence_PE_4b
,
# Fit saturated model
models$mod_sat_fit <- cfa(saturated, sample.cov = combined.cov, sample.nobs = combined.n, orthogonal = T)

```

```

## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative

```

```
fitMeasures(models$mod_sat_fit)
```

```

##           npar           fmin           chisq
##           90.000           0.164           142.171
##           df           pvalue    baseline.chisq
##           42.000           0.000           2130.224
##    baseline.df    baseline.pvalue           cfi
##           110.000           0.000           0.950
##           tli           nnfi           rfi
##           0.870           0.870           0.825
##           nfi           pnfi           ifi
##           0.933           0.356           0.952
##           rni           logl    unrestricted.logl
##           0.950          -5938.452          -5867.367
##           aic           bic           ntotal
##           12056.904          12423.271           433.000
##           bic2           rmsea    rmsea.ci.lower
##           12137.661           0.105           0.086
##    rmsea.ci.upper    rmsea.pvalue           rmr
##           0.124           0.000           0.107
##    rmr_nomean           srmr    srmr_bentler
##           0.107           0.104           0.104
##    srmr_bentler_nomean           crmr    crmr_nomean
##           0.104           0.062           0.062
##    srmr_mplus    srmr_mplus_nomean           cn_05
##           0.076           0.076           178.024
##           cn_01           gfi           agfi
##           202.640           0.943           0.822
##           pgfi           mfi
##           0.300           0.891

```

Mixed fit indices indicate an error or that the fit in step 1 was bad (based on Huang). The bad fit could be taken as indicator that there might be no interesting structural model at level 2. Since we can assure that no mistakes were made we continue with step 5.

Step 5

3x1-Modell

Here, we specify our hypothesized model. Initially, we model a latent overall factor. Secondly, we model the theory-based three factor model at level 2.

Therefore, we remove the 55 freely estimated covariances by the assumed level 2 model.

```

mod_3x1 <- '
f1 =~ Autonomy_PE_1 + c(a,a)*Autonomy_PE_2 + c(b,b)*Autonomy_PE_3 + c(c,c)*Autonomy_PE_4
f2 =~ Relatedness_PE_1 + c(d,d)*Relatedness_PE_2 + c(e,e)*Relatedness_PE_3
f3 =~ Competence_PE_1 + c(g,g)*Competence_PE_2 + c(h,h)*Competence_PE_3 + c(i,i)*Competence_
PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(k,k)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(l,l)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(v,v)*f1
f2 ~~ c(w,w)*f2
f3 ~~ c(x,x)*f3
f1 ~~ c(y,y)*f2
f1 ~~ c(z,z)*f3
f2 ~~ c(aa,aa)*f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Aut
onomy_PE_4b + c(0,NA)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE
_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,N
A)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model
models$mod_3x1_fit <- cfa(mod_3x1, sample.cov = combined.cov, sample.nobs = combined.n, orth
ogonal = T)

```

```

## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative

```

```

summary(models$mod_3x1_fit, fit.measures = T, standardized = T)

```

```

## lavaan 0.6-3 ended normally after 108 iterations
##
## Optimization method NLMINB
## Number of free parameters 70
## Number of equality constraints 24
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 209.600
## Degrees of freedom 86
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 143.049
## between 66.551
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.939
## Tucker-Lewis Index (TLI) 0.922
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5972.167
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 46
## Akaike (AIC) 12036.333
## Bayesian (BIC) 12223.587
## Sample-size adjusted Bayesian (BIC) 12077.609
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.081
## 90 Percent Confidence Interval 0.068 0.096
## P-value RMSEA <= 0.05 0.000
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.119

```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```



```

##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##
## Latent Variables:
## Estimate Std.Err z-value P(>|z|) Std.lv
## f1 =~
## Atnmy_PE_1 1.000 0.505
## Atnmy_PE_2 (a) 1.540 0.147 10.507 0.000 0.778
## Atnmy_PE_3 (b) 1.551 0.157 9.885 0.000 0.783
## Atnmy_PE_4 (c) 1.805 0.162 11.173 0.000 0.911
## f2 =~
## Rltdn_PE_1 1.000 0.608
## Rltdn_PE_2 (d) 1.625 0.135 12.025 0.000 0.987
## Rltdn_PE_3 (e) 1.385 0.115 12.079 0.000 0.841
## f3 =~
## Cmptn_PE_1 1.000 1.000
## Cmptn_PE_2 (g) 0.999 0.042 23.832 0.000 0.999
## Cmptn_PE_3 (h) 0.753 0.041 18.138 0.000 0.753
## Cmptn_PE_4 (i) 0.840 0.038 22.079 0.000 0.840
## Autonomy_PE_1b =~
## Atnmy_PE_1 (x) 1.000 0.000
## Autonomy_PE_2b =~
## Atnmy_PE_2 (x) 1.000 0.000
## Autonomy_PE_3b =~
## Atnmy_PE_3 (x) 1.000 0.000
## Autonomy_PE_4b =~
## Atnmy_PE_4 (x) 1.000 0.000
## Relatedness_PE_1b =~
## Rltdn_PE_1 (x) 1.000 0.000
## Relatedness_PE_2b =~
## Rltdn_PE_2 (x) 1.000 0.000
## Relatedness_PE_3b =~
## Rltdn_PE_3 (x) 1.000 0.000
## Competence_PE_1b =~
## Cmptn_PE_1 (x) 1.000 0.000
## Competence_PE_2b =~
## Cmptn_PE_2 (x) 1.000 0.000
## Competence_PE_3b =~
## Cmptn_PE_3 (x) 1.000 0.000
## Competence_PE_4b =~
## Cmptn_PE_4 (x) 1.000 0.000
## f1b =~
## Atnmy_PE_1 0.000 NaN
## Atnmy_PE_2 0.000 NaN
## Atnmy_PE_3 0.000 NaN
## Atnmy_PE_4 0.000 NaN
## Rltdn_PE_1 0.000 NaN
## Rltdn_PE_2 0.000 NaN
## Rltdn_PE_3 0.000 NaN
## Cmptn_PE_1 0.000 NaN
## Cmptn_PE_2 0.000 NaN
## Cmptn_PE_3 0.000 NaN
## Cmptn_PE_4 0.000 NaN

```

##						Std.all	
##							
##						0.556	
##						0.734	
##						0.661	
##						0.877	
##							
##						0.600	
##						0.905	
##						0.760	
##							
##						0.899	
##						0.829	
##						0.715	
##						0.798	
##							
##						0.000	
##							
##						0.000	
##							
##						0.000	
##							
##						0.000	
##							
##						0.000	
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##						0.000	
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##							
##						0.000	
##							
##						0.000	
##							
##						0.000	
##							
##						0.000	
##							
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##						NaN	
##	Covariances:						
##			Estimate	Std.Err	z-value	P(> z)	Std.lv Std.all
##	f1 ~~						
##	f2 (y)	0.123	0.022	5.520	0.000	0.401	0.401
##	f3 (z)	0.324	0.035	9.162	0.000	0.642	0.642
##	f2 ~~						
##	f3 (aa)	0.276	0.036	7.581	0.000	0.454	0.454
##	f1 ~~						
##	f1b	0.000				NaN	NaN
##	f2 ~~						

```

##      flb                0.000                NaN                NaN
##      f3 ~~
##      flb                0.000                NaN                NaN
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)    0.570   0.043  13.103   0.000   0.570   0.691
##      .Atnmy_PE_2 (k)    0.517   0.046  11.208   0.000   0.517   0.461
##      .Atnmy_PE_3 (l)    0.791   0.064  12.288   0.000   0.791   0.563
##      .Atnmy_PE_4 (m)    0.250   0.039   6.447   0.000   0.250   0.232
##      .Rltdn_PE_1 (n)    0.657   0.052  12.708   0.000   0.657   0.640
##      .Rltdn_PE_2 (o)    0.214   0.055   3.922   0.000   0.214   0.180
##      .Rltdn_PE_3 (p)    0.518   0.054   9.680   0.000   0.518   0.422
##      .Cmptn_PE_1 (r)    0.238   0.029   8.060   0.000   0.238   0.192
##      .Cmptn_PE_2 (s)    0.456   0.042  10.798   0.000   0.456   0.313
##      .Cmptn_PE_3 (t)    0.542   0.043  12.609   0.000   0.542   0.489
##      .Cmptn_PE_4 (u)    0.402   0.035  11.505   0.000   0.402   0.363
##      f1            (v)    0.255   0.045   5.700   0.000   1.000   1.000
##      f2            (w)    0.369   0.058   6.395   0.000   1.000   1.000
##      f3            (x)    1.000                1.000   1.000
##      Atnmy_PE_1      0.000                NaN                NaN
##      Atnmy_PE_2      0.000                NaN                NaN
##      Atnmy_PE_3      0.000                NaN                NaN
##      Atnmy_PE_4      0.000                NaN                NaN
##      Rltdn_PE_1      0.000                NaN                NaN
##      Rltdn_PE_2      0.000                NaN                NaN
##      Rltdn_PE_3      0.000                NaN                NaN
##      Cmptn_PE_1      0.000                NaN                NaN
##      Cmptn_PE_2      0.000                NaN                NaN
##      Cmptn_PE_3      0.000                NaN                NaN
##      Cmptn_PE_4      0.000                NaN                NaN
##      flb            0.000                NaN                NaN
##
##
## Group 2 [between]:
##
## Latent Variables:
##              Estimate Std.Err z-value P(>|z|) Std.lv
##      f1 =~
##      Atn_PE_1          1.000                0.505
##      Atn_PE_2 (a)      1.540   0.147  10.507   0.000   0.778
##      Atn_PE_3 (b)      1.551   0.157   9.885   0.000   0.783
##      Atn_PE_4 (c)      1.805   0.162  11.173   0.000   0.911
##      f2 =~
##      Rlt_PE_1          1.000                0.608
##      Rlt_PE_2 (d)      1.625   0.135  12.025   0.000   0.987
##      Rlt_PE_3 (e)      1.385   0.115  12.079   0.000   0.841
##      f3 =~
##      Cmp_PE_1          1.000                1.000
##      Cmp_PE_2 (g)      0.999   0.042  23.832   0.000   0.999
##      Cmp_PE_3 (h)      0.753   0.041  18.138   0.000   0.753
##      Cmp_PE_4 (i)      0.840   0.038  22.079   0.000   0.840
##      Autonomy_PE_1b =~
##      Atn_PE_1 (sqc)     1.000                1.694
##      Autonomy_PE_2b =~
##      Atn_PE_2 (sqc)     1.000                0.935
##      Autonomy_PE_3b =~
##      Atn_PE_3 (sqc)     1.000                0.924
##      Autonomy_PE_4b =~
##      Atn_PE_4 (sqc)     1.000                1.254

```

```

## Relatedness_PE_1b =~
## Rlt_PE_1 (sqc) 1.000 0.206
## Relatedness_PE_2b =~
## Rlt_PE_2 (sqc) 1.000 NaN
## Relatedness_PE_3b =~
## Rlt_PE_3 (sqc) 1.000 NaN
## Competence_PE_1b =~
## Cmp_PE_1 (sqc) 1.000 0.332
## Competence_PE_2b =~
## Cmp_PE_2 (sqc) 1.000 0.267
## Competence_PE_3b =~
## Cmp_PE_3 (sqc) 1.000 0.532
## Competence_PE_4b =~
## Cmp_PE_4 (sqc) 1.000 0.314
## flb =~
## Atn_PE_1 1.000 0.842
## Atn_PE_2 0.724 0.172 4.221 0.000 1.104
## Atn_PE_3 0.726 0.186 3.907 0.000 1.120
## Atn_PE_4 0.835 0.197 4.246 0.000 0.950
## Rlt_PE_1 0.096 0.147 0.655 0.513 0.666
## Rlt_PE_2 -0.008 0.151 -0.051 0.960 NaN
## Rlt_PE_3 0.038 0.145 0.265 0.791 NaN
## Cmp_PE_1 0.070 0.166 0.423 0.672 0.301
## Cmp_PE_2 0.174 0.172 1.014 0.311 0.928
## Cmp_PE_3 0.263 0.162 1.625 0.104 0.706
## Cmp_PE_4 0.019 0.159 0.118 0.906 0.085
## Std.all
##
## 0.263
## 0.550
## 0.521
## 0.559
##
## 0.588
## 0.953
## 0.831
##
## 0.861
## 0.809
## 0.638
## 0.765
##
## 0.881
##
## 0.662
##
## 0.615
##
## 0.770
##
## 0.200
##
## NaN
##
## NaN
##
## 0.286
##
## 0.216
##

```

```

##      0.451
##
##      0.286
##
##      0.842
##      1.104
##      1.120
##      0.950
##      0.666
##      NaN
##      NaN
##      0.301
##      0.928
##      0.706
##      0.085
##
## Covariances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 ~~
## f2      (y)    0.123   0.022   5.520   0.000   0.401   0.401
## f3      (z)    0.324   0.035   9.162   0.000   0.642   0.642
## f2 ~~
## f3      (aa)   0.276   0.036   7.581   0.000   0.454   0.454
## f1 ~~
## f1b      0.000
## f2 ~~
## f1b      0.000
## f3 ~~
## f1b      0.000
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .Atnmy_PE_1 (j)    0.570   0.043  13.103   0.000   0.570   0.154
## .Atnmy_PE_2 (k)    0.517   0.046  11.208   0.000   0.517   0.259
## .Atnmy_PE_3 (l)    0.791   0.064  12.288   0.000   0.791   0.350
## .Atnmy_PE_4 (m)    0.250   0.039   6.447   0.000   0.250   0.094
## .Rltdn_PE_1 (n)    0.657   0.052  12.708   0.000   0.657   0.615
## .Rltdn_PE_2 (o)    0.214   0.055   3.922   0.000   0.214   0.200
## .Rltdn_PE_3 (p)    0.518   0.054   9.680   0.000   0.518   0.506
## .Cmptn_PE_1 (r)    0.238   0.029   8.060   0.000   0.238   0.176
## .Cmptn_PE_2 (s)    0.456   0.042  10.798   0.000   0.456   0.299
## .Cmptn_PE_3 (t)    0.542   0.043  12.609   0.000   0.542   0.390
## .Cmptn_PE_4 (u)    0.402   0.035  11.505   0.000   0.402   0.334
## f1      (v)    0.255   0.045   5.700   0.000   1.000   1.000
## f2      (w)    0.369   0.058   6.395   0.000   1.000   1.000
## f3      (x)    1.000
##              1.000   1.000
## Atnmy_PE_1    0.837   0.462   1.814   0.070   0.292   0.292
## Atnmy_PE_2   -0.191   0.131  -1.462   0.144  -0.219  -0.219
## Atnmy_PE_3   -0.217   0.186  -1.164   0.244  -0.254  -0.254
## Atnmy_PE_4    0.154   0.163   0.947   0.343   0.098   0.098
## Rltdn_PE_1    0.024   0.184   0.129   0.897   0.557   0.557
## Rltdn_PE_2   -0.117   0.106  -1.102   0.270    NaN    NaN
## Rltdn_PE_3   -0.205   0.115  -1.784   0.074    NaN    NaN
## Cmptn_PE_1    0.100   0.135   0.744   0.457   0.910   0.910
## Cmptn_PE_2    0.010   0.158   0.063   0.950   0.139   0.139
## Cmptn_PE_3    0.142   0.194   0.731   0.465   0.502   0.502
## Cmptn_PE_4    0.098   0.156   0.627   0.530   0.993   0.993
## flb          2.032   0.923   2.202   0.028   1.000   1.000

```

Path diagramm

```
semPlot::semPaths(models$mod_3x1_fit,"std",edge.label.cex=0.5, curvePivot = TRUE)
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

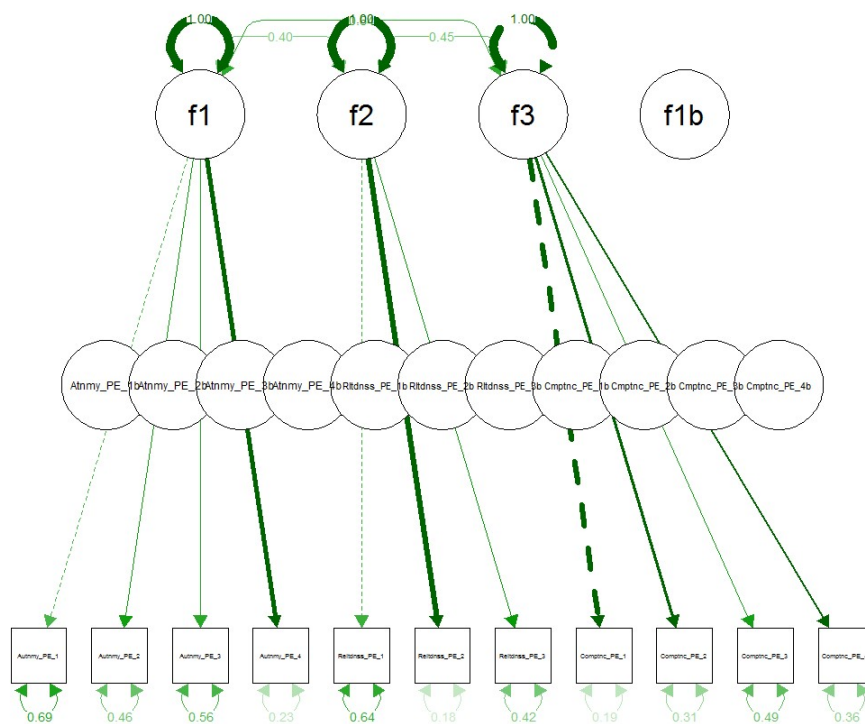
```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

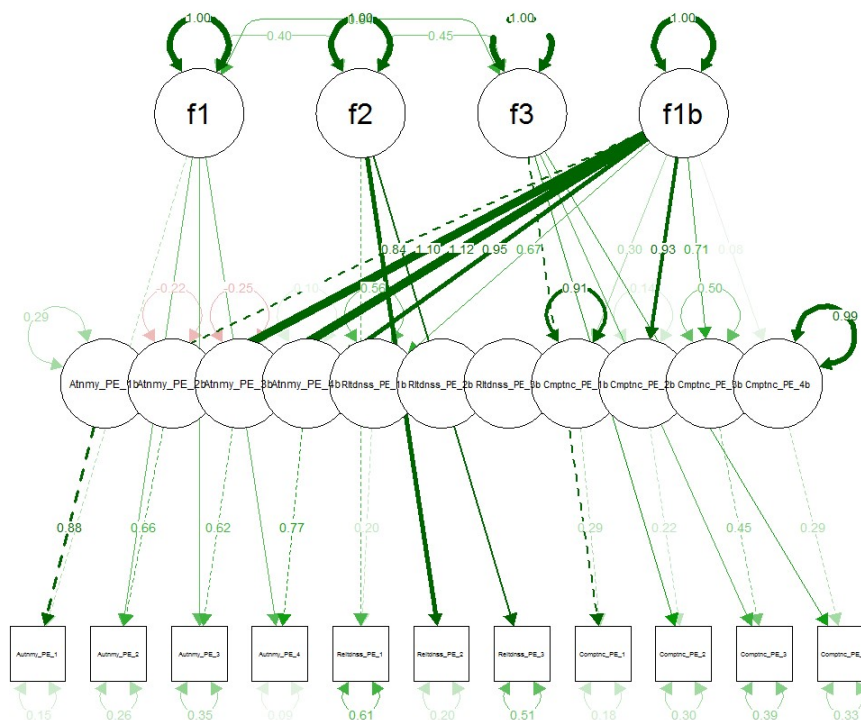
```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in qgraph::qgraph(Edgelist, labels = nLab, bidirectional = Bidir, :  
## Non-finite weights are omitted
```

```
## Warning in qgraph::qgraph(Edgelist, labels = nLab, bidirectional = Bidir, :  
## Non-finite weights are omitted
```

1





3x1, variances set to 0

Huang & Cornell, 2016: The presence of small negative residual variance estimates at the school level required residual variances to be fixed to zero for five items (see Table 1). Fixing residual variances at the group level to zero is often done in MLCFA and is recommended to allow the model to converge... **Model A**

```

mod_3x1_var <- '
f1 =~ Autonomy_PE_1 + c(a,a)*Autonomy_PE_2 + c(b,b)*Autonomy_PE_3 + c(c,c)*Autonomy_PE_4
f2 =~ Relatedness_PE_1 + c(d,d)*Relatedness_PE_2 + c(e,e)*Relatedness_PE_3
f3 =~ Competence_PE_1 + c(g,g)*Competence_PE_2 + c(h,h)*Competence_PE_3 + c(i,i)*Competence_
PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(NA,0)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(NA,0)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(NA,0)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(NA,0)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(v,v)*f1
f2 ~~ c(w,w)*f2
f3 ~~ c(x,x)*f3
f1 ~~ c(y,y)*f2
f1 ~~ c(z,z)*f3
f2 ~~ c(aa,aa)*f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Aut
onomy_PE_4b + c(0,NA)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE
_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,N
A)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model
models$mod_3x1_var_fit <- cfa(mod_3x1_var, sample.cov = combined.cov, sample.nobs = combine
d.n, orthogonal = T)
summary(models$mod_3x1_var_fit, fit.measures = T, standardized = T)

```



```

## lavaan 0.6-3 ended normally after 111 iterations
##
## Optimization method NLMINB
## Number of free parameters 66
## Number of equality constraints 20
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 209.600
## Degrees of freedom 86
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 143.049
## between 66.551
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.939
## Tucker-Lewis Index (TLI) 0.922
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5972.167
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 46
## Akaike (AIC) 12036.333
## Bayesian (BIC) 12223.587
## Sample-size adjusted Bayesian (BIC) 12077.609
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.081
## 90 Percent Confidence Interval 0.068 0.096
## P-value RMSEA <= 0.05 0.000
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.119
##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##

```

```

## Latent Variables:
##
##          Estimate  Std.Err  z-value  P(>|z|)  Std.lv
##  f1 =~
##    Atnmy_PE_1      1.000
##    Atnmy_PE_2 (a)   1.540    0.147   10.507    0.000    0.778
##    Atnmy_PE_3 (b)   1.551    0.157    9.885    0.000    0.783
##    Atnmy_PE_4 (c)   1.805    0.162   11.173    0.000    0.911
##  f2 =~
##    Rltdn_PE_1      1.000
##    Rltdn_PE_2 (d)   1.625    0.135   12.025    0.000    0.987
##    Rltdn_PE_3 (e)   1.385    0.115   12.079    0.000    0.841
##  f3 =~
##    Cmptn_PE_1      1.000
##    Cmptn_PE_2 (g)   0.999    0.042   23.832    0.000    0.999
##    Cmptn_PE_3 (h)   0.753    0.041   18.138    0.000    0.753
##    Cmptn_PE_4 (i)   0.840    0.038   22.079    0.000    0.840
##  Autonomy_PE_1b =~
##    Atnmy_PE_1 (x)   1.000
##  Autonomy_PE_2b =~
##    Atnmy_PE_2 (x)   1.000
##  Autonomy_PE_3b =~
##    Atnmy_PE_3 (x)   1.000
##  Autonomy_PE_4b =~
##    Atnmy_PE_4 (x)   1.000
##  Relatedness_PE_1b =~
##    Rltdn_PE_1 (x)   1.000
##  Relatedness_PE_2b =~
##    Rltdn_PE_2 (x)   1.000
##  Relatedness_PE_3b =~
##    Rltdn_PE_3 (x)   1.000
##  Competence_PE_1b =~
##    Cmptn_PE_1 (x)   1.000
##  Competence_PE_2b =~
##    Cmptn_PE_2 (x)   1.000
##  Competence_PE_3b =~
##    Cmptn_PE_3 (x)   1.000
##  Competence_PE_4b =~
##    Cmptn_PE_4 (x)   1.000
##  f1b =~
##    Atnmy_PE_1      0.000
##    Atnmy_PE_2      0.000
##    Atnmy_PE_3      0.000
##    Atnmy_PE_4      0.000
##    Rltdn_PE_1      0.000
##    Rltdn_PE_2      0.000
##    Rltdn_PE_3      0.000
##    Cmptn_PE_1      0.000
##    Cmptn_PE_2      0.000
##    Cmptn_PE_3      0.000
##    Cmptn_PE_4      0.000
##  Std.all
##
##    0.556
##    0.734
##    0.661
##    0.877
##
##    0.600
##    0.905
##    0.760

```

```

##
##      0.899
##      0.829
##      0.715
##      0.798
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 ~~
## f2      (y)    0.123   0.022   5.520   0.000   0.401   0.401
## f3      (z)    0.324   0.035   9.162   0.000   0.642   0.642
## f2 ~~
## f3      (aa)   0.276   0.036   7.581   0.000   0.454   0.454
## f1 ~~
## f1b      0.000                      NaN      NaN
## f2 ~~
## f1b      0.000                      NaN      NaN
## f3 ~~
## f1b      0.000                      NaN      NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .Atnmy_PE_1 (j)   0.570   0.043  13.103   0.000   0.570   0.691
## .Atnmy_PE_2      0.517   0.046  11.208   0.000   0.517   0.461
## .Atnmy_PE_3      0.791   0.064  12.288   0.000   0.791   0.563
## .Atnmy_PE_4 (m)   0.250   0.039   6.447   0.000   0.250   0.232

```

```

##      .Rltdn_PE_1 (n)      0.657      0.052      12.708      0.000      0.657      0.640
##      .Rltdn_PE_2      0.214      0.055      3.922      0.000      0.214      0.180
##      .Rltdn_PE_3      0.518      0.054      9.680      0.000      0.518      0.423
##      .Cmptn_PE_1 (r)      0.238      0.029      8.060      0.000      0.238      0.192
##      .Cmptn_PE_2 (s)      0.456      0.042      10.798      0.000      0.456      0.313
##      .Cmptn_PE_3 (t)      0.542      0.043      12.609      0.000      0.542      0.489
##      .Cmptn_PE_4 (u)      0.402      0.035      11.505      0.000      0.402      0.363
##      f1              (v)      0.255      0.045      5.700      0.000      1.000      1.000
##      f2              (w)      0.369      0.058      6.395      0.000      1.000      1.000
##      f3              (x)      1.000                                1.000      1.000
##      Atnmy_PE_1      0.000                                NaN      NaN
##      Atnmy_PE_2      0.000                                NaN      NaN
##      Atnmy_PE_3      0.000                                NaN      NaN
##      Atnmy_PE_4      0.000                                NaN      NaN
##      Rltdn_PE_1      0.000                                NaN      NaN
##      Rltdn_PE_2      0.000                                NaN      NaN
##      Rltdn_PE_3      0.000                                NaN      NaN
##      Cmptn_PE_1      0.000                                NaN      NaN
##      Cmptn_PE_2      0.000                                NaN      NaN
##      Cmptn_PE_3      0.000                                NaN      NaN
##      Cmptn_PE_4      0.000                                NaN      NaN
##      flb              0.000                                NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:
##              Estimate   Std.Err   z-value   P(>|z|)   Std.lv
## f1 =~
##   Atn_PE_1              1.000                                0.505
##   Atn_PE_2 (a)          1.540      0.147      10.507      0.000      0.778
##   Atn_PE_3 (b)          1.551      0.157      9.885      0.000      0.783
##   Atn_PE_4 (c)          1.805      0.162      11.173      0.000      0.911
## f2 =~
##   Rlt_PE_1              1.000                                0.608
##   Rlt_PE_2 (d)          1.625      0.135      12.025      0.000      0.987
##   Rlt_PE_3 (e)          1.385      0.115      12.079      0.000      0.841
## f3 =~
##   Cmp_PE_1              1.000                                1.000
##   Cmp_PE_2 (g)          0.999      0.042      23.832      0.000      0.999
##   Cmp_PE_3 (h)          0.753      0.041      18.138      0.000      0.753
##   Cmp_PE_4 (i)          0.840      0.038      22.079      0.000      0.840
## Autonomy_PE_1b =~
##   Atn_PE_1 (sqc)        1.000                                1.694
## Autonomy_PE_2b =~
##   Atn_PE_2 (sqc)        1.000                                1.179
## Autonomy_PE_3b =~
##   Atn_PE_3 (sqc)        1.000                                1.283
## Autonomy_PE_4b =~
##   Atn_PE_4 (sqc)        1.000                                1.254
## Relatedness_PE_1b =~
##   Rlt_PE_1 (sqc)        1.000                                0.206
## Relatedness_PE_2b =~
##   Rlt_PE_2 (sqc)        1.000                                0.313
## Relatedness_PE_3b =~
##   Rlt_PE_3 (sqc)        1.000                                0.562
## Competence_PE_1b =~
##   Cmp_PE_1 (sqc)        1.000                                0.332
## Competence_PE_2b =~
##   Cmp_PE_2 (sqc)        1.000                                0.267

```

##	Competence_PE_3b =~					
##	Cmp_PE_3 (sqc)	1.000				0.532
##	Competence_PE_4b =~					
##	Cmp_PE_4 (sqc)	1.000				0.314
##	f1b =~					
##	Atn_PE_1	1.000				0.842
##	Atn_PE_2	0.724	0.172	4.221	0.000	0.875
##	Atn_PE_3	0.726	0.186	3.907	0.000	0.807
##	Atn_PE_4	0.835	0.197	4.246	0.000	0.950
##	Rlt_PE_1	0.096	0.147	0.655	0.513	0.666
##	Rlt_PE_2	-0.008	0.151	-0.051	0.960	-0.035
##	Rlt_PE_3	0.038	0.145	0.265	0.791	0.098
##	Cmp_PE_1	0.070	0.166	0.423	0.672	0.301
##	Cmp_PE_2	0.174	0.172	1.014	0.311	0.928
##	Cmp_PE_3	0.263	0.162	1.625	0.104	0.706
##	Cmp_PE_4	0.019	0.159	0.118	0.906	0.085
##	Std.all					
##						
##	0.263					
##	0.550					
##	0.521					
##	0.559					
##						
##	0.588					
##	0.953					
##	0.831					
##						
##	0.861					
##	0.809					
##	0.638					
##	0.765					
##						
##	0.881					
##						
##	0.835					
##						
##	0.854					
##						
##	0.770					
##						
##	0.200					
##						
##	0.302					
##						
##	0.556					
##						
##	0.286					
##						
##	0.216					
##						
##	0.451					
##						
##	0.286					
##						
##	0.842					
##	0.875					
##	0.807					
##	0.950					
##	0.666					
##	-0.035					

```
##      0.098
##      0.301
##      0.928
##      0.706
##      0.085
##
## Covariances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 ~~
## f2      (y)  0.123   0.022   5.520   0.000   0.401   0.401
## f3      (z)  0.324   0.035   9.162   0.000   0.642   0.642
## f2 ~~
## f3      (aa)  0.276   0.036   7.581   0.000   0.454   0.454
## f1 ~~
## f1b      0.000      0.000   0.000   0.000   0.000   0.000
## f2 ~~
## f1b      0.000      0.000   0.000   0.000   0.000   0.000
## f3 ~~
## f1b      0.000      0.000   0.000   0.000   0.000   0.000
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .Atnmy_PE_1 (j)  0.570   0.043  13.103   0.000   0.570   0.154
## .Atnmy_PE_2      0.000      0.000   0.000   0.000   0.000   0.000
## .Atnmy_PE_3      0.000      0.000   0.000   0.000   0.000   0.000
## .Atnmy_PE_4 (m)  0.250   0.039   6.447   0.000   0.250   0.094
## .Rltdn_PE_1 (n)  0.657   0.052  12.708   0.000   0.657   0.615
## .Rltdn_PE_2      0.000      0.000   0.000   0.000   0.000   0.000
## .Rltdn_PE_3      0.000      0.000   0.000   0.000   0.000   0.000
## .Cmptn_PE_1 (r)  0.238   0.029   8.060   0.000   0.238   0.176
## .Cmptn_PE_2 (s)  0.456   0.042  10.798   0.000   0.456   0.299
## .Cmptn_PE_3 (t)  0.542   0.043  12.609   0.000   0.542   0.390
## .Cmptn_PE_4 (u)  0.402   0.035  11.505   0.000   0.402   0.334
## f1      (v)  0.255   0.045   5.700   0.000   1.000   1.000
## f2      (w)  0.369   0.058   6.395   0.000   1.000   1.000
## f3      (x)  1.000      0.000   0.000   0.000   1.000   1.000
## Atnmy_PE_1      0.837   0.462   1.814   0.070   0.292   0.292
## Atnmy_PE_2      0.325   0.123   2.645   0.008   0.234   0.234
## Atnmy_PE_3      0.574   0.175   3.276   0.001   0.349   0.349
## Atnmy_PE_4      0.154   0.163   0.947   0.344   0.098   0.098
## Rltdn_PE_1      0.024   0.184   0.129   0.897   0.557   0.557
## Rltdn_PE_2      0.098   0.106   0.922   0.356   0.999   0.999
## Rltdn_PE_3      0.313   0.108   2.889   0.004   0.990   0.990
## Cmptn_PE_1      0.100   0.135   0.744   0.457   0.910   0.910
## Cmptn_PE_2      0.010   0.158   0.063   0.950   0.139   0.139
## Cmptn_PE_3      0.142   0.194   0.731   0.465   0.502   0.502
## Cmptn_PE_4      0.098   0.156   0.627   0.530   0.993   0.993
## f1b      2.032   0.923   2.202   0.028   1.000   1.000
```

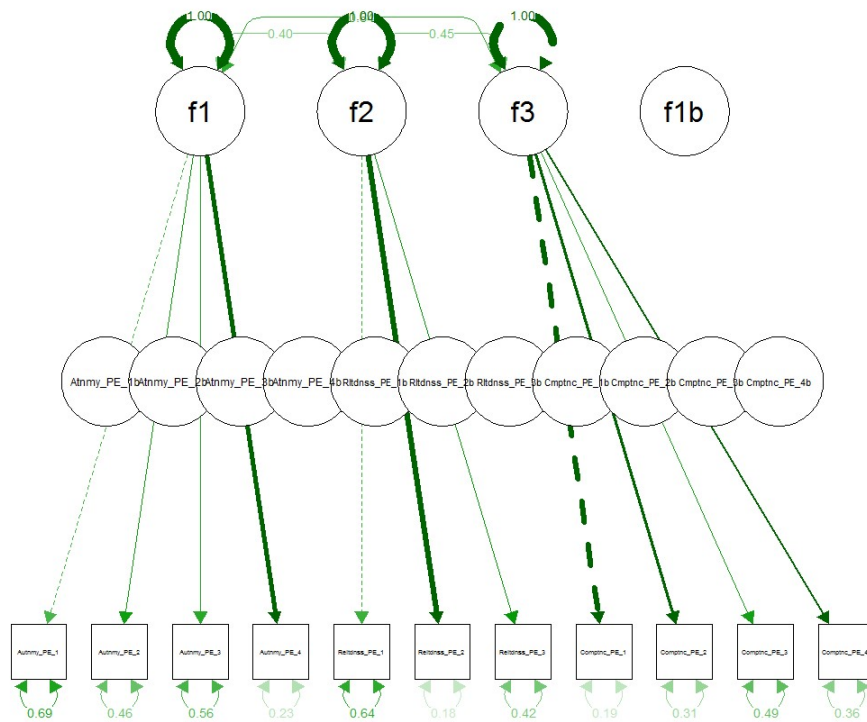
see fit indices of model A in table 2

Path diagramm

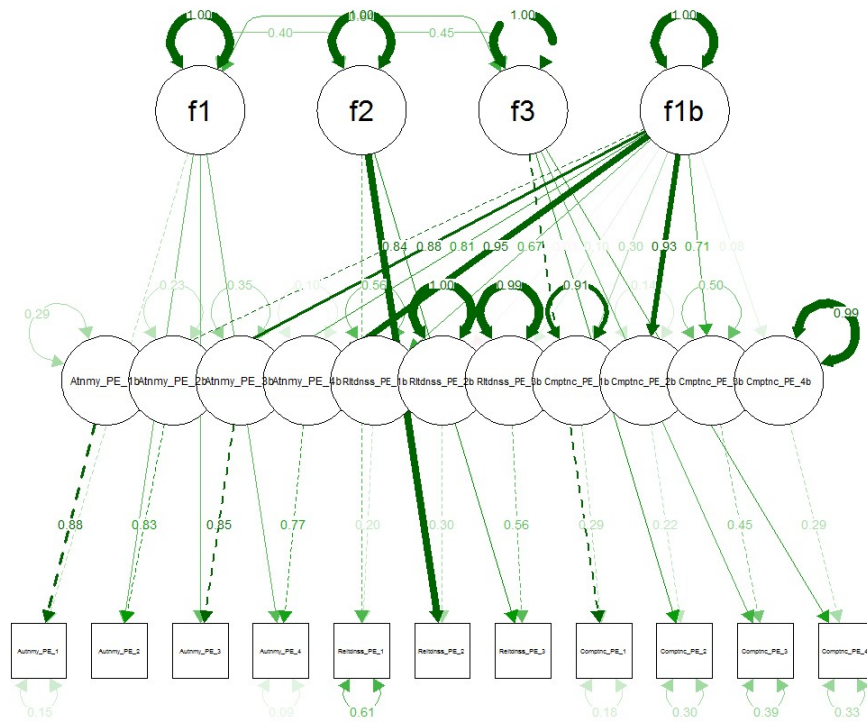
```
semPlot::semPaths(models$mod_3x1_var_fit,"std",edge.label.cex=0.5, curvePivot = TRUE)
```

```
## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

1



2



3x1, freely estimated loadings, variances and covariances

3x1-Modell, no equality constraints, freely estimated loadings, variances and covariances **model can't be identified.**

3x1, freely estimated loadings and latent factor variances and covariances, manifest variances set equal

3x1, factor loadings and covariances freely estimated, variances set equal

```

mod_3x1_free_vareq <- '
f1 =~ Autonomy_PE_1 + Autonomy_PE_2 + Autonomy_PE_3 + Autonomy_PE_4
f2 =~ Relatedness_PE_1 + Relatedness_PE_2 + Relatedness_PE_3
f3 =~ Competence_PE_1 + Competence_PE_2 + Competence_PE_3 + Competence_PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(k,k)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(l,l)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ f1
f2 ~~ f2
f3 ~~ f3
f1 ~~ f2
f1 ~~ f3
f2 ~~ f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b + c(0,NA)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit model
models$mod_3x1_free_vareq_fit <- cfa(mod_3x1_free_vareq, sample.cov = combined.cov, sample.n
obs = combined.n, orthogonal = T)

```

```

## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative

```

```

summary(models$mod_3x1_free_vareq_fit, fit.measures = T, standardized = T)

```



```

## lavaan 0.6-3 ended normally after 220 iterations
##
## Optimization method NLMINB
## Number of free parameters 72
## Number of equality constraints 11
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 157.964
## Degrees of freedom 71
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 124.159
## between 33.805
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.957
## Tucker-Lewis Index (TLI) 0.933
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5946.349
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 61
## Akaike (AIC) 12014.698
## Bayesian (BIC) 12263.013
## Sample-size adjusted Bayesian (BIC) 12069.432
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.075
## 90 Percent Confidence Interval 0.059 0.091
## P-value RMSEA <= 0.05 0.005
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.055

```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```

##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##
## Latent Variables:
## Estimate Std.Err z-value P(>|z|) Std.lv
## f1 =~
## Atnmy_PE_1 1.000 0.482
## Atnmy_PE_2 1.545 0.157 9.842 0.000 0.745
## Atnmy_PE_3 1.514 0.165 9.155 0.000 0.730
## Atnmy_PE_4 1.815 0.174 10.446 0.000 0.876
## f2 =~
## Rltdn_PE_1 1.000 0.589
## Rltdn_PE_2 1.642 0.148 11.120 0.000 0.966
## Rltdn_PE_3 1.466 0.130 11.258 0.000 0.863
## f3 =~
## Cmptn_PE_1 1.000 0.811
## Cmptn_PE_2 1.102 0.063 17.612 0.000 0.894
## Cmptn_PE_3 0.829 0.058 14.299 0.000 0.672
## Cmptn_PE_4 0.922 0.055 16.662 0.000 0.748
## Autonomy_PE_1b =~
## Atnmy_PE_1 (x) 1.000 0.000
## Autonomy_PE_2b =~
## Atnmy_PE_2 (x) 1.000 0.000
## Autonomy_PE_3b =~
## Atnmy_PE_3 (x) 1.000 0.000
## Autonomy_PE_4b =~
## Atnmy_PE_4 (x) 1.000 0.000
## Relatedness_PE_1b =~
## Rltdn_PE_1 (x) 1.000 0.000
## Relatedness_PE_2b =~
## Rltdn_PE_2 (x) 1.000 0.000
## Relatedness_PE_3b =~
## Rltdn_PE_3 (x) 1.000 0.000
## Competence_PE_1b =~
## Cmptn_PE_1 (x) 1.000 0.000
## Competence_PE_2b =~
## Cmptn_PE_2 (x) 1.000 0.000
## Competence_PE_3b =~
## Cmptn_PE_3 (x) 1.000 0.000
## Competence_PE_4b =~
## Cmptn_PE_4 (x) 1.000 0.000
## f1b =~
## Atnmy_PE_1 0.000 NaN
## Atnmy_PE_2 0.000 NaN
## Atnmy_PE_3 0.000 NaN
## Atnmy_PE_4 0.000 NaN
## Rltdn_PE_1 0.000 NaN
## Rltdn_PE_2 0.000 NaN
## Rltdn_PE_3 0.000 NaN
## Cmptn_PE_1 0.000 NaN
## Cmptn_PE_2 0.000 NaN
## Cmptn_PE_3 0.000 NaN
## Cmptn_PE_4 0.000 NaN

```

##		Std.all				
##						
##		0.538				
##		0.720				
##		0.633				
##		0.871				
##						
##		0.587				
##		0.896				
##		0.773				
##						
##		0.847				
##		0.801				
##		0.677				
##		0.765				
##						
##		0.000				
##						
##		0.000				
##						
##		0.000				
##						
##		0.000				
##						
##		0.000				
##						
##		0.000				
##						
##		0.000				
##						
##		0.000				
##						
##		0.000				
##						
##		0.000				
##						
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##		NaN				
##	Covariances:					
##		Estimate	Std.Err	z-value	P(> z)	Std.lv Std.all
##	f1 ~~					
##	f2	0.104	0.021	4.924	0.000	0.366 0.366
##	f3	0.233	0.033	7.057	0.000	0.595 0.595
##	f2 ~~					
##	f3	0.199	0.034	5.923	0.000	0.416 0.416
##	f1 ~~					
##	f1b	0.000				NaN NaN
##	f2 ~~					

```

##      flb                0.000                NaN      NaN
##      f3 ~~
##      flb                0.000                NaN      NaN
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)    0.570   0.044  13.090   0.000   0.570   0.710
##      .Atnmy_PE_2 (k)    0.517   0.047  11.079   0.000   0.517   0.482
##      .Atnmy_PE_3 (l)    0.797   0.065  12.352   0.000   0.797   0.599
##      .Atnmy_PE_4 (m)    0.244   0.040   6.091   0.000   0.244   0.242
##      .Rltdn_PE_1 (n)    0.658   0.052  12.736   0.000   0.658   0.655
##      .Rltdn_PE_2 (o)    0.229   0.057   4.049   0.000   0.229   0.197
##      .Rltdn_PE_3 (p)    0.500   0.056   8.879   0.000   0.500   0.402
##      .Cmptn_PE_1 (r)    0.259   0.029   8.850   0.000   0.259   0.283
##      .Cmptn_PE_2 (s)    0.446   0.043  10.376   0.000   0.446   0.358
##      .Cmptn_PE_3 (t)    0.534   0.043  12.416   0.000   0.534   0.541
##      .Cmptn_PE_4 (u)    0.397   0.035  11.213   0.000   0.397   0.415
##      f1                0.233   0.043   5.383   0.000   1.000   1.000
##      f2                0.346   0.058   5.955   0.000   1.000   1.000
##      f3                0.658   0.066   9.928   0.000   1.000   1.000
##      Atnmy_PE_1        0.000                NaN      NaN
##      Atnmy_PE_2        0.000                NaN      NaN
##      Atnmy_PE_3        0.000                NaN      NaN
##      Atnmy_PE_4        0.000                NaN      NaN
##      Rltdn_PE_1        0.000                NaN      NaN
##      Rltdn_PE_2        0.000                NaN      NaN
##      Rltdn_PE_3        0.000                NaN      NaN
##      Cmptn_PE_1        0.000                NaN      NaN
##      Cmptn_PE_2        0.000                NaN      NaN
##      Cmptn_PE_3        0.000                NaN      NaN
##      Cmptn_PE_4        0.000                NaN      NaN
##      flb                0.000                NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:
##              Estimate Std.Err z-value P(>|z|) Std.lv
##      f1 =~
##      Atn_PE_1          1.000                1.256
##      Atn_PE_2          0.837   0.176   4.753   0.000   1.051
##      Atn_PE_3          0.793   0.180   4.404   0.000   0.996
##      Atn_PE_4          1.043   0.209   4.992   0.000   1.310
##      f2 =~
##      Rlt_PE_1          1.000                0.719
##      Rlt_PE_2          0.952   0.232   4.105   0.000   0.685
##      Rlt_PE_3          0.653   0.188   3.473   0.001   0.470
##      f3 =~
##      Cmp_PE_1          1.000                NaN
##      Cmp_PE_2          0.442   0.547   0.808   0.419   NaN
##      Cmp_PE_3         -4.930   8.498  -0.580   0.562   NaN
##      Cmp_PE_4          1.312   0.638   2.056   0.040   NaN
##      Autonomy_PE_1b =~
##      Atn_PE_1 (sqc)     1.000                1.219
##      Autonomy_PE_2b =~
##      Atn_PE_2 (sqc)     1.000                0.520
##      Autonomy_PE_3b =~
##      Atn_PE_3 (sqc)     1.000                0.760
##      Autonomy_PE_4b =~
##      Atn_PE_4 (sqc)     1.000                0.709

```

```

## Relatedness_PE_1b =~
## Rlt_PE_1 (sqc) 1.000 NaN
## Relatedness_PE_2b =~
## Rlt_PE_2 (sqc) 1.000 0.315
## Relatedness_PE_3b =~
## Rlt_PE_3 (sqc) 1.000 NaN
## Competence_PE_1b =~
## Cmp_PE_1 (sqc) 1.000 0.844
## Competence_PE_2b =~
## Cmp_PE_2 (sqc) 1.000 0.857
## Competence_PE_3b =~
## Cmp_PE_3 (sqc) 1.000 1.206
## Competence_PE_4b =~
## Cmp_PE_4 (sqc) 1.000 0.813
## flb =~
## Atn_PE_1 1.000 0.530
## Atn_PE_2 1.010 0.395 2.556 0.011 1.254
## Atn_PE_3 1.502 0.673 2.232 0.026 1.275
## Atn_PE_4 0.995 0.378 2.635 0.008 0.906
## Rlt_PE_1 0.420 0.374 1.122 0.262 NaN
## Rlt_PE_2 0.553 0.373 1.482 0.138 1.135
## Rlt_PE_3 0.313 0.264 1.187 0.235 NaN
## Cmp_PE_1 1.290 0.770 1.675 0.094 0.987
## Cmp_PE_2 1.313 0.809 1.623 0.105 0.989
## Cmp_PE_3 0.732 0.498 1.468 0.142 0.392
## Cmp_PE_4 1.044 0.645 1.619 0.105 0.828
## Std.all
##
## 0.659
## 0.764
## 0.648
## 0.835
##
## 0.680
## 0.767
## 0.630
##
## NaN
## NaN
## NaN
## NaN
##
## 0.639
##
## 0.378
##
## 0.494
##
## 0.452
##
## NaN
##
## 0.353
##
## NaN
##
## 0.870
##
## 0.791
##

```

```

##      1.080
##
##      0.811
##
##      0.530
##      1.254
##      1.275
##      0.906
##      NaN
##      1.135
##      NaN
##      0.987
##      0.989
##      0.392
##      0.828
##
## Covariances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 ~~
## f2      0.008   0.245   0.033   0.974   0.009   0.009
## f3     -0.116   0.173  -0.668   0.504  -0.527  -0.527
## f2 ~~
## f3     -0.085   0.125  -0.676   0.499  -0.674  -0.674
## f1 ~~
## f1b      0.000             0.000   0.000
## f2 ~~
## f1b      0.000             0.000   0.000
## f3 ~~
## f1b      0.000             0.000   0.000
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .Atnmy_PE_1 (j)  0.570   0.044  13.090   0.000   0.570   0.157
## .Atnmy_PE_2 (k)  0.517   0.047  11.079   0.000   0.517   0.273
## .Atnmy_PE_3 (l)  0.797   0.065  12.352   0.000   0.797   0.337
## .Atnmy_PE_4 (m)  0.244   0.040   6.091   0.000   0.244   0.099
## .Rltdn_PE_1 (n)  0.658   0.052  12.736   0.000   0.658   0.589
## .Rltdn_PE_2 (o)  0.229   0.057   4.049   0.000   0.229   0.288
## .Rltdn_PE_3 (p)  0.500   0.056   8.879   0.000   0.500   0.900
## .Cmptn_PE_1 (r)  0.259   0.029   8.850   0.000   0.259   0.276
## .Cmptn_PE_2 (s)  0.446   0.043  10.376   0.000   0.446   0.380
## .Cmptn_PE_3 (t)  0.534   0.043  12.416   0.000   0.534   0.428
## .Cmptn_PE_4 (u)  0.397   0.035  11.213   0.000   0.397   0.394
## f1      1.578   0.746   2.114   0.034   1.000   1.000
## f2      0.517   0.250   2.069   0.039   1.000   1.000
## f3     -0.030   0.048  -0.640   0.522     NaN     NaN
## Atnmy_PE_1      1.069   0.439   2.435   0.015   0.720   0.720
## Atnmy_PE_2     -0.155   0.132  -1.174   0.240  -0.573  -0.573
## Atnmy_PE_3     -0.361   0.161  -2.249   0.025  -0.625  -0.625
## Atnmy_PE_4      0.090   0.153   0.590   0.555   0.180   0.180
## Rltdn_PE_1     -0.132   0.170  -0.776   0.438     NaN     NaN
## Rltdn_PE_2     -0.028   0.117  -0.243   0.808  -0.287  -0.287
## Rltdn_PE_3     -0.206   0.103  -2.010   0.044     NaN     NaN
## Cmptn_PE_1      0.018   0.135   0.137   0.891   0.026   0.026
## Cmptn_PE_2      0.016   0.178   0.090   0.928   0.022   0.022
## Cmptn_PE_3      1.231   2.037   0.604   0.546   0.847   0.847
## Cmptn_PE_4      0.208   0.182   1.144   0.252   0.314   0.314
## f1b      0.416   0.497   0.838   0.402   1.000   1.000

```

3x1, freely estimated loadings and latent factor variances and covariances, manifest variances set equal/fixed where necessary

```

mod_3x1_free_vareq_var <- '
f1 =~ Autonomy_PE_1 + Autonomy_PE_2 + Autonomy_PE_3 + Autonomy_PE_4
f2 =~ Relatedness_PE_1 + Relatedness_PE_2 + Relatedness_PE_3
f3 =~ Competence_PE_1 + Competence_PE_2 + Competence_PE_3 + Competence_PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(NA,0)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(NA,0)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(NA,0)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(NA,0)*Relatedness_PE_3
Competence_PE_1 ~~ c(l,l)*Competence_PE_1
Competence_PE_2 ~~ c(NA,0)*Competence_PE_2
Competence_PE_3 ~~ c(NA,0)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ f1
f2 ~~ f2
f3 ~~ f3
f1 ~~ f2
f1 ~~ f3
f2 ~~ f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b + c(0,NA)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,NA)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model
models$mod_3x1_free_vareq_var_fit <- cfa(mod_3x1_free_vareq_var, sample.cov = combined.cov,
sample.nobs = combined.n, orthogonal = T)

```

```

## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative

```

```

summary(models$mod_3x1_free_vareq_var_fit, fit.measures = T, standardized = T)

```

```

## lavaan 0.6-3 ended normally after 221 iterations
##
## Optimization method NLMINB
## Number of free parameters 66
## Number of equality constraints 5
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 157.964
## Degrees of freedom 71
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 124.159
## between 33.805
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.957
## Tucker-Lewis Index (TLI) 0.933
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5946.349
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 61
## Akaike (AIC) 12014.698
## Bayesian (BIC) 12263.013
## Sample-size adjusted Bayesian (BIC) 12069.432
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.075
## 90 Percent Confidence Interval 0.059 0.091
## P-value RMSEA <= 0.05 0.005
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.055

```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```



```

##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##
## Latent Variables:
## Estimate Std.Err z-value P(>|z|) Std.lv
## f1 =~
## Atnmy_PE_1 1.000 0.482
## Atnmy_PE_2 1.545 0.157 9.842 0.000 0.745
## Atnmy_PE_3 1.514 0.165 9.155 0.000 0.730
## Atnmy_PE_4 1.815 0.174 10.446 0.000 0.876
## f2 =~
## Rltdn_PE_1 1.000 0.589
## Rltdn_PE_2 1.642 0.148 11.120 0.000 0.966
## Rltdn_PE_3 1.466 0.130 11.258 0.000 0.863
## f3 =~
## Cmptn_PE_1 1.000 0.811
## Cmptn_PE_2 1.102 0.063 17.612 0.000 0.894
## Cmptn_PE_3 0.829 0.058 14.299 0.000 0.672
## Cmptn_PE_4 0.922 0.055 16.662 0.000 0.748
## Autonomy_PE_1b =~
## Atnmy_PE_1 (x) 1.000 0.000
## Autonomy_PE_2b =~
## Atnmy_PE_2 (x) 1.000 0.000
## Autonomy_PE_3b =~
## Atnmy_PE_3 (x) 1.000 0.000
## Autonomy_PE_4b =~
## Atnmy_PE_4 (x) 1.000 0.000
## Relatedness_PE_1b =~
## Rltdn_PE_1 (x) 1.000 0.000
## Relatedness_PE_2b =~
## Rltdn_PE_2 (x) 1.000 0.000
## Relatedness_PE_3b =~
## Rltdn_PE_3 (x) 1.000 0.000
## Competence_PE_1b =~
## Cmptn_PE_1 (x) 1.000 0.000
## Competence_PE_2b =~
## Cmptn_PE_2 (x) 1.000 0.000
## Competence_PE_3b =~
## Cmptn_PE_3 (x) 1.000 0.000
## Competence_PE_4b =~
## Cmptn_PE_4 (x) 1.000 0.000
## f1b =~
## Atnmy_PE_1 0.000 NaN
## Atnmy_PE_2 0.000 NaN
## Atnmy_PE_3 0.000 NaN
## Atnmy_PE_4 0.000 NaN
## Rltdn_PE_1 0.000 NaN
## Rltdn_PE_2 0.000 NaN
## Rltdn_PE_3 0.000 NaN
## Cmptn_PE_1 0.000 NaN
## Cmptn_PE_2 0.000 NaN
## Cmptn_PE_3 0.000 NaN
## Cmptn_PE_4 0.000 NaN

```

	Std.all					
##						
##	0.538					
##	0.720					
##	0.633					
##	0.871					
##						
##	0.587					
##	0.896					
##	0.773					
##						
##	0.847					
##	0.801					
##	0.677					
##	0.765					
##						
##	0.000					
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##	0.000					
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##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##	Covariances:					
##		Estimate	Std.Err	z-value	P(> z)	Std.lv Std.all
##	f1 ~~					
##	f2	0.104	0.021	4.924	0.000	0.366 0.366
##	f3	0.233	0.033	7.057	0.000	0.595 0.595
##	f2 ~~					
##	f3	0.199	0.034	5.923	0.000	0.416 0.416
##	f1 ~~					
##	f1b	0.000				NaN NaN
##	f2 ~~					

```

##      flb                0.000                NaN      NaN
##      f3 ~~
##      flb                0.000                NaN      NaN
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)    0.570   0.044  13.090   0.000   0.570   0.710
##      .Atnmy_PE_2        0.517   0.047  11.079   0.000   0.517   0.482
##      .Atnmy_PE_3        0.797   0.065  12.352   0.000   0.797   0.599
##      .Atnmy_PE_4 (m)    0.244   0.040   6.091   0.000   0.244   0.242
##      .Rltdn_PE_1 (n)    0.658   0.052  12.736   0.000   0.658   0.655
##      .Rltdn_PE_2        0.229   0.057   4.049   0.000   0.229   0.197
##      .Rltdn_PE_3        0.500   0.056   8.879   0.000   0.500   0.402
##      .Cmptn_PE_1 (l)    0.259   0.029   8.850   0.000   0.259   0.283
##      .Cmptn_PE_2        0.446   0.043  10.376   0.000   0.446   0.358
##      .Cmptn_PE_3        0.534   0.043  12.416   0.000   0.534   0.541
##      .Cmptn_PE_4 (u)    0.397   0.035  11.213   0.000   0.397   0.415
##      f1                 0.233   0.043   5.383   0.000   1.000   1.000
##      f2                 0.346   0.058   5.955   0.000   1.000   1.000
##      f3                 0.658   0.066   9.928   0.000   1.000   1.000
##      Atnmy_PE_1        0.000                NaN      NaN
##      Atnmy_PE_2        0.000                NaN      NaN
##      Atnmy_PE_3        0.000                NaN      NaN
##      Atnmy_PE_4        0.000                NaN      NaN
##      Rltdn_PE_1        0.000                NaN      NaN
##      Rltdn_PE_2        0.000                NaN      NaN
##      Rltdn_PE_3        0.000                NaN      NaN
##      Cmptn_PE_1        0.000                NaN      NaN
##      Cmptn_PE_2        0.000                NaN      NaN
##      Cmptn_PE_3        0.000                NaN      NaN
##      Cmptn_PE_4        0.000                NaN      NaN
##      flb               0.000                NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:
##              Estimate Std.Err z-value P(>|z|) Std.lv
##      f1 =~
##      Atn_PE_1          1.000                1.256
##      Atn_PE_2          0.837   0.176   4.753   0.000   1.051
##      Atn_PE_3          0.793   0.180   4.404   0.000   0.996
##      Atn_PE_4          1.043   0.209   4.992   0.000   1.310
##      f2 =~
##      Rlt_PE_1          1.000                0.719
##      Rlt_PE_2          0.952   0.232   4.105   0.000   0.685
##      Rlt_PE_3          0.653   0.188   3.473   0.001   0.470
##      f3 =~
##      Cmp_PE_1          1.000                NaN
##      Cmp_PE_2          0.442   0.547   0.808   0.419   NaN
##      Cmp_PE_3         -4.931   8.500  -0.580   0.562   NaN
##      Cmp_PE_4          1.312   0.638   2.056   0.040   NaN
##      Autonomy_PE_1b =~
##      Atn_PE_1 (sqc)     1.000                1.219
##      Autonomy_PE_2b =~
##      Atn_PE_2 (sqc)     1.000                0.887
##      Autonomy_PE_3b =~
##      Atn_PE_3 (sqc)     1.000                1.172
##      Autonomy_PE_4b =~
##      Atn_PE_4 (sqc)     1.000                0.709

```

```

## Relatedness_PE_1b =~
## Rlt_PE_1 (sqc) 1.000 NaN
## Relatedness_PE_2b =~
## Rlt_PE_2 (sqc) 1.000 0.573
## Relatedness_PE_3b =~
## Rlt_PE_3 (sqc) 1.000 0.579
## Competence_PE_1b =~
## Cmp_PE_1 (sqc) 1.000 0.844
## Competence_PE_2b =~
## Cmp_PE_2 (sqc) 1.000 1.086
## Competence_PE_3b =~
## Cmp_PE_3 (sqc) 1.000 1.410
## Competence_PE_4b =~
## Cmp_PE_4 (sqc) 1.000 0.813
## flb =~
## Atn_PE_1 1.000 0.530
## Atn_PE_2 1.010 0.395 2.556 0.011 0.735
## Atn_PE_3 1.502 0.673 2.232 0.026 0.827
## Atn_PE_4 0.995 0.378 2.635 0.008 0.906
## Rlt_PE_1 0.420 0.374 1.122 0.262 NaN
## Rlt_PE_2 0.553 0.373 1.482 0.138 0.623
## Rlt_PE_3 0.313 0.264 1.187 0.235 0.349
## Cmp_PE_1 1.290 0.770 1.675 0.094 0.987
## Cmp_PE_2 1.313 0.809 1.623 0.105 0.780
## Cmp_PE_3 0.732 0.498 1.468 0.142 0.335
## Cmp_PE_4 1.044 0.645 1.619 0.105 0.828
## Std.all
##
## 0.659
## 0.764
## 0.648
## 0.835
##
## 0.680
## 0.767
## 0.630
##
## NaN
## NaN
## NaN
## NaN
##
## 0.639
##
## 0.645
##
## 0.762
##
## 0.452
##
## NaN
##
## 0.642
##
## 0.776
##
## 0.870
##
## 1.003
##

```

```

##      1.263
##
##      0.811
##
##      0.530
##      0.735
##      0.827
##      0.906
##      NaN
##      0.623
##      0.349
##      0.987
##      0.780
##      0.335
##      0.828
##
## Covariances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 ~~
## f2      0.008   0.245   0.033   0.974   0.009   0.009
## f3     -0.116   0.173  -0.668   0.504  -0.527  -0.527
## f2 ~~
## f3     -0.085   0.125  -0.676   0.499  -0.674  -0.674
## f1 ~~
## f1b     0.000           0.000   0.000
## f2 ~~
## f1b     0.000           0.000   0.000
## f3 ~~
## f1b     0.000           0.000   0.000
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .Atnmy_PE_1 (j)  0.570   0.044  13.090   0.000   0.570   0.157
## .Atnmy_PE_2      0.000           0.000   0.000
## .Atnmy_PE_3      0.000           0.000   0.000
## .Atnmy_PE_4 (m)  0.244   0.040   6.091   0.000   0.244   0.099
## .Rltdn_PE_1 (n)  0.658   0.052  12.736   0.000   0.658   0.589
## .Rltdn_PE_2      0.000           0.000   0.000
## .Rltdn_PE_3      0.000           0.000   0.000
## .Cmptn_PE_1 (l)  0.259   0.029   8.850   0.000   0.259   0.276
## .Cmptn_PE_2      0.000           0.000   0.000
## .Cmptn_PE_3      0.000           0.000   0.000
## .Cmptn_PE_4 (u)  0.397   0.035  11.213   0.000   0.397   0.394
## f1      1.578   0.746   2.114   0.034   1.000   1.000
## f2      0.517   0.250   2.069   0.039   1.000   1.000
## f3     -0.030   0.048  -0.640   0.522     NaN     NaN
## Atnmy_PE_1      1.069   0.439   2.435   0.015   0.720   0.720
## Atnmy_PE_2      0.362   0.123   2.932   0.003   0.460   0.460
## Atnmy_PE_3      0.435   0.147   2.960   0.003   0.317   0.317
## Atnmy_PE_4      0.090   0.153   0.590   0.555   0.180   0.180
## Rltdn_PE_1     -0.132   0.170  -0.776   0.438     NaN     NaN
## Rltdn_PE_2      0.201   0.102   1.964   0.050   0.612   0.612
## Rltdn_PE_3      0.294   0.086   3.427   0.001   0.878   0.878
## Cmptn_PE_1      0.018   0.135   0.137   0.891   0.026   0.026
## Cmptn_PE_2      0.462   0.172   2.683   0.007   0.392   0.392
## Cmptn_PE_3      1.765   2.037   0.867   0.386   0.888   0.888
## Cmptn_PE_4      0.208   0.182   1.144   0.252   0.314   0.314
## flb      0.416   0.497   0.838   0.402   1.000   1.000

```

Path diagramm

```
semPlot::semPaths(models$mod_3x1_free_vareq_var_fit,"std",edge.label.cex=0.5, curvePivot = T
RUE)
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

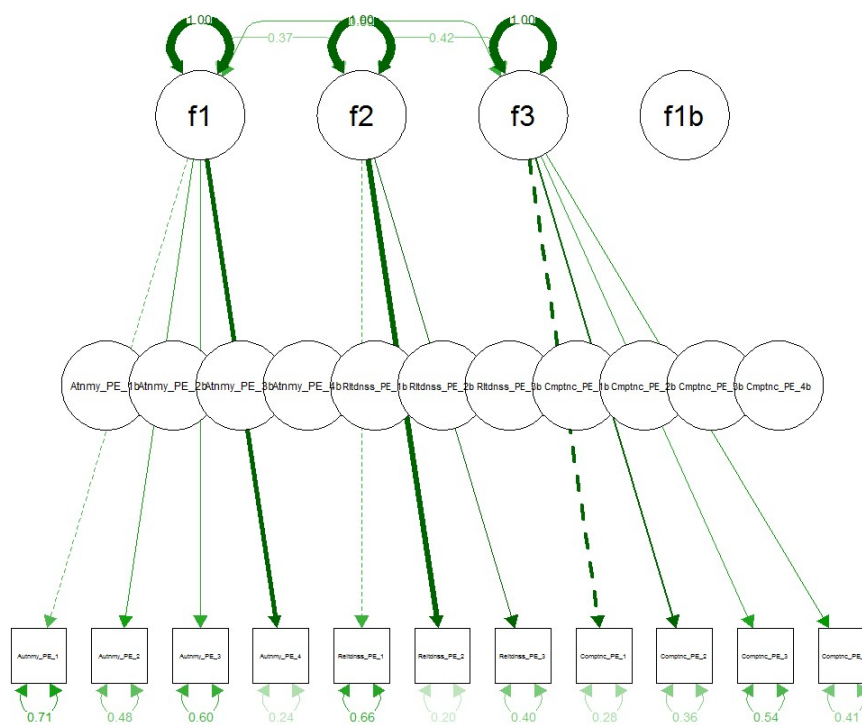
```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

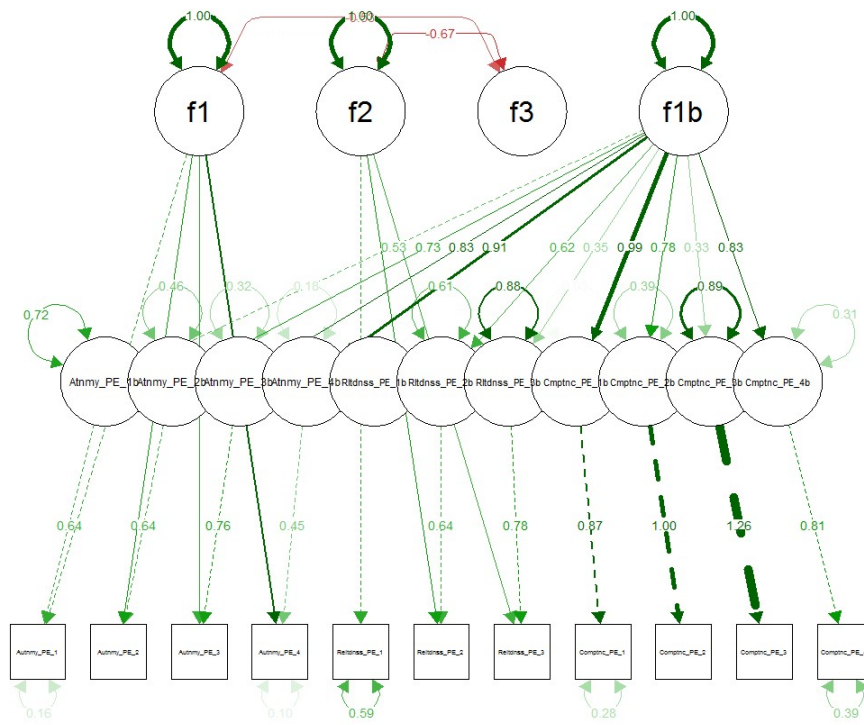
```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in qgraph::qgraph(Edgelist, labels = nLab, bidirectional = Bidir, :  
## Non-finite weights are omitted
```

```
## Warning in qgraph::qgraph(Edgelist, labels = nLab, bidirectional = Bidir, :  
## Non-finite weights are omitted
```

1





3x1, not nested

estimate 3x1-Model not nested, so 3 factors only at level 1 and one factor at level 2

```

mod_3x1_sep <- '
f1 =~ c(1,0)*Autonomy_PE_1 + c(NA,0)*Autonomy_PE_2 + c(NA,0)*Autonomy_PE_3 + c(NA,0)*Autonomy_PE_4
f2 =~ c(1,0)*Relatedness_PE_1 + c(NA,0)*Relatedness_PE_2 + c(NA,0)*Relatedness_PE_3
f3 =~ c(1,0)*Competence_PE_1 + c(NA,0)*Competence_PE_2 + c(NA,0)*Competence_PE_3 + c(NA,0)*Competence_PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(k,k)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(l,l)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(NA,0)*f1
f2 ~~ c(NA,0)*f2
f3 ~~ c(NA,0)*f3
f1 ~~ c(NA,0)*f2
f1 ~~ c(NA,0)*f3
f2 ~~ c(NA,0)*f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b + c(0,1)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,1)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model
models$mod_3x1_sep_fit <- cfa(mod_3x1_sep, sample.cov = combined.cov, sample.nobs = combined.n, orthogonal = T)

```

```

## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative

```



```
summary(models$mod_3x1_sep_fit, fit.measures = T, standardized = T)
```

```

## lavaan 0.6-3 ended normally after 100 iterations
##
## Optimization method NLMINB
## Number of free parameters 56
## Number of equality constraints 11
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 253.129
## Degrees of freedom 87
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 124.159
## between 128.970
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.918
## Tucker-Lewis Index (TLI) 0.896
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5993.931
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 45
## Akaike (AIC) 12077.862
## Bayesian (BIC) 12261.045
## Sample-size adjusted Bayesian (BIC) 12118.240
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.094
## 90 Percent Confidence Interval 0.081 0.107
## P-value RMSEA <= 0.05 0.000
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.065
##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##

```

```

## Latent Variables:
##
##           Estimate   Std.Err   z-value   P(>|z|)   Std.lv
## f1 =~
##   Atnmy_PE_1         1.000
##   Atnmy_PE_2         1.545     0.157     9.842     0.000     0.745
##   Atnmy_PE_3         1.514     0.165     9.155     0.000     0.730
##   Atnmy_PE_4         1.815     0.174    10.446     0.000     0.876
## f2 =~
##   Rltdn_PE_1         1.000
##   Rltdn_PE_2         1.642     0.148    11.120     0.000     0.966
##   Rltdn_PE_3         1.466     0.130    11.258     0.000     0.863
## f3 =~
##   Cmptn_PE_1         1.000
##   Cmptn_PE_2         1.102     0.063    17.612     0.000     0.894
##   Cmptn_PE_3         0.829     0.058    14.299     0.000     0.672
##   Cmptn_PE_4         0.922     0.055    16.662     0.000     0.748
## Autonomy_PE_1b =~
##   Atnmy_PE_1 (x)         1.000
## Autonomy_PE_2b =~
##   Atnmy_PE_2 (x)         1.000
## Autonomy_PE_3b =~
##   Atnmy_PE_3 (x)         1.000
## Autonomy_PE_4b =~
##   Atnmy_PE_4 (x)         1.000
## Relatedness_PE_1b =~
##   Rltdn_PE_1 (x)         1.000
## Relatedness_PE_2b =~
##   Rltdn_PE_2 (x)         1.000
## Relatedness_PE_3b =~
##   Rltdn_PE_3 (x)         1.000
## Competence_PE_1b =~
##   Cmptn_PE_1 (x)         1.000
## Competence_PE_2b =~
##   Cmptn_PE_2 (x)         1.000
## Competence_PE_3b =~
##   Cmptn_PE_3 (x)         1.000
## Competence_PE_4b =~
##   Cmptn_PE_4 (x)         1.000
## f1b =~
##   Atnmy_PE_1         0.000
##   Atnmy_PE_2         0.000
##   Atnmy_PE_3         0.000
##   Atnmy_PE_4         0.000
##   Rltdn_PE_1         0.000
##   Rltdn_PE_2         0.000
##   Rltdn_PE_3         0.000
##   Cmptn_PE_1         0.000
##   Cmptn_PE_2         0.000
##   Cmptn_PE_3         0.000
##   Cmptn_PE_4         0.000
## Std.all
##
##   0.538
##   0.720
##   0.633
##   0.871
##
##   0.587
##   0.896
##   0.773

```

```

##
##      0.847
##      0.801
##      0.677
##      0.765
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      f1 ~~
##      f2      0.104   0.021   4.924   0.000   0.366   0.366
##      f3      0.233   0.033   7.057   0.000   0.595   0.595
##      f2 ~~
##      f3      0.199   0.034   5.923   0.000   0.416   0.416
##      f1 ~~
##      f1b     0.000                NaN      NaN
##      f2 ~~
##      f1b     0.000                NaN      NaN
##      f3 ~~
##      f1b     0.000                NaN      NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)  0.570   0.044  13.090   0.000   0.570   0.710
##      .Atnmy_PE_2 (k)  0.517   0.047  11.079   0.000   0.517   0.482
##      .Atnmy_PE_3 (l)  0.797   0.065  12.352   0.000   0.797   0.599
##      .Atnmy_PE_4 (m)  0.244   0.040   6.091   0.000   0.244   0.242

```

```

##      .Rltdn_PE_1 (n)      0.658      0.052     12.736      0.000      0.658      0.655
##      .Rltdn_PE_2 (o)      0.229      0.057      4.049      0.000      0.229      0.197
##      .Rltdn_PE_3 (p)      0.500      0.056      8.879      0.000      0.500      0.402
##      .Cmptn_PE_1 (r)      0.259      0.029      8.850      0.000      0.259      0.283
##      .Cmptn_PE_2 (s)      0.446      0.043     10.376      0.000      0.446      0.358
##      .Cmptn_PE_3 (t)      0.534      0.043     12.416      0.000      0.534      0.541
##      .Cmptn_PE_4 (u)      0.397      0.035     11.213      0.000      0.397      0.415
##      f1                0.233      0.043      5.383      0.000      1.000      1.000
##      f2                0.346      0.058      5.955      0.000      1.000      1.000
##      f3                0.658      0.066      9.928      0.000      1.000      1.000
##      Atnmy_PE_1         0.000                                NaN      NaN
##      Atnmy_PE_2         0.000                                NaN      NaN
##      Atnmy_PE_3         0.000                                NaN      NaN
##      Atnmy_PE_4         0.000                                NaN      NaN
##      Rltdn_PE_1         0.000                                NaN      NaN
##      Rltdn_PE_2         0.000                                NaN      NaN
##      Rltdn_PE_3         0.000                                NaN      NaN
##      Cmptn_PE_1         0.000                                NaN      NaN
##      Cmptn_PE_2         0.000                                NaN      NaN
##      Cmptn_PE_3         0.000                                NaN      NaN
##      Cmptn_PE_4         0.000                                NaN      NaN
##      flb                0.000                                NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:
##
##      Estimate  Std.Err  z-value  P(>|z|)  Std.lv
##      f1 =~
##      Atn_PE_1      0.000                                0.000
##      Atn_PE_2      0.000                                0.000
##      Atn_PE_3      0.000                                0.000
##      Atn_PE_4      0.000                                0.000
##      f2 =~
##      Rlt_PE_1      0.000                                0.000
##      Rlt_PE_2      0.000                                0.000
##      Rlt_PE_3      0.000                                0.000
##      f3 =~
##      Cmp_PE_1      0.000                                0.000
##      Cmp_PE_2      0.000                                0.000
##      Cmp_PE_3      0.000                                0.000
##      Cmp_PE_4      0.000                                0.000
##      Autonomy_PE_1b =~
##      Atn_PE_1 (sqc)  1.000                                1.515
##      Autonomy_PE_2b =~
##      Atn_PE_2 (sqc)  1.000                                1.173
##      Autonomy_PE_3b =~
##      Atn_PE_3 (sqc)  1.000                                1.253
##      Autonomy_PE_4b =~
##      Atn_PE_4 (sqc)  1.000                                1.490
##      Relatedness_PE_1b =~
##      Rlt_PE_1 (sqc)  1.000                                0.813
##      Relatedness_PE_2b =~
##      Rlt_PE_2 (sqc)  1.000                                0.754
##      Relatedness_PE_3b =~
##      Rlt_PE_3 (sqc)  1.000                                0.235
##      Competence_PE_1b =~
##      Cmp_PE_1 (sqc)  1.000                                0.871
##      Competence_PE_2b =~
##      Cmp_PE_2 (sqc)  1.000                                0.853

```

##	Competence_PE_3b =~					
##	Cmp_PE_3 (sqc)	1.000				0.844
##	Competence_PE_4b =~					
##	Cmp_PE_4 (sqc)	1.000				0.781
##	f1b =~					
##	Atn_PE_1	1.000				0.341
##	Atn_PE_2	2.301	0.552	4.170	0.000	1.015
##	Atn_PE_3	2.693	0.626	4.302	0.000	1.112
##	Atn_PE_4	2.629	0.630	4.175	0.000	0.913
##	Rlt_PE_1	1.000				0.637
##	Rlt_PE_2	0.537	0.318	1.687	0.092	0.369
##	Rlt_PE_3	0.393	0.264	1.488	0.137	0.865
##	Cmp_PE_1	1.000				0.594
##	Cmp_PE_2	1.137	0.401	2.835	0.005	0.690
##	Cmp_PE_3	1.401	0.423	3.311	0.001	0.858
##	Cmp_PE_4	0.739	0.361	2.048	0.041	0.490
##	Std.all					
##						
##	0.000					
##	0.000					
##	0.000					
##	0.000					
##						
##	0.000					
##	0.000					
##	0.000					
##						
##	0.000					
##	0.000					
##	0.000					
##	0.000					
##						
##	0.895					
##						
##	0.853					
##						
##	0.814					
##						
##	0.949					
##						
##	0.708					
##						
##	0.844					
##						
##	0.316					
##						
##	0.863					
##						
##	0.787					
##						
##	0.756					
##						
##	0.778					
##						
##	0.341					
##	1.015					
##	1.112					
##	0.913					
##	0.637					
##	0.369					

```
##      0.865
##      0.594
##      0.690
##      0.858
##      0.490
##
## Covariances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 ~~
## f2      0.000      NaN      NaN
## f3      0.000      NaN      NaN
## f2 ~~
## f3      0.000      NaN      NaN
## f1 ~~
## f1b     0.000      NaN      NaN
## f2 ~~
## f1b     0.000      NaN      NaN
## f3 ~~
## f1b     0.000      NaN      NaN
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .Atnmy_PE_1 (j)  0.570  0.044  13.090  0.000  0.570  0.199
## .Atnmy_PE_2 (k)  0.517  0.047  11.079  0.000  0.517  0.273
## .Atnmy_PE_3 (l)  0.797  0.065  12.352  0.000  0.797  0.337
## .Atnmy_PE_4 (m)  0.244  0.040   6.091  0.000  0.244  0.099
## .Rltdn_PE_1 (n)  0.658  0.052  12.736  0.000  0.658  0.499
## .Rltdn_PE_2 (o)  0.229  0.057   4.049  0.000  0.229  0.288
## .Rltdn_PE_3 (p)  0.500  0.056   8.879  0.000  0.500  0.900
## .Cmptn_PE_1 (r)  0.259  0.029   8.850  0.000  0.259  0.255
## .Cmptn_PE_2 (s)  0.446  0.043  10.376  0.000  0.446  0.380
## .Cmptn_PE_3 (t)  0.534  0.043  12.416  0.000  0.534  0.428
## .Cmptn_PE_4 (u)  0.397  0.035  11.213  0.000  0.397  0.394
## f1      0.000      NaN      NaN
## f2      0.000      NaN      NaN
## f3      0.000      NaN      NaN
## Atnmy_PE_1      2.029  0.646   3.140  0.002  0.883  0.883
## Atnmy_PE_2     -0.042  0.162  -0.257  0.798 -0.030 -0.030
## Atnmy_PE_3     -0.370  0.180  -2.059  0.039 -0.236 -0.236
## Atnmy_PE_4      0.369  0.205   1.799  0.072  0.166  0.166
## Rltdn_PE_1      0.393  0.269   1.462  0.144  0.595  0.595
## Rltdn_PE_2      0.491  0.188   2.617  0.009  0.864  0.864
## Rltdn_PE_3      0.014  0.139   0.100  0.920  0.252  0.252
## Cmptn_PE_1      0.490  0.192   2.555  0.011  0.647  0.647
## Cmptn_PE_2      0.382  0.215   1.774  0.076  0.524  0.524
## Cmptn_PE_3      0.188  0.193   0.972  0.331  0.264  0.264
## Cmptn_PE_4      0.463  0.217   2.129  0.033  0.760  0.760
## flb      0.268  0.132   2.025  0.043  1.000  1.000
```

3x1, not nested, var set to 0

Model B

```

mod_3x1_sep_var <- '
f1 =~ c(1,0)*Autonomy_PE_1 + c(NA,0)*Autonomy_PE_2 + c(NA,0)*Autonomy_PE_3 + c(NA,0)*Autonomy_PE_4
f2 =~ c(1,0)*Relatedness_PE_1 + c(NA,0)*Relatedness_PE_2 + c(NA,0)*Relatedness_PE_3
f3 =~ c(1,0)*Competence_PE_1 + c(NA,0)*Competence_PE_2 + c(NA,0)*Competence_PE_3 + c(NA,0)*Competence_PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(NA,0)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(NA,0)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(NA,0)*f1
f2 ~~ c(NA,0)*f2
f3 ~~ c(NA,0)*f3
f1 ~~ c(NA,0)*f2
f1 ~~ c(NA,0)*f3
f2 ~~ c(NA,0)*f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b + c(0,1)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b + c(0,1)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model
models$mod_3x1_sep_var_fit <- cfa(mod_3x1_sep_var, sample.cov = combined.cov, sample.nobs = combined.n, orthogonal = T)
summary(models$mod_3x1_sep_var_fit, fit.measures = T, standardized = T)

```



```

## lavaan 0.6-3 ended normally after 97 iterations
##
## Optimization method NLMINB
## Number of free parameters 54
## Number of equality constraints 9
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 253.129
## Degrees of freedom 87
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 124.159
## between 128.970
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.918
## Tucker-Lewis Index (TLI) 0.896
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5993.931
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 45
## Akaike (AIC) 12077.862
## Bayesian (BIC) 12261.045
## Sample-size adjusted Bayesian (BIC) 12118.240
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.094
## 90 Percent Confidence Interval 0.081 0.107
## P-value RMSEA <= 0.05 0.000
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.065
##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##

```

```

## Latent Variables:
##
##      Estimate   Std.Err   z-value   P(>|z|)   Std.lv
##      f1 =~
##      Atnmy_PE_1      1.000
##      Atnmy_PE_2      1.545      0.157      9.842      0.000      0.745
##      Atnmy_PE_3      1.514      0.165      9.155      0.000      0.730
##      Atnmy_PE_4      1.815      0.174     10.446      0.000      0.876
##      f2 =~
##      Rltdn_PE_1      1.000
##      Rltdn_PE_2      1.642      0.148     11.120      0.000      0.966
##      Rltdn_PE_3      1.466      0.130     11.258      0.000      0.863
##      f3 =~
##      Cmptn_PE_1      1.000
##      Cmptn_PE_2      1.102      0.063     17.612      0.000      0.894
##      Cmptn_PE_3      0.829      0.058     14.299      0.000      0.672
##      Cmptn_PE_4      0.922      0.055     16.662      0.000      0.748
##      Autonomy_PE_1b =~
##      Atnmy_PE_1 (x)      1.000
##      Autonomy_PE_2b =~
##      Atnmy_PE_2 (x)      1.000
##      Autonomy_PE_3b =~
##      Atnmy_PE_3 (x)      1.000
##      Autonomy_PE_4b =~
##      Atnmy_PE_4 (x)      1.000
##      Relatedness_PE_1b =~
##      Rltdn_PE_1 (x)      1.000
##      Relatedness_PE_2b =~
##      Rltdn_PE_2 (x)      1.000
##      Relatedness_PE_3b =~
##      Rltdn_PE_3 (x)      1.000
##      Competence_PE_1b =~
##      Cmptn_PE_1 (x)      1.000
##      Competence_PE_2b =~
##      Cmptn_PE_2 (x)      1.000
##      Competence_PE_3b =~
##      Cmptn_PE_3 (x)      1.000
##      Competence_PE_4b =~
##      Cmptn_PE_4 (x)      1.000
##      f1b =~
##      Atnmy_PE_1      0.000
##      Atnmy_PE_2      0.000
##      Atnmy_PE_3      0.000
##      Atnmy_PE_4      0.000
##      Rltdn_PE_1      0.000
##      Rltdn_PE_2      0.000
##      Rltdn_PE_3      0.000
##      Cmptn_PE_1      0.000
##      Cmptn_PE_2      0.000
##      Cmptn_PE_3      0.000
##      Cmptn_PE_4      0.000
##      Std.all
##
##      0.538
##      0.720
##      0.633
##      0.871
##
##      0.587
##      0.896
##      0.773

```

```

##
##      0.847
##      0.801
##      0.677
##      0.765
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      f1 ~~
##      f2      0.104   0.021   4.924   0.000   0.366   0.366
##      f3      0.233   0.033   7.057   0.000   0.595   0.595
##      f2 ~~
##      f3      0.199   0.034   5.923   0.000   0.416   0.416
##      f1 ~~
##      f1b     0.000                NaN      NaN
##      f2 ~~
##      f1b     0.000                NaN      NaN
##      f3 ~~
##      f1b     0.000                NaN      NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)  0.570   0.044  13.090   0.000   0.570   0.710
##      .Atnmy_PE_2      0.517   0.047  11.079   0.000   0.517   0.482
##      .Atnmy_PE_3      0.797   0.065  12.352   0.000   0.797   0.599
##      .Atnmy_PE_4 (m)  0.244   0.040   6.091   0.000   0.244   0.242

```

```

##      .Rltdn_PE_1 (n)      0.658      0.052      12.736      0.000      0.658      0.655
##      .Rltdn_PE_2 (o)      0.229      0.057       4.049      0.000      0.229      0.197
##      .Rltdn_PE_3 (p)      0.500      0.056       8.879      0.000      0.500      0.402
##      .Cmptn_PE_1 (r)      0.259      0.029       8.850      0.000      0.259      0.283
##      .Cmptn_PE_2 (s)      0.446      0.043      10.376      0.000      0.446      0.358
##      .Cmptn_PE_3 (t)      0.534      0.043      12.416      0.000      0.534      0.541
##      .Cmptn_PE_4 (u)      0.397      0.035      11.213      0.000      0.397      0.415
##      f1                0.233      0.043       5.383      0.000      1.000      1.000
##      f2                0.346      0.058       5.955      0.000      1.000      1.000
##      f3                0.658      0.066       9.928      0.000      1.000      1.000
##      Atnmy_PE_1         0.000                                NaN      NaN
##      Atnmy_PE_2         0.000                                NaN      NaN
##      Atnmy_PE_3         0.000                                NaN      NaN
##      Atnmy_PE_4         0.000                                NaN      NaN
##      Rltdn_PE_1         0.000                                NaN      NaN
##      Rltdn_PE_2         0.000                                NaN      NaN
##      Rltdn_PE_3         0.000                                NaN      NaN
##      Cmptn_PE_1         0.000                                NaN      NaN
##      Cmptn_PE_2         0.000                                NaN      NaN
##      Cmptn_PE_3         0.000                                NaN      NaN
##      Cmptn_PE_4         0.000                                NaN      NaN
##      flb                0.000                                NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:
##
##      Estimate  Std.Err  z-value  P(>|z|)  Std.lv
##      f1 =~
##      Atn_PE_1      0.000                                0.000
##      Atn_PE_2      0.000                                0.000
##      Atn_PE_3      0.000                                0.000
##      Atn_PE_4      0.000                                0.000
##      f2 =~
##      Rlt_PE_1      0.000                                0.000
##      Rlt_PE_2      0.000                                0.000
##      Rlt_PE_3      0.000                                0.000
##      f3 =~
##      Cmp_PE_1      0.000                                0.000
##      Cmp_PE_2      0.000                                0.000
##      Cmp_PE_3      0.000                                0.000
##      Cmp_PE_4      0.000                                0.000
##      Autonomy_PE_1b =~
##      Atn_PE_1 (sqc)  1.000                                1.515
##      Autonomy_PE_2b =~
##      Atn_PE_2 (sqc)  1.000                                1.375
##      Autonomy_PE_3b =~
##      Atn_PE_3 (sqc)  1.000                                1.539
##      Autonomy_PE_4b =~
##      Atn_PE_4 (sqc)  1.000                                1.490
##      Relatedness_PE_1b =~
##      Rlt_PE_1 (sqc)  1.000                                0.813
##      Relatedness_PE_2b =~
##      Rlt_PE_2 (sqc)  1.000                                0.754
##      Relatedness_PE_3b =~
##      Rlt_PE_3 (sqc)  1.000                                0.235
##      Competence_PE_1b =~
##      Cmp_PE_1 (sqc)  1.000                                0.871
##      Competence_PE_2b =~
##      Cmp_PE_2 (sqc)  1.000                                0.853

```

##	Competence_PE_3b =~					
##	Cmp_PE_3 (sqc)	1.000				0.844
##	Competence_PE_4b =~					
##	Cmp_PE_4 (sqc)	1.000				0.781
##	f1b =~					
##	Atn_PE_1	1.000				0.341
##	Atn_PE_2	2.301	0.552	4.170	0.000	0.865
##	Atn_PE_3	2.693	0.626	4.302	0.000	0.905
##	Atn_PE_4	2.629	0.630	4.175	0.000	0.913
##	Rlt_PE_1	1.000				0.637
##	Rlt_PE_2	0.537	0.318	1.687	0.092	0.369
##	Rlt_PE_3	0.393	0.264	1.488	0.137	0.865
##	Cmp_PE_1	1.000				0.594
##	Cmp_PE_2	1.137	0.401	2.835	0.005	0.690
##	Cmp_PE_3	1.401	0.423	3.311	0.001	0.858
##	Cmp_PE_4	0.739	0.361	2.048	0.041	0.490
##	Std.all					
##						
##	0.000					
##	0.000					
##	0.000					
##	0.000					
##						
##	0.000					
##	0.000					
##	0.000					
##						
##	0.000					
##	0.000					
##	0.000					
##	0.000					
##						
##	0.895					
##						
##	1.000					
##						
##	1.000					
##						
##	0.949					
##						
##	0.708					
##						
##	0.844					
##						
##	0.316					
##						
##	0.863					
##						
##	0.787					
##						
##	0.756					
##						
##	0.778					
##						
##	0.341					
##	0.865					
##	0.905					
##	0.913					
##	0.637					
##	0.369					

```
##      0.865
##      0.594
##      0.690
##      0.858
##      0.490
##
## Covariances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 ~~
## f2      0.000      NaN      NaN
## f3      0.000      NaN      NaN
## f2 ~~
## f3      0.000      NaN      NaN
## f1 ~~
## f1b     0.000      NaN      NaN
## f2 ~~
## f1b     0.000      NaN      NaN
## f3 ~~
## f1b     0.000      NaN      NaN
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## .Atnmy_PE_1 (j)  0.570   0.044  13.090   0.000   0.570   0.199
## .Atnmy_PE_2      0.000      0.000   0.000   0.000   0.000   0.000
## .Atnmy_PE_3      0.000      0.000   0.000   0.000   0.000   0.000
## .Atnmy_PE_4 (m)  0.244   0.040   6.091   0.000   0.244   0.099
## .Rltdn_PE_1 (n)  0.658   0.052  12.736   0.000   0.658   0.499
## .Rltdn_PE_2 (o)  0.229   0.057   4.049   0.000   0.229   0.288
## .Rltdn_PE_3 (p)  0.500   0.056   8.879   0.000   0.500   0.900
## .Cmptn_PE_1 (r)  0.259   0.029   8.850   0.000   0.259   0.255
## .Cmptn_PE_2 (s)  0.446   0.043  10.376   0.000   0.446   0.380
## .Cmptn_PE_3 (t)  0.534   0.043  12.416   0.000   0.534   0.428
## .Cmptn_PE_4 (u)  0.397   0.035  11.213   0.000   0.397   0.394
## f1      0.000      NaN      NaN
## f2      0.000      NaN      NaN
## f3      0.000      NaN      NaN
## Atnmy_PE_1  2.029   0.646   3.140   0.002   0.883   0.883
## Atnmy_PE_2  0.475   0.155   3.061   0.002   0.251   0.251
## Atnmy_PE_3  0.427   0.168   2.543   0.011   0.180   0.180
## Atnmy_PE_4  0.369   0.205   1.799   0.072   0.166   0.166
## Rltdn_PE_1  0.393   0.269   1.462   0.144   0.595   0.595
## Rltdn_PE_2  0.491   0.188   2.617   0.009   0.864   0.864
## Rltdn_PE_3  0.014   0.139   0.100   0.920   0.252   0.252
## Cmptn_PE_1  0.490   0.192   2.555   0.011   0.647   0.647
## Cmptn_PE_2  0.382   0.215   1.774   0.076   0.524   0.524
## Cmptn_PE_3  0.188   0.193   0.972   0.331   0.264   0.264
## Cmptn_PE_4  0.463   0.217   2.130   0.033   0.760   0.760
## flb       0.268   0.132   2.025   0.043   1.000   1.000
```

see Fit indices of Model B in table 2

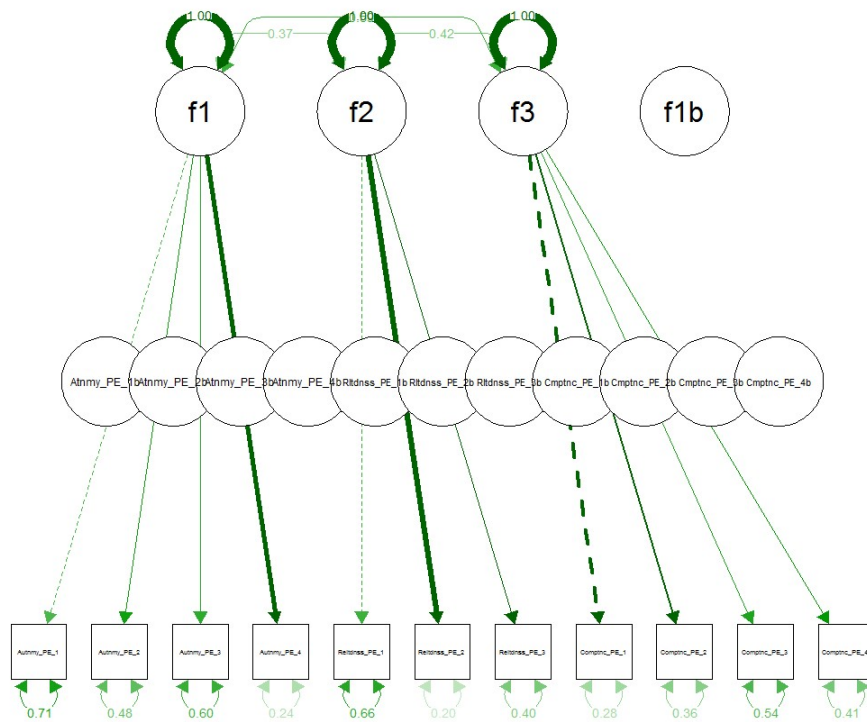
Path diagramm

```
semPlot::semPaths(models$mod_3x1_sep_var_fit,"std",edge.label.cex=0.5, curvePivot = TRUE)
```

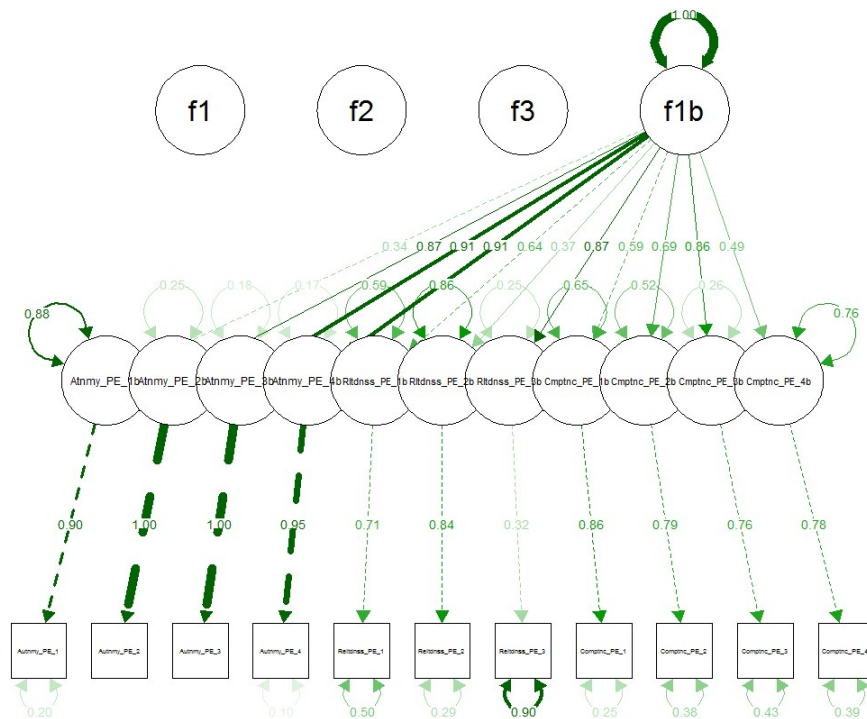
```
## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

```
## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

1



2



3x3-Modell

3 latent overall factors at level 2

```

mod_3x3 <- '
f1 =~ Autonomy_PE_1 + c(a,a)*Autonomy_PE_2 + c(b,b)*Autonomy_PE_3 + c(c,c)*Autonomy_PE_4
f2 =~ Relatedness_PE_1 + c(d,d)*Relatedness_PE_2 + c(e,e)*Relatedness_PE_3
f3 =~ Competence_PE_1 + c(g,g)*Competence_PE_2 + c(h,h)*Competence_PE_3 + c(i,i)*Competence_
PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(k,k)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(l,l)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(v,v)*f1
f2 ~~ c(w,w)*f2
f3 ~~ c(x,x)*f3
f1 ~~ c(y,y)*f2
f1 ~~ c(z,z)*f3
f2 ~~ c(aa,aa)*f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Aut
onomy_PE_4b
f2b =~ c(0,1)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b
f3b =~ c(0,1)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,N
A)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f2b + c(0,NA)*f3b
f2b ~~ c(0,NA)*f2b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f3b
f3b ~~ c(0,NA)*f3b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model
models$mod_3x3_fit <- cfa(mod_3x3, sample.cov = combined.cov, sample.nobs = combined.n, orth
ogonal = T)

```



```
## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative
```

```
# summary
summary(models$mod_3x3_fit, fit.measures = T, standardized = T)
```

```
## lavaan 0.6-3 ended normally after 323 iterations
##
## Optimization method NLMINB
## Number of free parameters 73
## Number of equality constraints 24
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 189.720
## Degrees of freedom 83
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 143.065
## between 46.655
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.947
## Tucker-Lewis Index (TLI) 0.930
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5962.227
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 49
## Akaike (AIC) 12022.453
## Bayesian (BIC) 12221.920
## Sample-size adjusted Bayesian (BIC) 12066.421
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.077
## 90 Percent Confidence Interval 0.063 0.092
## P-value RMSEA <= 0.05 0.001
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.118
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```

##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##
## Latent Variables:
## Estimate Std.Err z-value P(>|z|) Std.lv
## f1 =~
## Atnmy_PE_1 1.000 0.508
## Atnmy_PE_2 (a) 1.533 0.145 10.582 0.000 0.778
## Atnmy_PE_3 (b) 1.543 0.155 9.950 0.000 0.783
## Atnmy_PE_4 (c) 1.791 0.159 11.250 0.000 0.909
## f2 =~
## Rltdn_PE_1 1.000 0.606
## Rltdn_PE_2 (d) 1.624 0.137 11.841 0.000 0.984
## Rltdn_PE_3 (e) 1.389 0.117 11.918 0.000 0.842
## f3 =~
## Cmptn_PE_1 1.000 1.000
## Cmptn_PE_2 (g) 1.006 0.042 23.989 0.000 1.006
## Cmptn_PE_3 (h) 0.757 0.041 18.271 0.000 0.757
## Cmptn_PE_4 (i) 0.836 0.038 21.996 0.000 0.836
## Autonomy_PE_1b =~
## Atnmy_PE_1 (x) 1.000 0.000
## Autonomy_PE_2b =~
## Atnmy_PE_2 (x) 1.000 0.000
## Autonomy_PE_3b =~
## Atnmy_PE_3 (x) 1.000 0.000
## Autonomy_PE_4b =~
## Atnmy_PE_4 (x) 1.000 0.000
## Relatedness_PE_1b =~
## Rltdn_PE_1 (x) 1.000 0.000
## Relatedness_PE_2b =~
## Rltdn_PE_2 (x) 1.000 0.000
## Relatedness_PE_3b =~
## Rltdn_PE_3 (x) 1.000 0.000
## Competence_PE_1b =~
## Cmptn_PE_1 (x) 1.000 0.000
## Competence_PE_2b =~
## Cmptn_PE_2 (x) 1.000 0.000
## Competence_PE_3b =~
## Cmptn_PE_3 (x) 1.000 0.000
## Competence_PE_4b =~
## Cmptn_PE_4 (x) 1.000 0.000
## f1b =~
## Atnmy_PE_1 0.000 NaN
## Atnmy_PE_2 0.000 NaN
## Atnmy_PE_3 0.000 NaN
## Atnmy_PE_4 0.000 NaN
## f2b =~
## Rltdn_PE_1 0.000 NaN
## Rltdn_PE_2 0.000 NaN
## Rltdn_PE_3 0.000 NaN
## f3b =~
## Cmptn_PE_1 0.000 NaN
## Cmptn_PE_2 0.000 NaN

```

##	Cmptn_PE_3		0.000				NaN
##	Cmptn_PE_4		0.000				NaN
##	Std.all						
##							
##	0.558						
##	0.735						
##	0.661						
##	0.876						
##							
##	0.599						
##	0.905						
##	0.760						
##							
##	0.899						
##	0.831						
##	0.717						
##	0.796						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	NaN						
##	NaN						
##	NaN						
##	NaN						
##							
##	NaN						
##	NaN						
##	NaN						
##							
##	NaN						
##	NaN						
##	NaN						
##	NaN						
##							
##	Covariances:						
##		Estimate	Std.Err	z-value	P(> z)	Std.lv	Std.all
##	f1 ~~						
##	f2 (y)	0.122	0.022	5.502	0.000	0.395	0.395
##	f3 (z)	0.326	0.035	9.260	0.000	0.643	0.643
##	f2 ~~						

```

##      f3      (aa)      0.269      0.036      7.481      0.000      0.443      0.443
##      f1 ~~
##      f1b      0.000      NaN      NaN
##      f2 ~~
##      f1b      0.000      NaN      NaN
##      f3 ~~
##      f1b      0.000      NaN      NaN
##      f1b ~~
##      f2b      0.000      NaN      NaN
##      f3b      0.000      NaN      NaN
##      f1 ~~
##      f2b      0.000      NaN      NaN
##      f2 ~~
##      f2b      0.000      NaN      NaN
##      f3 ~~
##      f2b      0.000      NaN      NaN
##      f2b ~~
##      f3b      0.000      NaN      NaN
##      f1 ~~
##      f3b      0.000      NaN      NaN
##      f2 ~~
##      f3b      0.000      NaN      NaN
##      f3 ~~
##      f3b      0.000      NaN      NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)      0.569      0.043      13.088      0.000      0.569      0.688
##      .Atnmy_PE_2 (k)      0.516      0.046      11.204      0.000      0.516      0.460
##      .Atnmy_PE_3 (l)      0.791      0.064      12.287      0.000      0.791      0.563
##      .Atnmy_PE_4 (m)      0.252      0.039      6.499      0.000      0.252      0.233
##      .Rltdn_PE_1 (n)      0.657      0.052      12.701      0.000      0.657      0.641
##      .Rltdn_PE_2 (o)      0.214      0.055      3.911      0.000      0.214      0.181
##      .Rltdn_PE_3 (p)      0.517      0.054      9.617      0.000      0.517      0.422
##      .Cmptn_PE_1 (r)      0.238      0.029      8.076      0.000      0.238      0.192
##      .Cmptn_PE_2 (s)      0.454      0.042      10.744      0.000      0.454      0.310
##      .Cmptn_PE_3 (t)      0.542      0.043      12.591      0.000      0.542      0.486
##      .Cmptn_PE_4 (u)      0.403      0.035      11.545      0.000      0.403      0.366
##      f1      (v)      0.258      0.045      5.744      0.000      1.000      1.000
##      f2      (w)      0.367      0.059      6.221      0.000      1.000      1.000
##      f3      (x)      1.000      1.000      1.000
##      Atnmy_PE_1      0.000      NaN      NaN
##      Atnmy_PE_2      0.000      NaN      NaN
##      Atnmy_PE_3      0.000      NaN      NaN
##      Atnmy_PE_4      0.000      NaN      NaN
##      Rltdn_PE_1      0.000      NaN      NaN
##      Rltdn_PE_2      0.000      NaN      NaN
##      Rltdn_PE_3      0.000      NaN      NaN
##      Cmptn_PE_1      0.000      NaN      NaN
##      Cmptn_PE_2      0.000      NaN      NaN
##      Cmptn_PE_3      0.000      NaN      NaN
##      Cmptn_PE_4      0.000      NaN      NaN
##      f1b      0.000      NaN      NaN
##      f2b      0.000      NaN      NaN
##      f3b      0.000      NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:

```

		Estimate	Std.Err	z-value	P(> z)	Std.lv
##	f1 =~					
##	Atn_PE_1	1.000				0.508
##	Atn_PE_2 (a)	1.533	0.145	10.582	0.000	0.778
##	Atn_PE_3 (b)	1.543	0.155	9.950	0.000	0.783
##	Atn_PE_4 (c)	1.791	0.159	11.250	0.000	0.909
##	f2 =~					
##	Rlt_PE_1	1.000				0.606
##	Rlt_PE_2 (d)	1.624	0.137	11.841	0.000	0.984
##	Rlt_PE_3 (e)	1.389	0.117	11.918	0.000	0.842
##	f3 =~					
##	Cmp_PE_1	1.000				1.000
##	Cmp_PE_2 (g)	1.006	0.042	23.989	0.000	1.006
##	Cmp_PE_3 (h)	0.757	0.041	18.271	0.000	0.757
##	Cmp_PE_4 (i)	0.836	0.038	21.996	0.000	0.836
##	Autonomy_PE_1b =~					
##	Atn_PE_1 (sqc)	1.000				1.652
##	Autonomy_PE_2b =~					
##	Atn_PE_2 (sqc)	1.000				0.889
##	Autonomy_PE_3b =~					
##	Atn_PE_3 (sqc)	1.000				0.880
##	Autonomy_PE_4b =~					
##	Atn_PE_4 (sqc)	1.000				1.217
##	Relatedness_PE_1b =~					
##	Rlt_PE_1 (sqc)	1.000				0.083
##	Relatedness_PE_2b =~					
##	Rlt_PE_2 (sqc)	1.000				NaN
##	Relatedness_PE_3b =~					
##	Rlt_PE_3 (sqc)	1.000				NaN
##	Competence_PE_1b =~					
##	Cmp_PE_1 (sqc)	1.000				0.283
##	Competence_PE_2b =~					
##	Cmp_PE_2 (sqc)	1.000				NaN
##	Competence_PE_3b =~					
##	Cmp_PE_3 (sqc)	1.000				0.495
##	Competence_PE_4b =~					
##	Cmp_PE_4 (sqc)	1.000				0.387
##	f1b =~					
##	Atn_PE_1	1.000				0.808
##	Atn_PE_2	0.741	0.179	4.131	0.000	1.113
##	Atn_PE_3	0.746	0.195	3.826	0.000	1.132
##	Atn_PE_4	0.866	0.207	4.187	0.000	0.950
##	f2b =~					
##	Rlt_PE_1	1.000				NaN
##	Rlt_PE_2	0.754	0.233	3.241	0.001	NaN
##	Rlt_PE_3	0.693	0.227	3.058	0.002	NaN
##	f3b =~					
##	Cmp_PE_1	1.000				NaN
##	Cmp_PE_2	2.606	3.097	0.842	0.400	NaN
##	Cmp_PE_3	33.347	0.444	75.092	0.000	NaN
##	Cmp_PE_4	-2.916	5.371	-0.543	0.587	NaN
##	Std.all					
##						
##	0.269					
##	0.563					
##	0.531					
##	0.568					
##						
##	0.597					
##	0.955					

```

##      0.852
##
##      0.871
##      0.840
##      0.649
##      0.747
##
##      0.876
##
##      0.643
##
##      0.596
##
##      0.761
##
##      0.082
##
##      NaN
##
##      NaN
##
##      0.247
##
##      NaN
##
##      0.425
##
##      0.346
##
##      0.808
##      1.113
##      1.132
##      0.950
##
##      NaN
##      NaN
##      NaN
##
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##           Estimate Std.Err z-value P(>|z|) Std.lv Std.all
## f1 ~~
## f2      (y)    0.122   0.022   5.502   0.000   0.395   0.395
## f3      (z)    0.326   0.035   9.260   0.000   0.643   0.643
## f2 ~~
## f3      (aa)   0.269   0.036   7.481   0.000   0.443   0.443
## f1 ~~
## f1b      0.000              0.000   0.000
## f2 ~~
## f1b      0.000              0.000   0.000
## f3 ~~
## f1b      0.000              0.000   0.000
## f1b ~~
## f2b      0.044   0.258   0.172   0.864   0.139   0.139
## f3b      0.016   0.008   1.944   0.052   0.357   0.357
## f1 ~~

```

```
##      f2b                0.000                0.000      0.000
##      f2 ~~
##      f2b                0.000                0.000      0.000
##      f3 ~~
##      f2b                0.000                0.000      0.000
##      f2b ~~
##      f3b                0.014      0.005      2.705      0.007      1.742      1.742
##      f1 ~~
##      f3b                0.000                0.000      0.000
##      f2 ~~
##      f3b                0.000                0.000      0.000
##      f3 ~~
##      f3b                0.000                0.000      0.000
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)    0.569    0.043   13.088    0.000    0.569    0.160
##      .Atnmy_PE_2 (k)    0.516    0.046   11.204    0.000    0.516    0.270
##      .Atnmy_PE_3 (l)    0.791    0.064   12.287    0.000    0.791    0.363
##      .Atnmy_PE_4 (m)    0.252    0.039    6.499    0.000    0.252    0.098
##      .Rltdn_PE_1 (n)    0.657    0.052   12.701    0.000    0.657    0.637
##      .Rltdn_PE_2 (o)    0.214    0.055    3.911    0.000    0.214    0.202
##      .Rltdn_PE_3 (p)    0.517    0.054    9.617    0.000    0.517    0.529
##      .Cmptn_PE_1 (r)    0.238    0.029    8.076    0.000    0.238    0.181
##      .Cmptn_PE_2 (s)    0.454    0.042   10.744    0.000    0.454    0.317
##      .Cmptn_PE_3 (t)    0.542    0.043   12.591    0.000    0.542    0.398
##      .Cmptn_PE_4 (u)    0.403    0.035   11.545    0.000    0.403    0.322
##      f1      (v)    0.258    0.045    5.744    0.000    1.000    1.000
##      f2      (w)    0.367    0.059    6.221    0.000    1.000    1.000
##      f3      (x)    1.000                1.000    1.000
##      Atnmy_PE_1      0.948    0.461    2.054    0.040    0.347    0.347
##      Atnmy_PE_2     -0.189    0.131   -1.445    0.149   -0.239   -0.239
##      Atnmy_PE_3     -0.217    0.186   -1.168    0.243   -0.280   -0.280
##      Atnmy_PE_4      0.144    0.162    0.887    0.375    0.097    0.097
##      Rltdn_PE_1      0.064    0.215    0.296    0.767    9.281    9.281
##      Rltdn_PE_2     -0.088    0.109   -0.810    0.418      NaN      NaN
##      Rltdn_PE_3     -0.222    0.114   -1.941    0.052      NaN      NaN
##      Cmptn_PE_1      0.081    0.133    0.610    0.542    1.015    1.015
##      Cmptn_PE_2     -0.026    0.160   -0.160    0.873      NaN      NaN
##      Cmptn_PE_3      1.557    2.547    0.611    0.541    6.347    6.347
##      Cmptn_PE_4      0.160    0.176    0.911    0.363    1.067    1.067
##      f1b            1.782    0.840    2.121    0.034    1.000    1.000
##      f2b           -0.057    0.243   -0.234    0.815      NaN      NaN
##      f3b           -0.001    0.002   -0.521    0.602      NaN      NaN
```

Path diagramm

```
semPlot::semPaths(models$mod_3x3_fit,"std",edge.label.cex=0.5, curvePivot = TRUE)
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

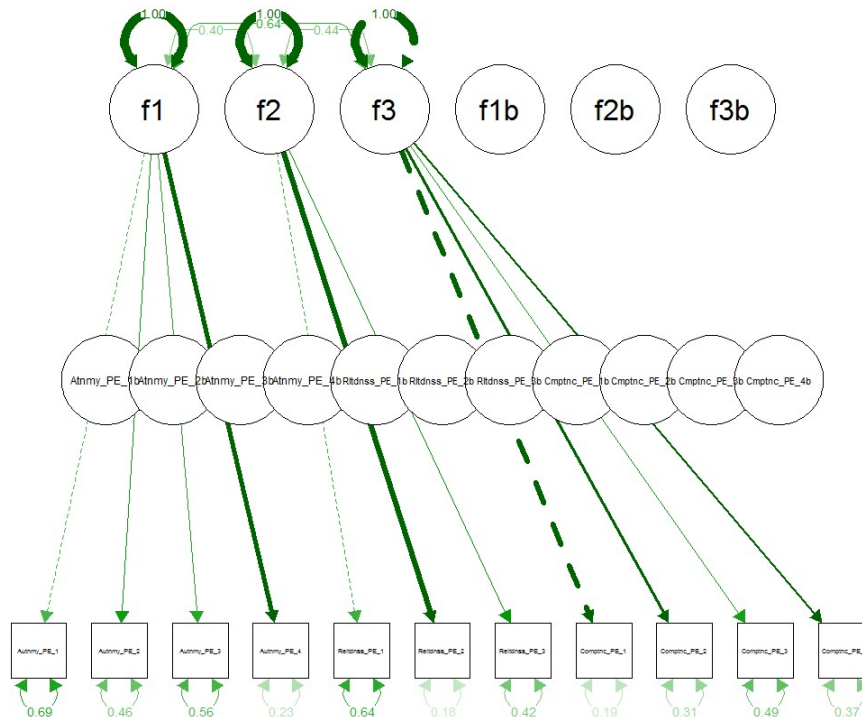
```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```



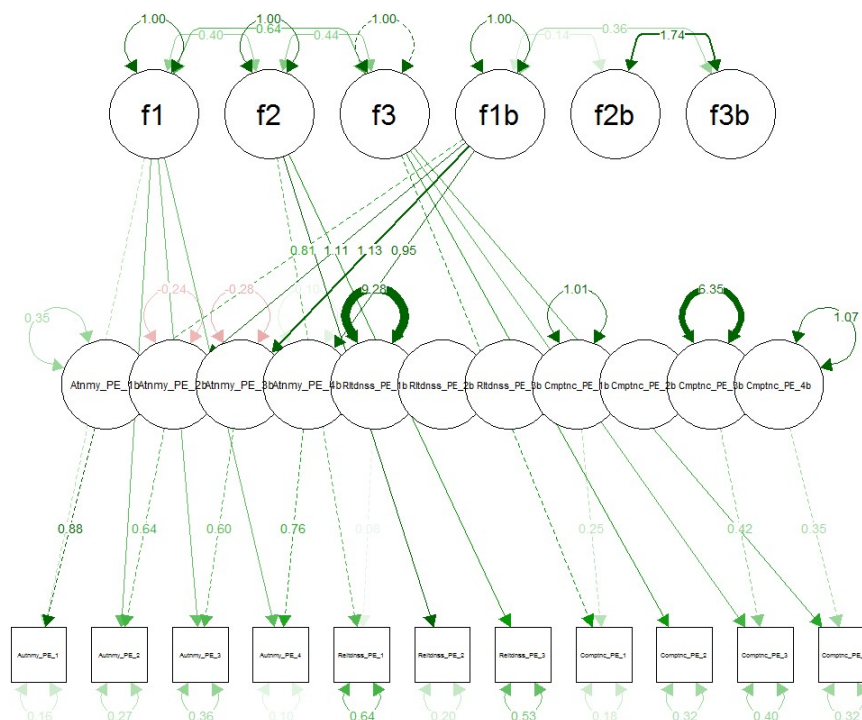
```
## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted

## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

1



2



3x3, Variances set to 0 where necessary at A2, A3, R2, R3

Huang & Cornell, 2016: The presence of small negative residual variance estimates at the school level required residual variances to be fixed to zero for five items (see Table 1). Fixing residual variances at the group level to zero is often done in MCFA and is recommended to allow the model to converge...

```
mod_3x3_var <- '
f1 =~ Autonomy_PE_1 + c(a,a)*Autonomy_PE_2 + c(b,b)*Autonomy_PE_3 + c(c,c)*Autonomy_PE_4
f2 =~ Relatedness_PE_1 + c(d,d)*Relatedness_PE_2 + c(e,e)*Relatedness_PE_3
f3 =~ Competence_PE_1 + c(g,g)*Competence_PE_2 + c(h,h)*Competence_PE_3 + c(i,i)*Competence_
PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(NA,0)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(NA,0)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(NA,0)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(NA,0)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(NA,0)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(v,v)*f1
f2 ~~ c(w,w)*f2
f3 ~~ c(x,x)*f3
f1 ~~ c(y,y)*f2
f1 ~~ c(z,z)*f3
f2 ~~ c(aa,aa)*f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Aut
onomy_PE_4b
f2b =~ c(0,1)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b
f3b =~ c(0,1)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,N
A)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f2b + c(0,NA)*f3b
f2b ~~ c(0,NA)*f2b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f3b
f3b ~~ c(0,NA)*f3b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
,
# fit hypothesized model
models$mod_3x3_var_fit <- cfa(mod_3x3_var, sample.cov = combined.cov, sample.nobs = combine
d.n, orthogonal = T)
```

```
## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative
```

```
summary(models$mod_3x3_var_fit, fit.measures = T, standardized = T)
```

```
## lavaan 0.6-3 ended normally after 312 iterations
##
## Optimization method              NLMINB
## Number of free parameters        68
## Number of equality constraints    19
##
## Number of observations per group
##   within                        400
##   between                       33
##
## Estimator                        ML
## Model Fit Test Statistic         189.720
## Degrees of freedom               83
## P-value (Chi-square)             0.000
##
## Chi-square for each group:
##
##   within                        143.065
##   between                       46.655
##
## Model test baseline model:
##
## Minimum Function Test Statistic  2130.224
## Degrees of freedom               110
## P-value                          0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI)      0.947
## Tucker-Lewis Index (TLI)         0.930
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0)     -5962.227
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters         49
## Akaike (AIC)                     12022.453
## Bayesian (BIC)                   12221.920
## Sample-size adjusted Bayesian (BIC) 12066.421
##
## Root Mean Square Error of Approximation:
##
## RMSEA                            0.077
## 90 Percent Confidence Interval    0.063 0.092
## P-value RMSEA <= 0.05            0.001
##
## Standardized Root Mean Square Residual:
##
## SRMR                              0.118
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```

##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##
## Latent Variables:
## Estimate Std.Err z-value P(>|z|) Std.lv
## f1 =~
## Atnmy_PE_1 1.000 0.508
## Atnmy_PE_2 (a) 1.533 0.145 10.582 0.000 0.778
## Atnmy_PE_3 (b) 1.543 0.155 9.950 0.000 0.783
## Atnmy_PE_4 (c) 1.791 0.159 11.250 0.000 0.909
## f2 =~
## Rltdn_PE_1 1.000 0.606
## Rltdn_PE_2 (d) 1.624 0.137 11.841 0.000 0.984
## Rltdn_PE_3 (e) 1.389 0.117 11.918 0.000 0.842
## f3 =~
## Cmptn_PE_1 1.000 1.000
## Cmptn_PE_2 (g) 1.006 0.042 23.989 0.000 1.006
## Cmptn_PE_3 (h) 0.757 0.041 18.271 0.000 0.757
## Cmptn_PE_4 (i) 0.836 0.038 21.996 0.000 0.836
## Autonomy_PE_1b =~
## Atnmy_PE_1 (x) 1.000 0.000
## Autonomy_PE_2b =~
## Atnmy_PE_2 (x) 1.000 0.000
## Autonomy_PE_3b =~
## Atnmy_PE_3 (x) 1.000 0.000
## Autonomy_PE_4b =~
## Atnmy_PE_4 (x) 1.000 0.000
## Relatedness_PE_1b =~
## Rltdn_PE_1 (x) 1.000 0.000
## Relatedness_PE_2b =~
## Rltdn_PE_2 (x) 1.000 0.000
## Relatedness_PE_3b =~
## Rltdn_PE_3 (x) 1.000 0.000
## Competence_PE_1b =~
## Cmptn_PE_1 (x) 1.000 0.000
## Competence_PE_2b =~
## Cmptn_PE_2 (x) 1.000 0.000
## Competence_PE_3b =~
## Cmptn_PE_3 (x) 1.000 0.000
## Competence_PE_4b =~
## Cmptn_PE_4 (x) 1.000 0.000
## f1b =~
## Atnmy_PE_1 0.000 NaN
## Atnmy_PE_2 0.000 NaN
## Atnmy_PE_3 0.000 NaN
## Atnmy_PE_4 0.000 NaN
## f2b =~
## Rltdn_PE_1 0.000 NaN
## Rltdn_PE_2 0.000 NaN
## Rltdn_PE_3 0.000 NaN
## f3b =~
## Cmptn_PE_1 0.000 NaN
## Cmptn_PE_2 0.000 NaN

```

##	Cmptn_PE_3		0.000			NaN	
##	Cmptn_PE_4		0.000			NaN	
##	Std.all						
##							
##	0.558						
##	0.735						
##	0.661						
##	0.876						
##							
##	0.599						
##	0.905						
##	0.760						
##							
##	0.899						
##	0.831						
##	0.717						
##	0.796						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
##							
##	0.000						
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##	NaN						
##	NaN						
##	NaN						
##							
##	NaN						
##	NaN						
##	NaN						
##	NaN						
##							
##	Covariances:						
##		Estimate	Std.Err	z-value	P(> z)	Std.lv	Std.all
##	f1 ~~						
##	f2 (y)	0.122	0.022	5.502	0.000	0.395	0.395
##	f3 (z)	0.326	0.035	9.260	0.000	0.643	0.643
##	f2 ~~						

```

##      f3      (aa)      0.269      0.036      7.481      0.000      0.443      0.443
##      f1 ~~
##      f1b      0.000      NaN      NaN
##      f2 ~~
##      f1b      0.000      NaN      NaN
##      f3 ~~
##      f1b      0.000      NaN      NaN
##      f1b ~~
##      f2b      0.000      NaN      NaN
##      f3b      0.000      NaN      NaN
##      f1 ~~
##      f2b      0.000      NaN      NaN
##      f2 ~~
##      f2b      0.000      NaN      NaN
##      f3 ~~
##      f2b      0.000      NaN      NaN
##      f2b ~~
##      f3b      0.000      NaN      NaN
##      f1 ~~
##      f3b      0.000      NaN      NaN
##      f2 ~~
##      f3b      0.000      NaN      NaN
##      f3 ~~
##      f3b      0.000      NaN      NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)      0.569      0.043      13.088      0.000      0.569      0.688
##      .Atnmy_PE_2      0.516      0.046      11.204      0.000      0.516      0.460
##      .Atnmy_PE_3      0.791      0.064      12.287      0.000      0.791      0.563
##      .Atnmy_PE_4 (m)      0.252      0.039      6.499      0.000      0.252      0.233
##      .Rltdn_PE_1 (n)      0.657      0.052      12.701      0.000      0.657      0.641
##      .Rltdn_PE_2      0.214      0.055      3.911      0.000      0.214      0.181
##      .Rltdn_PE_3      0.517      0.054      9.617      0.000      0.517      0.422
##      .Cmptn_PE_1 (r)      0.238      0.029      8.076      0.000      0.238      0.192
##      .Cmptn_PE_2      0.454      0.042      10.744      0.000      0.454      0.310
##      .Cmptn_PE_3 (t)      0.542      0.043      12.591      0.000      0.542      0.486
##      .Cmptn_PE_4 (u)      0.403      0.035      11.545      0.000      0.403      0.366
##      f1      (v)      0.258      0.045      5.744      0.000      1.000      1.000
##      f2      (w)      0.367      0.059      6.221      0.000      1.000      1.000
##      f3      (x)      1.000      1.000      1.000
##      Atnmy_PE_1      0.000      NaN      NaN
##      Atnmy_PE_2      0.000      NaN      NaN
##      Atnmy_PE_3      0.000      NaN      NaN
##      Atnmy_PE_4      0.000      NaN      NaN
##      Rltdn_PE_1      0.000      NaN      NaN
##      Rltdn_PE_2      0.000      NaN      NaN
##      Rltdn_PE_3      0.000      NaN      NaN
##      Cmptn_PE_1      0.000      NaN      NaN
##      Cmptn_PE_2      0.000      NaN      NaN
##      Cmptn_PE_3      0.000      NaN      NaN
##      Cmptn_PE_4      0.000      NaN      NaN
##      f1b      0.000      NaN      NaN
##      f2b      0.000      NaN      NaN
##      f3b      0.000      NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:

```

##		Estimate	Std.Err	z-value	P(> z)	Std.lv
##	f1 =~					
##	Atn_PE_1	1.000				0.508
##	Atn_PE_2 (a)	1.533	0.145	10.582	0.000	0.778
##	Atn_PE_3 (b)	1.543	0.155	9.950	0.000	0.783
##	Atn_PE_4 (c)	1.791	0.159	11.250	0.000	0.909
##	f2 =~					
##	Rlt_PE_1	1.000				0.606
##	Rlt_PE_2 (d)	1.624	0.137	11.841	0.000	0.984
##	Rlt_PE_3 (e)	1.389	0.117	11.918	0.000	0.842
##	f3 =~					
##	Cmp_PE_1	1.000				1.000
##	Cmp_PE_2 (g)	1.006	0.042	23.989	0.000	1.006
##	Cmp_PE_3 (h)	0.757	0.041	18.271	0.000	0.757
##	Cmp_PE_4 (i)	0.836	0.038	21.996	0.000	0.836
##	Autonomy_PE_1b =~					
##	Atn_PE_1 (sqc)	1.000				1.652
##	Autonomy_PE_2b =~					
##	Atn_PE_2 (sqc)	1.000				1.143
##	Autonomy_PE_3b =~					
##	Atn_PE_3 (sqc)	1.000				1.251
##	Autonomy_PE_4b =~					
##	Atn_PE_4 (sqc)	1.000				1.217
##	Relatedness_PE_1b =~					
##	Rlt_PE_1 (sqc)	1.000				0.083
##	Relatedness_PE_2b =~					
##	Rlt_PE_2 (sqc)	1.000				0.306
##	Relatedness_PE_3b =~					
##	Rlt_PE_3 (sqc)	1.000				0.518
##	Competence_PE_1b =~					
##	Cmp_PE_1 (sqc)	1.000				0.283
##	Competence_PE_2b =~					
##	Cmp_PE_2 (sqc)	1.000				0.649
##	Competence_PE_3b =~					
##	Cmp_PE_3 (sqc)	1.000				0.495
##	Competence_PE_4b =~					
##	Cmp_PE_4 (sqc)	1.000				0.387
##	f1b =~					
##	Atn_PE_1	1.000				0.808
##	Atn_PE_2	0.741	0.179	4.131	0.000	0.866
##	Atn_PE_3	0.746	0.195	3.826	0.000	0.796
##	Atn_PE_4	0.866	0.207	4.187	0.000	0.950
##	f2b =~					
##	Rlt_PE_1	1.000				NaN
##	Rlt_PE_2	0.754	0.233	3.241	0.001	NaN
##	Rlt_PE_3	0.693	0.227	3.058	0.002	NaN
##	f3b =~					
##	Cmp_PE_1	1.000				NaN
##	Cmp_PE_2	2.606	3.096	0.842	0.400	NaN
##	Cmp_PE_3	33.345	0.444	75.085	0.000	NaN
##	Cmp_PE_4	-2.916	5.371	-0.543	0.587	NaN
##	Std.all					
##						
##	0.269					
##	0.563					
##	0.531					
##	0.568					
##						
##	0.597					
##	0.955					


```

##      0.852
##
##      0.871
##      0.840
##      0.649
##      0.747
##
##      0.876
##
##      0.827
##
##      0.848
##
##      0.761
##
##      0.082
##
##      0.297
##
##      0.524
##
##      0.247
##
##      0.542
##
##      0.425
##
##      0.346
##
##      0.808
##      0.866
##      0.796
##      0.950
##
##      NaN
##      NaN
##      NaN
##
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      f1 ~~
##      f2      (y)    0.122   0.022   5.502   0.000   0.395   0.395
##      f3      (z)    0.326   0.035   9.260   0.000   0.643   0.643
##      f2 ~~
##      f3      (aa)   0.269   0.036   7.481   0.000   0.443   0.443
##      f1 ~~
##      f1b      0.000      0.000   0.000   0.000   0.000   0.000
##      f2 ~~
##      f1b      0.000      0.000   0.000   0.000   0.000   0.000
##      f3 ~~
##      f1b      0.000      0.000   0.000   0.000   0.000   0.000
##      f1b ~~
##      f2b      0.044   0.258   0.172   0.864   0.139   0.139
##      f3b      0.016   0.008   1.944   0.052   0.357   0.357
##      f1 ~~

```

```
##      f2b                0.000                0.000  0.000
##      f2 ~~
##      f2b                0.000                0.000  0.000
##      f3 ~~
##      f2b                0.000                0.000  0.000
##      f2b ~~
##      f3b                0.014      0.005      2.705      0.007      1.742      1.742
##      f1 ~~
##      f3b                0.000                0.000  0.000
##      f2 ~~
##      f3b                0.000                0.000  0.000
##      f3 ~~
##      f3b                0.000                0.000  0.000
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)      0.569      0.043     13.088      0.000      0.569      0.160
##      .Atnmy_PE_2          0.000                0.000  0.000
##      .Atnmy_PE_3          0.000                0.000  0.000
##      .Atnmy_PE_4 (m)      0.252      0.039      6.499      0.000      0.252      0.098
##      .Rltdn_PE_1 (n)      0.657      0.052     12.701      0.000      0.657      0.637
##      .Rltdn_PE_2          0.000                0.000  0.000
##      .Rltdn_PE_3          0.000                0.000  0.000
##      .Cmptn_PE_1 (r)      0.238      0.029      8.076      0.000      0.238      0.181
##      .Cmptn_PE_2          0.000                0.000  0.000
##      .Cmptn_PE_3 (t)      0.542      0.043     12.591      0.000      0.542      0.398
##      .Cmptn_PE_4 (u)      0.403      0.035     11.545      0.000      0.403      0.322
##      f1      (v)      0.258      0.045      5.744      0.000      1.000      1.000
##      f2      (w)      0.367      0.059      6.221      0.000      1.000      1.000
##      f3      (x)      1.000                1.000  1.000
##      Atnmy_PE_1          0.948      0.461      2.054      0.040      0.347      0.347
##      Atnmy_PE_2          0.328      0.123      2.665      0.008      0.251      0.251
##      Atnmy_PE_3          0.574      0.175      3.278      0.001      0.366      0.366
##      Atnmy_PE_4          0.144      0.162      0.887      0.375      0.097      0.097
##      Rltdn_PE_1          0.064      0.215      0.296      0.767      9.278      9.278
##      Rltdn_PE_2          0.126      0.109      1.160      0.246      1.345      1.345
##      Rltdn_PE_3          0.295      0.108      2.744      0.006      1.102      1.102
##      Cmptn_PE_1          0.081      0.133      0.610      0.542      1.015      1.015
##      Cmptn_PE_2          0.429      0.155      2.758      0.006      1.019      1.019
##      Cmptn_PE_3          1.557      2.547      0.611      0.541      6.347      6.347
##      Cmptn_PE_4          0.160      0.176      0.911      0.363      1.067      1.067
##      f1b                1.782      0.840      2.121      0.034      1.000      1.000
##      f2b               -0.057      0.243     -0.234      0.815      NaN      NaN
##      f3b               -0.001      0.002     -0.521      0.602      NaN      NaN
```

Path diagramm

```
semPlot::semPaths(models$mod_3x3_var_fit,"std",edge.label.cex=0.5, curvePivot = TRUE)
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

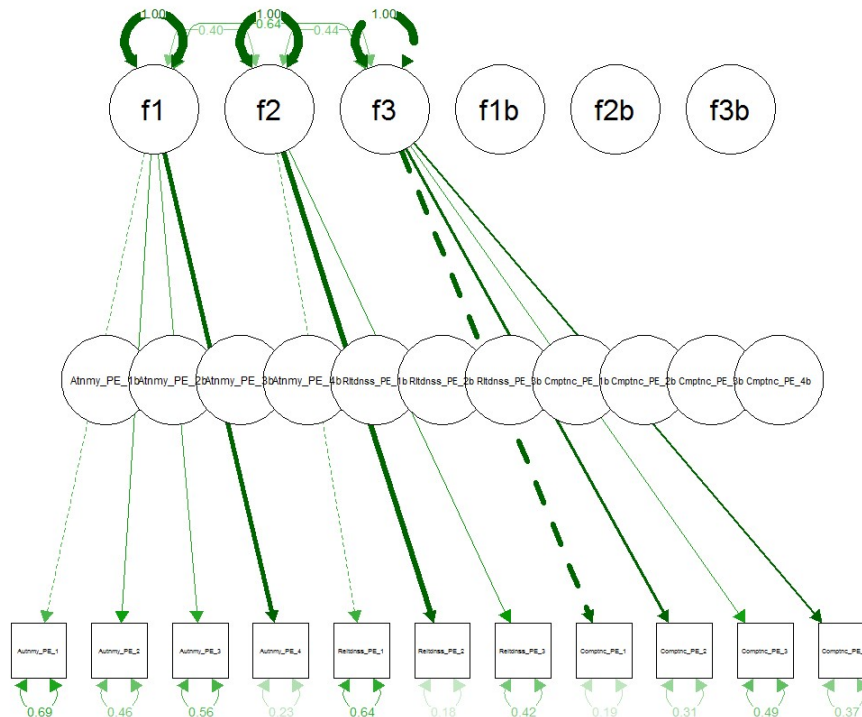
```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

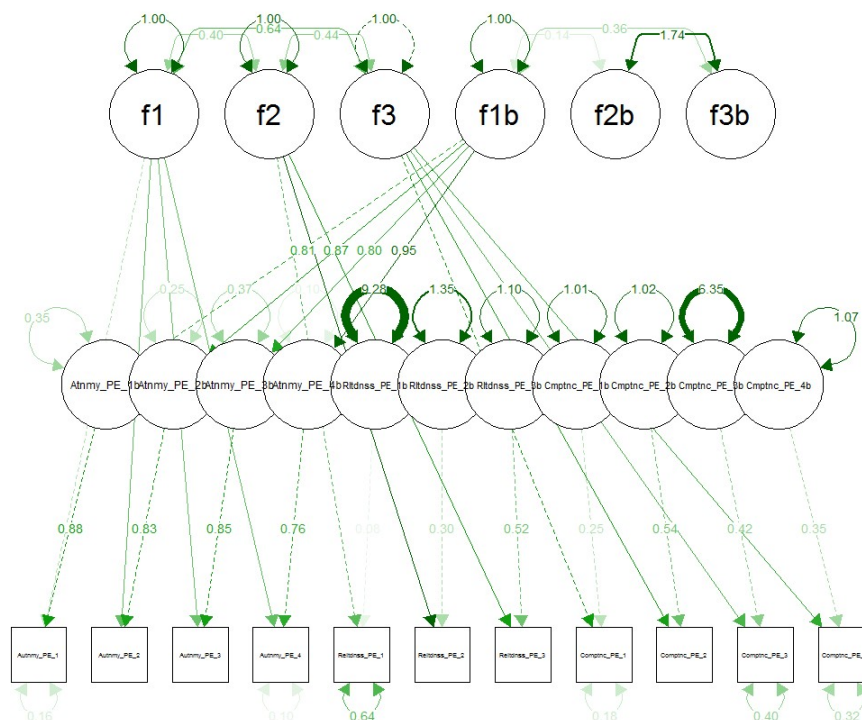
```
## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted

## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

1



2



3x3, freely estimated loadings, variances and covariances

model probably not identifiable

3x3, freely estimated loadings and latent factor variances and covariances, manifest variances set equal

```

mod_3x3_free_vareq <- '
f1 =~ Autonomy_PE_1 + Autonomy_PE_2 + Autonomy_PE_3 + Autonomy_PE_4
f2 =~ Relatedness_PE_1 + Relatedness_PE_2 + Relatedness_PE_3
f3 =~ Competence_PE_1 + Competence_PE_2 + Competence_PE_3 + Competence_PE_4
Autonomy_PE_1 ~~ c(a,a)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(b,b)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(c,c)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(d,d)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(e,e)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(f,f)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(g,g)*Relatedness_PE_3
Competence_PE_1 ~~ c(i,i)*Competence_PE_1
Competence_PE_2 ~~ c(j,j)*Competence_PE_2
Competence_PE_3 ~~ c(k,k)*Competence_PE_3
Competence_PE_4 ~~ c(l,l)*Competence_PE_4
f1 ~~ f1
f2 ~~ f2
f3 ~~ f3
f1 ~~ f2
f1 ~~ f3
f2 ~~ f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b
f2b =~ c(0,1)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b
f3b =~ c(0,1)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f2b + c(0,NA)*f3b
f2b ~~ c(0,NA)*f2b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f3b
f3b ~~ c(0,NA)*f3b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model

models$mod_3x3_free_vareq_fit <- cfa(mod_3x3_free_vareq, sample.cov = combined.cov, sample.n
obs = combined.n, orthogonal = T)

```

```

## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative

```

```
summary(models$mod_3x3_free_vareq_fit, fit.measures = T, standardized = T)
```

```
## lavaan 0.6-3 ended normally after 477 iterations
##
## Optimization method          NLMINB
## Number of free parameters      75
## Number of equality constraints  11
##
## Number of observations per group
## within                        400
## between                       33
##
## Estimator                      ML
## Model Fit Test Statistic      146.746
## Degrees of freedom            68
## P-value (Chi-square)          0.000
##
## Chi-square for each group:
##
## within                        124.159
## between                       22.587
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom             110
## P-value                        0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI)      0.961
## Tucker-Lewis Index (TLI)        0.937
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0)    -5940.740
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters        64
## Akaike (AIC)                    12009.480
## Bayesian (BIC)                   12270.007
## Sample-size adjusted Bayesian (BIC) 12066.907
##
## Root Mean Square Error of Approximation:
##
## RMSEA                          0.073
## 90 Percent Confidence Interval    0.057  0.089
## P-value RMSEA <= 0.05            0.011
##
## Standardized Root Mean Square Residual:
##
## SRMR                           0.056
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```

##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##
## Latent Variables:
## Estimate Std.Err z-value P(>|z|) Std.lv
## f1 =~
## Atnmy_PE_1 1.000 0.482
## Atnmy_PE_2 1.545 0.157 9.842 0.000 0.745
## Atnmy_PE_3 1.514 0.165 9.155 0.000 0.730
## Atnmy_PE_4 1.815 0.174 10.446 0.000 0.876
## f2 =~
## Rltdn_PE_1 1.000 0.589
## Rltdn_PE_2 1.642 0.148 11.120 0.000 0.966
## Rltdn_PE_3 1.466 0.130 11.258 0.000 0.863
## f3 =~
## Cmptn_PE_1 1.000 0.811
## Cmptn_PE_2 1.102 0.063 17.612 0.000 0.894
## Cmptn_PE_3 0.829 0.058 14.299 0.000 0.672
## Cmptn_PE_4 0.922 0.055 16.662 0.000 0.748
## Autonomy_PE_1b =~
## Atnmy_PE_1 (x) 1.000 0.000
## Autonomy_PE_2b =~
## Atnmy_PE_2 (x) 1.000 0.000
## Autonomy_PE_3b =~
## Atnmy_PE_3 (x) 1.000 0.000
## Autonomy_PE_4b =~
## Atnmy_PE_4 (x) 1.000 0.000
## Relatedness_PE_1b =~
## Rltdn_PE_1 (x) 1.000 0.000
## Relatedness_PE_2b =~
## Rltdn_PE_2 (x) 1.000 0.000
## Relatedness_PE_3b =~
## Rltdn_PE_3 (x) 1.000 0.000
## Competence_PE_1b =~
## Cmptn_PE_1 (x) 1.000 0.000
## Competence_PE_2b =~
## Cmptn_PE_2 (x) 1.000 0.000
## Competence_PE_3b =~
## Cmptn_PE_3 (x) 1.000 0.000
## Competence_PE_4b =~
## Cmptn_PE_4 (x) 1.000 0.000
## f1b =~
## Atnmy_PE_1 0.000 NaN
## Atnmy_PE_2 0.000 NaN
## Atnmy_PE_3 0.000 NaN
## Atnmy_PE_4 0.000 NaN
## f2b =~
## Rltdn_PE_1 0.000 NaN
## Rltdn_PE_2 0.000 NaN
## Rltdn_PE_3 0.000 NaN
## f3b =~
## Cmptn_PE_1 0.000 NaN
## Cmptn_PE_2 0.000 NaN

```

##	Cmptn_PE_3	0.000				NaN
##	Cmptn_PE_4	0.000				NaN
##	Std.all					
##						
##	0.538					
##	0.720					
##	0.633					
##	0.871					
##						
##	0.587					
##	0.896					
##	0.773					
##						
##	0.847					
##	0.801					
##	0.677					
##	0.765					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##						
##	NaN					
##	NaN					
##	NaN					
##						
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##						
##	Covariances:					
##		Estimate	Std.Err	z-value	P(> z)	Std.lv Std.all
##	f1 ~~					
##	f2	0.104	0.021	4.924	0.000	0.366 0.366
##	f3	0.233	0.033	7.057	0.000	0.595 0.595
##	f2 ~~					


```

##      f3              0.199      0.034      5.923      0.000      0.416      0.416
##      f1 ~~
##      f1b            0.000
##      f2 ~~
##      f1b            0.000
##      f3 ~~
##      f1b            0.000
##      f1b ~~
##      f2b            0.000
##      f3b            0.000
##      f1 ~~
##      f2b            0.000
##      f2 ~~
##      f2b            0.000
##      f3 ~~
##      f2b            0.000
##      f2b ~~
##      f3b            0.000
##      f1 ~~
##      f3b            0.000
##      f2 ~~
##      f3b            0.000
##      f3 ~~
##      f3b            0.000
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (a)  0.570   0.044  13.090   0.000   0.570   0.710
##      .Atnmy_PE_2 (b)  0.517   0.047  11.079   0.000   0.517   0.482
##      .Atnmy_PE_3 (c)  0.797   0.065  12.352   0.000   0.797   0.599
##      .Atnmy_PE_4 (d)  0.244   0.040   6.091   0.000   0.244   0.242
##      .Rltdn_PE_1 (e)  0.658   0.052  12.736   0.000   0.658   0.655
##      .Rltdn_PE_2 (f)  0.229   0.057   4.049   0.000   0.229   0.197
##      .Rltdn_PE_3 (g)  0.500   0.056   8.879   0.000   0.500   0.402
##      .Cmptn_PE_1 (i)  0.259   0.029   8.850   0.000   0.259   0.283
##      .Cmptn_PE_2 (j)  0.446   0.043  10.376   0.000   0.446   0.358
##      .Cmptn_PE_3 (k)  0.534   0.043  12.416   0.000   0.534   0.541
##      .Cmptn_PE_4 (l)  0.397   0.035  11.213   0.000   0.397   0.415
##      f1            0.233   0.043   5.383   0.000   1.000   1.000
##      f2            0.346   0.058   5.955   0.000   1.000   1.000
##      f3            0.658   0.066   9.928   0.000   1.000   1.000
##      Atnmy_PE_1    0.000
##      Atnmy_PE_2    0.000
##      Atnmy_PE_3    0.000
##      Atnmy_PE_4    0.000
##      Rltdn_PE_1    0.000
##      Rltdn_PE_2    0.000
##      Rltdn_PE_3    0.000
##      Cmptn_PE_1    0.000
##      Cmptn_PE_2    0.000
##      Cmptn_PE_3    0.000
##      Cmptn_PE_4    0.000
##      f1b           0.000
##      f2b           0.000
##      f3b           0.000
##
##
## Group 2 [between]:
##
## Latent Variables:

```

	Estimate	Std.Err	z-value	P(> z)	Std.lv
##					
##	f1 =~				
##	Atn_PE_1	1.000			NaN
##	Atn_PE_2	-0.632	2.071	-0.305	0.760
##	Atn_PE_3	-1.746	3.830	-0.456	0.648
##	Atn_PE_4	-0.230	1.691	-0.136	0.892
##	f2 =~				
##	Rlt_PE_1	1.000			0.393
##	Rlt_PE_2	1.899	1.161	1.635	0.102
##	Rlt_PE_3	1.020	0.629	1.623	0.105
##	f3 =~				
##	Cmp_PE_1	1.000			0.832
##	Cmp_PE_2	1.119	0.266	4.208	0.000
##	Cmp_PE_3	1.032	0.485	2.128	0.033
##	Cmp_PE_4	0.791	0.249	3.179	0.001
##	Autonomy_PE_1b =~				
##	Atn_PE_1 (sqc)	1.000			1.777
##	Autonomy_PE_2b =~				
##	Atn_PE_2 (sqc)	1.000			1.178
##	Autonomy_PE_3b =~				
##	Atn_PE_3 (sqc)	1.000			1.320
##	Autonomy_PE_4b =~				
##	Atn_PE_4 (sqc)	1.000			1.489
##	Relatedness_PE_1b =~				
##	Rlt_PE_1 (sqc)	1.000			0.571
##	Relatedness_PE_2b =~				
##	Rlt_PE_2 (sqc)	1.000			0.203
##	Relatedness_PE_3b =~				
##	Rlt_PE_3 (sqc)	1.000			NaN
##	Competence_PE_1b =~				
##	Cmp_PE_1 (sqc)	1.000			NaN
##	Competence_PE_2b =~				
##	Cmp_PE_2 (sqc)	1.000			NaN
##	Competence_PE_3b =~				
##	Cmp_PE_3 (sqc)	1.000			NaN
##	Competence_PE_4b =~				
##	Cmp_PE_4 (sqc)	1.000			0.413
##	f1b =~				
##	Atn_PE_1	1.000			0.779
##	Atn_PE_2	0.908	0.207	4.396	0.000
##	Atn_PE_3	0.964	0.266	3.630	0.000
##	Atn_PE_4	1.042	0.222	4.684	0.000
##	f2b =~				
##	Rlt_PE_1	1.000			1.144
##	Rlt_PE_2	0.737	0.241	3.059	0.002
##	Rlt_PE_3	0.470	0.185	2.541	0.011
##	f3b =~				
##	Cmp_PE_1	1.000			NaN
##	Cmp_PE_2	1.340	0.446	3.003	0.003
##	Cmp_PE_3	3.239	2.375	1.364	0.173
##	Cmp_PE_4	0.376	0.549	0.685	0.493
##	Std.all				
##					
##	NaN				
##	NaN				
##	NaN				
##	NaN				
##					
##	0.368				
##	0.820				

```

##      0.533
##
##      0.866
##      0.868
##      0.786
##      0.658
##
##      0.929
##
##      0.860
##
##      0.866
##
##      0.950
##
##      0.535
##
##      0.224
##
##      NaN
##
##      NaN
##
##      NaN
##
##      NaN
##
##      0.413
##
##      0.779
##      1.068
##      1.011
##      0.969
##
##      1.144
##      2.366
##      NaN
##
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##      Estimate   Std.Err   z-value   P(>|z|)   Std.lv   Std.all
##      f1 ~~
##      f2      -0.103    0.181    -0.571    0.568    -0.994    -0.994
##      f3      -0.148    0.241    -0.613    0.540    -0.669    -0.669
##      f2 ~~
##      f3      0.015    0.111     0.139    0.889     0.047     0.047
##      f1 ~~
##      f1b      0.000                0.000     0.000
##      f2 ~~
##      f1b      0.000                0.000     0.000
##      f3 ~~
##      f1b      0.000                0.000     0.000
##      f1b ~~
##      f2b      0.207    0.339     0.612    0.541     0.229     0.229
##      f3b      0.222    0.229     0.970    0.332     0.570     0.570
##      f1 ~~

```

```
##      f2b          0.000          0.000  0.000
##      f2 ~~
##      f2b          0.000          0.000  0.000
##      f3 ~~
##      f2b          0.000          0.000  0.000
##      f2b ~~
##      f3b          0.207    0.192    1.078    0.281    1.128    1.128
##      f1 ~~
##      f3b          0.000          0.000  0.000
##      f2 ~~
##      f3b          0.000          0.000  0.000
##      f3 ~~
##      f3b          0.000          0.000  0.000
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (a)    0.570    0.044   13.090    0.000    0.570    0.156
##      .Atnmy_PE_2 (b)    0.517    0.047   11.079    0.000    0.517    0.275
##      .Atnmy_PE_3 (c)    0.797    0.065   12.352    0.000    0.797    0.343
##      .Atnmy_PE_4 (d)    0.244    0.040    6.091    0.000    0.244    0.099
##      .Rltdn_PE_1 (e)    0.658    0.052   12.736    0.000    0.658    0.578
##      .Rltdn_PE_2 (f)    0.229    0.057    4.049    0.000    0.229    0.277
##      .Rltdn_PE_3 (g)    0.500    0.056    8.879    0.000    0.500    0.884
##      .Cmptn_PE_1 (i)    0.259    0.029    8.850    0.000    0.259    0.281
##      .Cmptn_PE_2 (j)    0.446    0.043   10.376    0.000    0.446    0.388
##      .Cmptn_PE_3 (k)    0.534    0.043   12.416    0.000    0.534    0.447
##      .Cmptn_PE_4 (l)    0.397    0.035   11.213    0.000    0.397    0.396
##      f1          -0.070    0.212   -0.332    0.740      NaN      NaN
##      f2           0.154    0.245    0.630    0.529    1.000    1.000
##      f3           0.693    0.327    2.121    0.034    1.000    1.000
##      Atnmy_PE_1     1.241    0.594    2.089    0.037    0.393    0.393
##      Atnmy_PE_2    -0.194    0.140   -1.383    0.167   -0.140   -0.140
##      Atnmy_PE_3    -0.040    0.359   -0.111    0.911   -0.023   -0.023
##      Atnmy_PE_4     0.136    0.173    0.786    0.432    0.061    0.061
##      Rltdn_PE_1    -0.100    0.212   -0.472    0.637   -0.308   -0.308
##      Rltdn_PE_2    -0.190    0.159   -1.198    0.231   -4.599   -4.599
##      Rltdn_PE_3    -0.189    0.106   -1.789    0.074      NaN      NaN
##      Cmptn_PE_1     0.051    0.138    0.373    0.709      NaN      NaN
##      Cmptn_PE_2    -0.021    0.177   -0.121    0.904      NaN      NaN
##      Cmptn_PE_3     0.753    0.765    0.984    0.325      NaN      NaN
##      Cmptn_PE_4     0.182    0.181    1.008    0.313    1.066    1.066
##      f1b           1.918    0.873    2.196    0.028    1.000    1.000
##      f2b           0.426    0.397    1.074    0.283    1.000    1.000
##      f3b          -0.079    0.181   -0.438    0.661      NaN      NaN
```

Path diagramm

```
semPlot::semPaths(models$mod_3x3_free_vareq_fit,"std",edge.label.cex=0.5, curvePivot = TRUE)
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

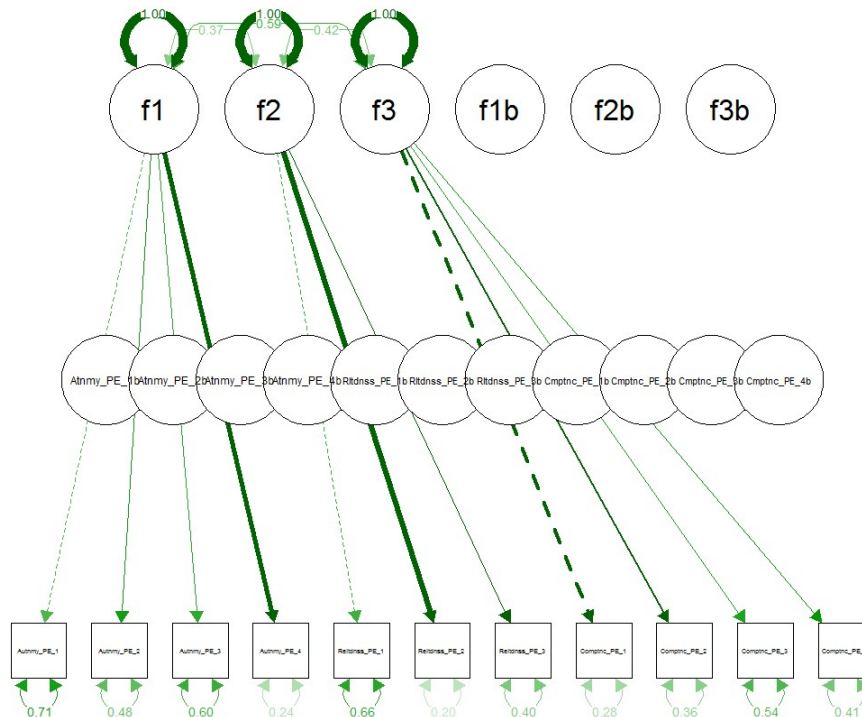
```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

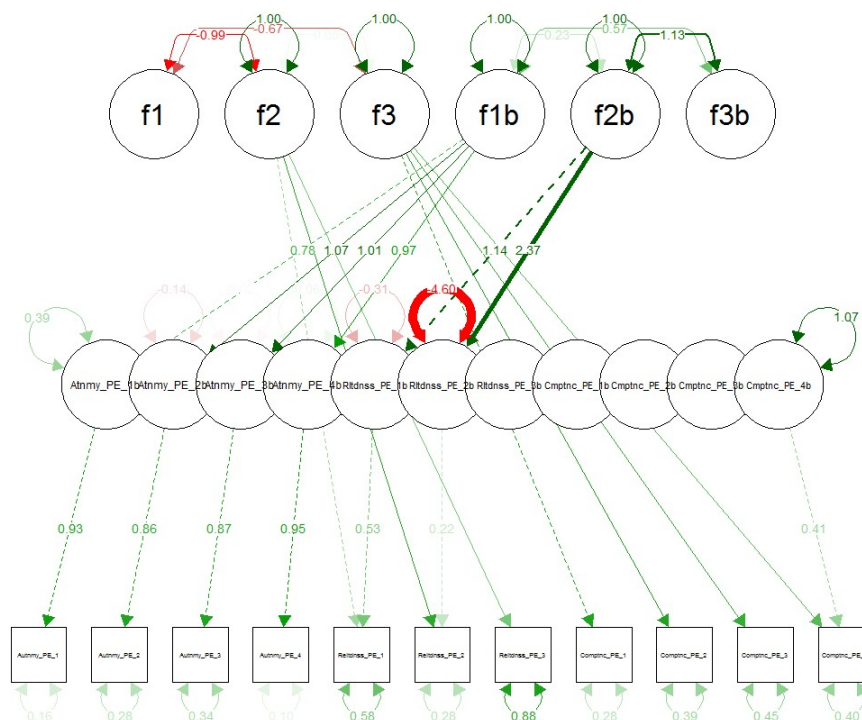
```
## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted

## Warning in qqgraph::qqgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

1



2



3x3, freely estimated loadings and latent factor variances and

covariances, manifest variances set equal/fixed where necessary

```
mod_3x3_free_vareq_var <- '
f1 =~ Autonomy_PE_1 + Autonomy_PE_2 + Autonomy_PE_3 + Autonomy_PE_4
f2 =~ Relatedness_PE_1 + Relatedness_PE_2 + Relatedness_PE_3
f3 =~ Competence_PE_1 + Competence_PE_2 + Competence_PE_3 + Competence_PE_4
Autonomy_PE_1 ~~ c(a,a)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(NA,0)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(NA,0)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(d,d)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(NA,0)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(NA,0)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(NA,0)*Relatedness_PE_3
Competence_PE_1 ~~ c(e,e)*Competence_PE_1
Competence_PE_2 ~~ c(NA,0)*Competence_PE_2
Competence_PE_3 ~~ c(m,m)*Competence_PE_3
Competence_PE_4 ~~ c(NA,0)*Competence_PE_4
f1 ~~ f1
f2 ~~ f2
f3 ~~ f3
f1 ~~ f2
f1 ~~ f3
f2 ~~ f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b
f2b =~ c(0,1)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b
f3b =~ c(0,1)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f2b + c(0,NA)*f3b
f2b ~~ c(0,NA)*f2b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f3b
f3b ~~ c(0,NA)*f3b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# fit measures
models$mod_3x3_free_vareq_var_fit <- cfa(mod_3x3_free_vareq_var, sample.cov = combined.cov,
sample.nobs = combined.n, orthogonal = T)
```

```
## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv
## variances are negative
```

```
summary(models$mod_3x3_free_vareq_var_fit, fit.measures = T, standardized = T)
```

```
## lavaan 0.6-3 ended normally after 483 iterations
##
## Optimization method              NLMINB
## Number of free parameters        68
## Number of equality constraints     4
##
## Number of observations per group
##   within                        400
##   between                       33
##
## Estimator                        ML
## Model Fit Test Statistic          146.746
## Degrees of freedom                68
## P-value (Chi-square)              0.000
##
## Chi-square for each group:
##
##   within                        124.159
##   between                       22.587
##
## Model test baseline model:
##
## Minimum Function Test Statistic    2130.224
## Degrees of freedom                 110
## P-value                           0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI)        0.961
## Tucker-Lewis Index (TLI)          0.937
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0)      -5940.740
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters          64
## Akaike (AIC)                      12009.480
## Bayesian (BIC)                    12270.007
## Sample-size adjusted Bayesian (BIC) 12066.907
##
## Root Mean Square Error of Approximation:
##
## RMSEA                             0.073
## 90 Percent Confidence Interval      0.057 0.089
## P-value RMSEA <= 0.05              0.011
##
## Standardized Root Mean Square Residual:
##
## SRMR                              0.056
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```

```
## Warning in sqrt(ETA2): NaNs wurden erzeugt
```



```

##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##
## Latent Variables:
## Estimate Std.Err z-value P(>|z|) Std.lv
## f1 =~
## Atnmy_PE_1 1.000 0.482
## Atnmy_PE_2 1.545 0.157 9.842 0.000 0.745
## Atnmy_PE_3 1.514 0.165 9.155 0.000 0.730
## Atnmy_PE_4 1.815 0.174 10.446 0.000 0.876
## f2 =~
## Rltdn_PE_1 1.000 0.589
## Rltdn_PE_2 1.642 0.148 11.120 0.000 0.966
## Rltdn_PE_3 1.466 0.130 11.258 0.000 0.863
## f3 =~
## Cmptn_PE_1 1.000 0.811
## Cmptn_PE_2 1.102 0.063 17.612 0.000 0.894
## Cmptn_PE_3 0.829 0.058 14.299 0.000 0.672
## Cmptn_PE_4 0.922 0.055 16.662 0.000 0.748
## Autonomy_PE_1b =~
## Atnmy_PE_1 (x) 1.000 0.000
## Autonomy_PE_2b =~
## Atnmy_PE_2 (x) 1.000 0.000
## Autonomy_PE_3b =~
## Atnmy_PE_3 (x) 1.000 0.000
## Autonomy_PE_4b =~
## Atnmy_PE_4 (x) 1.000 0.000
## Relatedness_PE_1b =~
## Rltdn_PE_1 (x) 1.000 0.000
## Relatedness_PE_2b =~
## Rltdn_PE_2 (x) 1.000 0.000
## Relatedness_PE_3b =~
## Rltdn_PE_3 (x) 1.000 0.000
## Competence_PE_1b =~
## Cmptn_PE_1 (x) 1.000 0.000
## Competence_PE_2b =~
## Cmptn_PE_2 (x) 1.000 0.000
## Competence_PE_3b =~
## Cmptn_PE_3 (x) 1.000 0.000
## Competence_PE_4b =~
## Cmptn_PE_4 (x) 1.000 0.000
## f1b =~
## Atnmy_PE_1 0.000 NaN
## Atnmy_PE_2 0.000 NaN
## Atnmy_PE_3 0.000 NaN
## Atnmy_PE_4 0.000 NaN
## f2b =~
## Rltdn_PE_1 0.000 NaN
## Rltdn_PE_2 0.000 NaN
## Rltdn_PE_3 0.000 NaN
## f3b =~
## Cmptn_PE_1 0.000 NaN
## Cmptn_PE_2 0.000 NaN

```

##	Cmptn_PE_3	0.000				NaN
##	Cmptn_PE_4	0.000				NaN
##	Std.all					
##						
##	0.538					
##	0.720					
##	0.633					
##	0.871					
##						
##	0.587					
##	0.896					
##	0.773					
##						
##	0.847					
##	0.801					
##	0.677					
##	0.765					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	0.000					
##						
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##						
##	NaN					
##	NaN					
##	NaN					
##						
##	NaN					
##	NaN					
##	NaN					
##	NaN					
##						
##	Covariances:					
##		Estimate	Std.Err	z-value	P(> z)	Std.lv Std.all
##	f1 ~~					
##	f2	0.104	0.021	4.924	0.000	0.366 0.366
##	f3	0.233	0.033	7.057	0.000	0.595 0.595
##	f2 ~~					

```

##      f3                0.199    0.034    5.923    0.000    0.416    0.416
##      f1 ~~
##      f1b                0.000                                NaN    NaN
##      f2 ~~
##      f1b                0.000                                NaN    NaN
##      f3 ~~
##      f1b                0.000                                NaN    NaN
##      f1b ~~
##      f2b                0.000                                NaN    NaN
##      f3b                0.000                                NaN    NaN
##      f1 ~~
##      f2b                0.000                                NaN    NaN
##      f2 ~~
##      f2b                0.000                                NaN    NaN
##      f3 ~~
##      f2b                0.000                                NaN    NaN
##      f2b ~~
##      f3b                0.000                                NaN    NaN
##      f1 ~~
##      f3b                0.000                                NaN    NaN
##      f2 ~~
##      f3b                0.000                                NaN    NaN
##      f3 ~~
##      f3b                0.000                                NaN    NaN
##
## Variances:
##              Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (a)    0.570   0.044  13.090   0.000   0.570   0.710
##      .Atnmy_PE_2        0.517   0.047  11.079   0.000   0.517   0.482
##      .Atnmy_PE_3        0.797   0.065  12.352   0.000   0.797   0.599
##      .Atnmy_PE_4 (d)    0.244   0.040   6.091   0.000   0.244   0.242
##      .Rltdn_PE_1        0.658   0.052  12.736   0.000   0.658   0.655
##      .Rltdn_PE_2        0.229   0.057   4.049   0.000   0.229   0.197
##      .Rltdn_PE_3        0.500   0.056   8.879   0.000   0.500   0.402
##      .Cmptn_PE_1 (e)    0.259   0.029   8.850   0.000   0.259   0.283
##      .Cmptn_PE_2        0.446   0.043  10.376   0.000   0.446   0.358
##      .Cmptn_PE_3 (m)    0.534   0.043  12.416   0.000   0.534   0.541
##      .Cmptn_PE_4        0.397   0.035  11.213   0.000   0.397   0.415
##      f1                0.233   0.043   5.383   0.000   1.000   1.000
##      f2                0.346   0.058   5.955   0.000   1.000   1.000
##      f3                0.658   0.066   9.928   0.000   1.000   1.000
##      Atnmy_PE_1        0.000                                NaN    NaN
##      Atnmy_PE_2        0.000                                NaN    NaN
##      Atnmy_PE_3        0.000                                NaN    NaN
##      Atnmy_PE_4        0.000                                NaN    NaN
##      Rltdn_PE_1        0.000                                NaN    NaN
##      Rltdn_PE_2        0.000                                NaN    NaN
##      Rltdn_PE_3        0.000                                NaN    NaN
##      Cmptn_PE_1        0.000                                NaN    NaN
##      Cmptn_PE_2        0.000                                NaN    NaN
##      Cmptn_PE_3        0.000                                NaN    NaN
##      Cmptn_PE_4        0.000                                NaN    NaN
##      f1b                0.000                                NaN    NaN
##      f2b                0.000                                NaN    NaN
##      f3b                0.000                                NaN    NaN
##
##
## Group 2 [between]:
##
## Latent Variables:

```

	Estimate	Std.Err	z-value	P(> z)	Std.lv
##					
##	f1 =~				
##	Atn_PE_1	1.000			NaN
##	Atn_PE_2	-0.632	2.071	-0.305	0.760
##	Atn_PE_3	-1.746	3.830	-0.456	0.648
##	Atn_PE_4	-0.230	1.691	-0.136	0.892
##	f2 =~				
##	Rlt_PE_1	1.000			0.393
##	Rlt_PE_2	1.899	1.161	1.635	0.102
##	Rlt_PE_3	1.020	0.629	1.623	0.105
##	f3 =~				
##	Cmp_PE_1	1.000			0.832
##	Cmp_PE_2	1.119	0.266	4.208	0.000
##	Cmp_PE_3	1.032	0.485	2.128	0.033
##	Cmp_PE_4	0.791	0.249	3.179	0.001
##	Autonomy_PE_1b =~				
##	Atn_PE_1 (sqc)	1.000			1.777
##	Autonomy_PE_2b =~				
##	Atn_PE_2 (sqc)	1.000			1.380
##	Autonomy_PE_3b =~				
##	Atn_PE_3 (sqc)	1.000			1.593
##	Autonomy_PE_4b =~				
##	Atn_PE_4 (sqc)	1.000			1.489
##	Relatedness_PE_1b =~				
##	Rlt_PE_1 (sqc)	1.000			0.992
##	Relatedness_PE_2b =~				
##	Rlt_PE_2 (sqc)	1.000			0.520
##	Relatedness_PE_3b =~				
##	Rlt_PE_3 (sqc)	1.000			0.636
##	Competence_PE_1b =~				
##	Cmp_PE_1 (sqc)	1.000			NaN
##	Competence_PE_2b =~				
##	Cmp_PE_2 (sqc)	1.000			0.532
##	Competence_PE_3b =~				
##	Cmp_PE_3 (sqc)	1.000			NaN
##	Competence_PE_4b =~				
##	Cmp_PE_4 (sqc)	1.000			0.753
##	f1b =~				
##	Atn_PE_1	1.000			0.779
##	Atn_PE_2	0.908	0.207	4.396	0.000
##	Atn_PE_3	0.964	0.266	3.630	0.000
##	Atn_PE_4	1.042	0.222	4.684	0.000
##	f2b =~				
##	Rlt_PE_1	1.000			0.658
##	Rlt_PE_2	0.737	0.241	3.059	0.002
##	Rlt_PE_3	0.470	0.185	2.541	0.011
##	f3b =~				
##	Cmp_PE_1	1.000			NaN
##	Cmp_PE_2	1.340	0.446	3.004	0.003
##	Cmp_PE_3	3.239	2.375	1.364	0.173
##	Cmp_PE_4	0.376	0.549	0.685	0.493
##	Std.all				
##					
##	NaN				
##	NaN				
##	NaN				
##	NaN				
##					
##	0.368				
##	0.820				

```

##      0.533
##
##      0.866
##      0.868
##      0.786
##      0.658
##
##      0.929
##
##      1.007
##
##      1.045
##
##      0.950
##
##      0.930
##
##      0.572
##
##      0.846
##
##      NaN
##
##      0.496
##
##      NaN
##
##      0.753
##
##      0.779
##      0.911
##      0.838
##      0.969
##
##      0.658
##      0.925
##      0.481
##
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##      Estimate   Std.Err   z-value   P(>|z|)   Std.lv   Std.all
##      f1 ~~
##      f2      -0.103    0.181    -0.571    0.568    -0.994    -0.994
##      f3      -0.148    0.241    -0.613    0.540    -0.669    -0.669
##      f2 ~~
##      f3      0.015    0.111     0.139    0.890     0.047     0.047
##      f1 ~~
##      f1b      0.000                0.000     0.000
##      f2 ~~
##      f1b      0.000                0.000     0.000
##      f3 ~~
##      f1b      0.000                0.000     0.000
##      f1b ~~
##      f2b      0.207    0.339     0.612    0.541     0.229     0.229
##      f3b      0.222    0.229     0.970    0.332     0.570     0.570
##      f1 ~~

```

```

##      f2b                0.000                0.000  0.000
##      f2 ~~
##      f2b                0.000                0.000  0.000
##      f3 ~~
##      f2b                0.000                0.000  0.000
##      f2b ~~
##      f3b                0.207      0.192      1.078      0.281      1.128      1.128
##      f1 ~~
##      f3b                0.000                0.000  0.000
##      f2 ~~
##      f3b                0.000                0.000  0.000
##      f3 ~~
##      f3b                0.000                0.000  0.000
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (a)    0.570    0.044   13.090    0.000    0.570    0.156
##      .Atnmy_PE_2        0.000                0.000  0.000
##      .Atnmy_PE_3        0.000                0.000  0.000
##      .Atnmy_PE_4 (d)    0.244    0.040    6.091    0.000    0.244    0.099
##      .Rltdn_PE_1        0.000                0.000  0.000
##      .Rltdn_PE_2        0.000                0.000  0.000
##      .Rltdn_PE_3        0.000                0.000  0.000
##      .Cmptn_PE_1 (e)    0.259    0.029    8.850    0.000    0.259    0.281
##      .Cmptn_PE_2        0.000                0.000  0.000
##      .Cmptn_PE_3 (m)    0.534    0.043   12.416    0.000    0.534    0.447
##      .Cmptn_PE_4        0.000                0.000  0.000
##      f1               -0.070    0.212   -0.332    0.740      NaN      NaN
##      f2                0.154    0.245    0.630    0.529    1.000    1.000
##      f3                0.693    0.327    2.121    0.034    1.000    1.000
##      Atnmy_PE_1        1.241    0.594    2.089    0.037    0.393    0.393
##      Atnmy_PE_2        0.322    0.132    2.434    0.015    0.169    0.169
##      Atnmy_PE_3        0.757    0.354    2.141    0.032    0.298    0.298
##      Atnmy_PE_4        0.136    0.173    0.786    0.432    0.061    0.061
##      Rltdn_PE_1        0.558    0.206    2.708    0.007    0.567    0.567
##      Rltdn_PE_2        0.039    0.148    0.265    0.791    0.145    0.145
##      Rltdn_PE_3        0.311    0.089    3.484    0.000    0.768    0.768
##      Cmptn_PE_1        0.051    0.138    0.373    0.709      NaN      NaN
##      Cmptn_PE_2        0.425    0.172    2.472    0.013    1.503    1.503
##      Cmptn_PE_3        0.753    0.765    0.984    0.325      NaN      NaN
##      Cmptn_PE_4        0.579    0.177    3.270    0.001    1.020    1.020
##      f1b               1.918    0.873    2.196    0.028    1.000    1.000
##      f2b               0.426    0.397    1.074    0.283    1.000    1.000
##      f3b              -0.079    0.181   -0.438    0.661      NaN      NaN

```

3x3, not nested, separated

Idea of a separate measurement and structural model on both levels for the 3x3 models

```

mod_3x3_sep <- '
f1 =~ c(1,0)*Autonomy_PE_1 + c(NA,0)*Autonomy_PE_2 + c(NA,0)*Autonomy_PE_3 + c(NA,0)*Autonomy_PE_4
f2 =~ c(1,0)*Relatedness_PE_1 + c(NA,0)*Relatedness_PE_2 + c(NA,0)*Relatedness_PE_3
f3 =~ c(1,0)*Competence_PE_1 + c(NA,0)*Competence_PE_2 + c(NA,0)*Competence_PE_3 + c(NA,0)*Competence_PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(k,k)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(l,l)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(n,n)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(o,o)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(p,p)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(NA,0)*f1
f2 ~~ c(NA,0)*f2
f3 ~~ c(NA,0)*f3
f1 ~~ c(NA,0)*f2
f1 ~~ c(NA,0)*f3
f2 ~~ c(NA,0)*f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b
f2b =~ c(0,1)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b
f3b =~ c(0,1)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f2b + c(0,NA)*f3b
f2b ~~ c(0,NA)*f2b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f3b
f3b ~~ c(0,NA)*f3b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model
models$mod_3x3_sep_fit <- cfa(mod_3x3_sep, sample.cov = combined.cov, sample.nobs = combined.n, orthogonal = T)

```

```
## Warning in lav_object_post_check(object): lavaan WARNING: some estimated lv  
## variances are negative
```

```
summary(models$mod_3x3_sep_fit, fit.measures = T, standardized = T)
```



```

## lavaan 0.6-3 ended normally after 91 iterations
##
## Optimization method NLMINB
## Number of free parameters 61
## Number of equality constraints 11
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 186.377
## Degrees of freedom 82
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 124.159
## between 62.218
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.948
## Tucker-Lewis Index (TLI) 0.931
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5960.555
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 50
## Akaike (AIC) 12021.111
## Bayesian (BIC) 12224.647
## Sample-size adjusted Bayesian (BIC) 12065.975
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.077
## 90 Percent Confidence Interval 0.062 0.091
## P-value RMSEA <= 0.05 0.002
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.058
##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##

```

```

## Latent Variables:
##
##           Estimate   Std.Err   z-value   P(>|z|)   Std.lv
## f1 =~
##   Atnmy_PE_1         1.000
##   Atnmy_PE_2         1.545     0.157     9.842     0.000     0.745
##   Atnmy_PE_3         1.514     0.165     9.155     0.000     0.730
##   Atnmy_PE_4         1.815     0.174    10.446     0.000     0.876
## f2 =~
##   Rltdn_PE_1         1.000
##   Rltdn_PE_2         1.642     0.148    11.120     0.000     0.966
##   Rltdn_PE_3         1.466     0.130    11.258     0.000     0.863
## f3 =~
##   Cmptn_PE_1         1.000
##   Cmptn_PE_2         1.102     0.063    17.612     0.000     0.894
##   Cmptn_PE_3         0.829     0.058    14.299     0.000     0.672
##   Cmptn_PE_4         0.922     0.055    16.662     0.000     0.748
## Autonomy_PE_1b =~
##   Atnmy_PE_1 (x)         1.000
## Autonomy_PE_2b =~
##   Atnmy_PE_2 (x)         1.000
## Autonomy_PE_3b =~
##   Atnmy_PE_3 (x)         1.000
## Autonomy_PE_4b =~
##   Atnmy_PE_4 (x)         1.000
## Relatedness_PE_1b =~
##   Rltdn_PE_1 (x)         1.000
## Relatedness_PE_2b =~
##   Rltdn_PE_2 (x)         1.000
## Relatedness_PE_3b =~
##   Rltdn_PE_3 (x)         1.000
## Competence_PE_1b =~
##   Cmptn_PE_1 (x)         1.000
## Competence_PE_2b =~
##   Cmptn_PE_2 (x)         1.000
## Competence_PE_3b =~
##   Cmptn_PE_3 (x)         1.000
## Competence_PE_4b =~
##   Cmptn_PE_4 (x)         1.000
## f1b =~
##   Atnmy_PE_1         0.000
##   Atnmy_PE_2         0.000
##   Atnmy_PE_3         0.000
##   Atnmy_PE_4         0.000
## f2b =~
##   Rltdn_PE_1         0.000
##   Rltdn_PE_2         0.000
##   Rltdn_PE_3         0.000
## f3b =~
##   Cmptn_PE_1         0.000
##   Cmptn_PE_2         0.000
##   Cmptn_PE_3         0.000
##   Cmptn_PE_4         0.000
## Std.all
##
##   0.538
##   0.720
##   0.633
##   0.871
##
##   0.587

```

```

##      0.896
##      0.773
##
##      0.847
##      0.801
##      0.677
##      0.765
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      NaN
##      NaN
##      NaN
##      NaN
##
##      NaN
##      NaN
##      NaN
##
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      f1 ~~
##      f2      0.104   0.021   4.924   0.000   0.366   0.366
##      f3      0.233   0.033   7.057   0.000   0.595   0.595
##      f2 ~~
##      f3      0.199   0.034   5.923   0.000   0.416   0.416
##      f1 ~~
##      f1b     0.000                NaN      NaN
##      f2 ~~
##      f1b     0.000                NaN      NaN
##      f3 ~~
##      f1b     0.000                NaN      NaN
##      f1b ~~
##      f2b     0.000                NaN      NaN
##      f3b     0.000                NaN      NaN

```

```

##      f1 ~~
##      f2b          0.000                      NaN      NaN
##      f2 ~~
##      f2b          0.000                      NaN      NaN
##      f3 ~~
##      f2b          0.000                      NaN      NaN
##      f2b ~~
##      f3b          0.000                      NaN      NaN
##      f1 ~~
##      f3b          0.000                      NaN      NaN
##      f2 ~~
##      f3b          0.000                      NaN      NaN
##      f3 ~~
##      f3b          0.000                      NaN      NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)  0.570   0.044  13.090   0.000   0.570   0.710
##      .Atnmy_PE_2 (k)  0.517   0.047  11.079   0.000   0.517   0.482
##      .Atnmy_PE_3 (l)  0.797   0.065  12.352   0.000   0.797   0.599
##      .Atnmy_PE_4 (m)  0.244   0.040   6.091   0.000   0.244   0.242
##      .Rltdn_PE_1 (n)  0.658   0.052  12.736   0.000   0.658   0.655
##      .Rltdn_PE_2 (o)  0.229   0.057   4.049   0.000   0.229   0.197
##      .Rltdn_PE_3 (p)  0.500   0.056   8.879   0.000   0.500   0.402
##      .Cmptn_PE_1 (r)  0.259   0.029   8.850   0.000   0.259   0.283
##      .Cmptn_PE_2 (s)  0.446   0.043  10.376   0.000   0.446   0.358
##      .Cmptn_PE_3 (t)  0.534   0.043  12.416   0.000   0.534   0.541
##      .Cmptn_PE_4 (u)  0.397   0.035  11.213   0.000   0.397   0.415
##      f1          0.233   0.043   5.383   0.000   1.000   1.000
##      f2          0.346   0.058   5.955   0.000   1.000   1.000
##      f3          0.658   0.066   9.928   0.000   1.000   1.000
##      Atnmy_PE_1    0.000                      NaN      NaN
##      Atnmy_PE_2    0.000                      NaN      NaN
##      Atnmy_PE_3    0.000                      NaN      NaN
##      Atnmy_PE_4    0.000                      NaN      NaN
##      Rltdn_PE_1    0.000                      NaN      NaN
##      Rltdn_PE_2    0.000                      NaN      NaN
##      Rltdn_PE_3    0.000                      NaN      NaN
##      Cmptn_PE_1    0.000                      NaN      NaN
##      Cmptn_PE_2    0.000                      NaN      NaN
##      Cmptn_PE_3    0.000                      NaN      NaN
##      Cmptn_PE_4    0.000                      NaN      NaN
##      f1b          0.000                      NaN      NaN
##      f2b          0.000                      NaN      NaN
##      f3b          0.000                      NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:
##      Estimate Std.Err z-value P(>|z|) Std.lv
##      f1 =~
##      Atn_PE_1      0.000                      0.000
##      Atn_PE_2      0.000                      0.000
##      Atn_PE_3      0.000                      0.000
##      Atn_PE_4      0.000                      0.000
##      f2 =~
##      Rlt_PE_1      0.000                      0.000
##      Rlt_PE_2      0.000                      0.000
##      Rlt_PE_3      0.000                      0.000

```

##	f3 =~				
##	Cmp_PE_1	0.000			0.000
##	Cmp_PE_2	0.000			0.000
##	Cmp_PE_3	0.000			0.000
##	Cmp_PE_4	0.000			0.000
##	Autonomy_PE_1b =~				
##	Atn_PE_1 (sqc)	1.000			1.750
##	Autonomy_PE_2b =~				
##	Atn_PE_2 (sqc)	1.000			1.173
##	Autonomy_PE_3b =~				
##	Atn_PE_3 (sqc)	1.000			1.253
##	Autonomy_PE_4b =~				
##	Atn_PE_4 (sqc)	1.000			1.490
##	Relatedness_PE_1b =~				
##	Rlt_PE_1 (sqc)	1.000			0.677
##	Relatedness_PE_2b =~				
##	Rlt_PE_2 (sqc)	1.000			0.754
##	Relatedness_PE_3b =~				
##	Rlt_PE_3 (sqc)	1.000			0.235
##	Competence_PE_1b =~				
##	Cmp_PE_1 (sqc)	1.000			0.825
##	Competence_PE_2b =~				
##	Cmp_PE_2 (sqc)	1.000			0.853
##	Competence_PE_3b =~				
##	Cmp_PE_3 (sqc)	1.000			0.844
##	Competence_PE_4b =~				
##	Cmp_PE_4 (sqc)	1.000			0.781
##	f1b =~				
##	Atn_PE_1	1.000			0.809
##	Atn_PE_2	0.878	0.163	5.381	0.000
##	Atn_PE_3	0.956	0.183	5.228	0.000
##	Atn_PE_4	1.010	0.186	5.429	0.000
##	f2b =~				
##	Rlt_PE_1	1.000			1.005
##	Rlt_PE_2	1.256	0.369	3.401	0.001
##	Rlt_PE_3	0.734	0.217	3.386	0.001
##	f3b =~				
##	Cmp_PE_1	1.000			0.890
##	Cmp_PE_2	1.095	0.283	3.873	0.000
##	Cmp_PE_3	1.058	0.289	3.658	0.000
##	Cmp_PE_4	0.931	0.259	3.590	0.000
##	Std.all				
##					
##	0.000				
##	0.000				
##	0.000				
##	0.000				
##					
##	0.000				
##	0.000				
##	0.000				
##					
##	0.000				
##	0.000				
##	0.000				
##	0.000				
##					
##	0.918				
##					
##	0.853				

```

##
##      0.814
##
##      0.949
##
##      0.641
##
##      0.844
##
##      0.316
##
##      0.851
##
##      0.787
##
##      0.756
##
##      0.778
##
##      0.809
##      1.060
##      1.080
##      0.961
##
##      1.005
##      1.134
##      2.124
##
##      0.890
##      0.942
##      0.920
##      0.876
##
## Covariances:
##      Estimate   Std.Err   z-value   P(>|z|)   Std.lv   Std.all
##      f1 ~~
##      f2          0.000                NaN      NaN
##      f3          0.000                NaN      NaN
##      f2 ~~
##      f3          0.000                NaN      NaN
##      f1 ~~
##      f1b         0.000                NaN      NaN
##      f2 ~~
##      f1b         0.000                NaN      NaN
##      f3 ~~
##      f1b         0.000                NaN      NaN
##      f1b ~~
##      f2b         0.192      0.193      0.993      0.321      0.199      0.199
##      f3b         0.584      0.263      2.219      0.026      0.561      0.561
##      f1 ~~
##      f2b         0.000                NaN      NaN
##      f2 ~~
##      f2b         0.000                NaN      NaN
##      f3 ~~
##      f2b         0.000                NaN      NaN
##      f2b ~~
##      f3b         0.206      0.124      1.665      0.096      0.413      0.413
##      f1 ~~
##      f3b         0.000                NaN      NaN
##      f2 ~~

```

```
##      f3b                0.000                NaN                NaN
##      f3 ~~
##      f3b                0.000                NaN                NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)    0.570    0.044   13.090    0.000    0.570    0.157
##      .Atnmy_PE_2 (k)    0.517    0.047   11.079    0.000    0.517    0.273
##      .Atnmy_PE_3 (l)    0.797    0.065   12.352    0.000    0.797    0.337
##      .Atnmy_PE_4 (m)    0.244    0.040    6.091    0.000    0.244    0.099
##      .Rltdn_PE_1 (n)    0.658    0.052   12.736    0.000    0.658    0.589
##      .Rltdn_PE_2 (o)    0.229    0.057    4.049    0.000    0.229    0.288
##      .Rltdn_PE_3 (p)    0.500    0.056    8.879    0.000    0.500    0.900
##      .Cmptn_PE_1 (r)    0.259    0.029    8.850    0.000    0.259    0.276
##      .Cmptn_PE_2 (s)    0.446    0.043   10.376    0.000    0.446    0.380
##      .Cmptn_PE_3 (t)    0.534    0.043   12.416    0.000    0.534    0.428
##      .Cmptn_PE_4 (u)    0.397    0.035   11.213    0.000    0.397    0.394
##      f1                0.000                NaN                NaN
##      f2                0.000                NaN                NaN
##      f3                0.000                NaN                NaN
##      Atnmy_PE_1        1.056    0.441    2.396    0.017    0.345    0.345
##      Atnmy_PE_2       -0.171    0.136   -1.261    0.207   -0.125   -0.125
##      Atnmy_PE_3       -0.263    0.187   -1.403    0.161   -0.167   -0.167
##      Atnmy_PE_4         0.170    0.166    1.025    0.305    0.077    0.077
##      Rltdn_PE_1       -0.005    0.196   -0.023    0.982   -0.010   -0.010
##      Rltdn_PE_2       -0.162    0.164   -0.990    0.322   -0.285   -0.285
##      Rltdn_PE_3       -0.194    0.108   -1.798    0.072   -3.510   -3.510
##      Cmptn_PE_1        0.142    0.140    1.013    0.311    0.208    0.208
##      Cmptn_PE_2        0.081    0.179    0.454    0.650    0.112    0.112
##      Cmptn_PE_3        0.109    0.201    0.545    0.586    0.153    0.153
##      Cmptn_PE_4        0.141    0.165    0.856    0.392    0.232    0.232
##      f1b                2.007    0.820    2.448    0.014    1.000    1.000
##      f2b                0.463    0.244    1.898    0.058    1.000    1.000
##      f3b                0.539    0.230    2.347    0.019    1.000    1.000
```

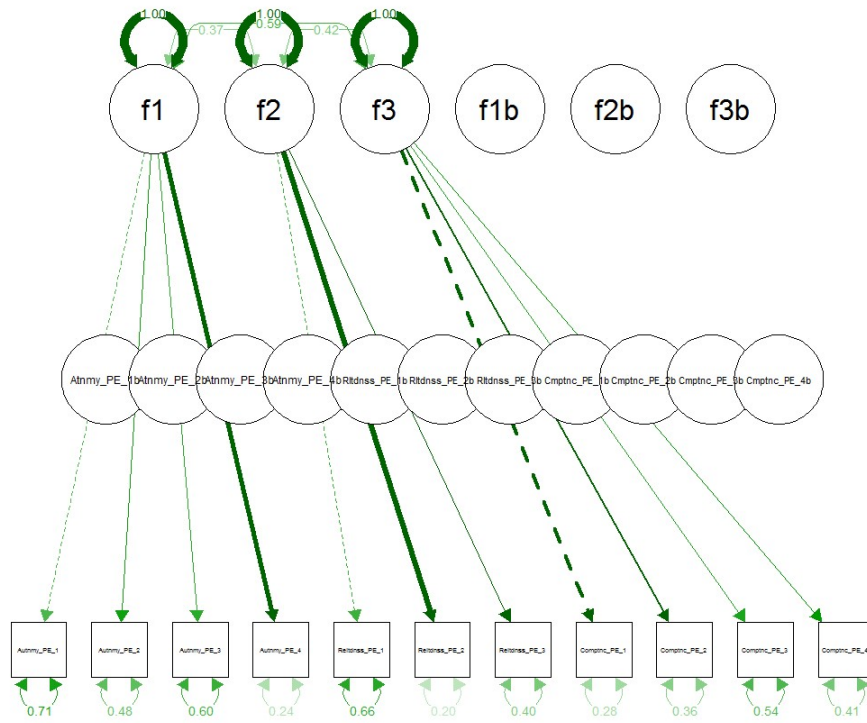
Path diagramm

```
semPlot::semPaths(models$mod_3x3_sep_fit,"std",edge.label.cex=0.5, curvePivot = TRUE)
```

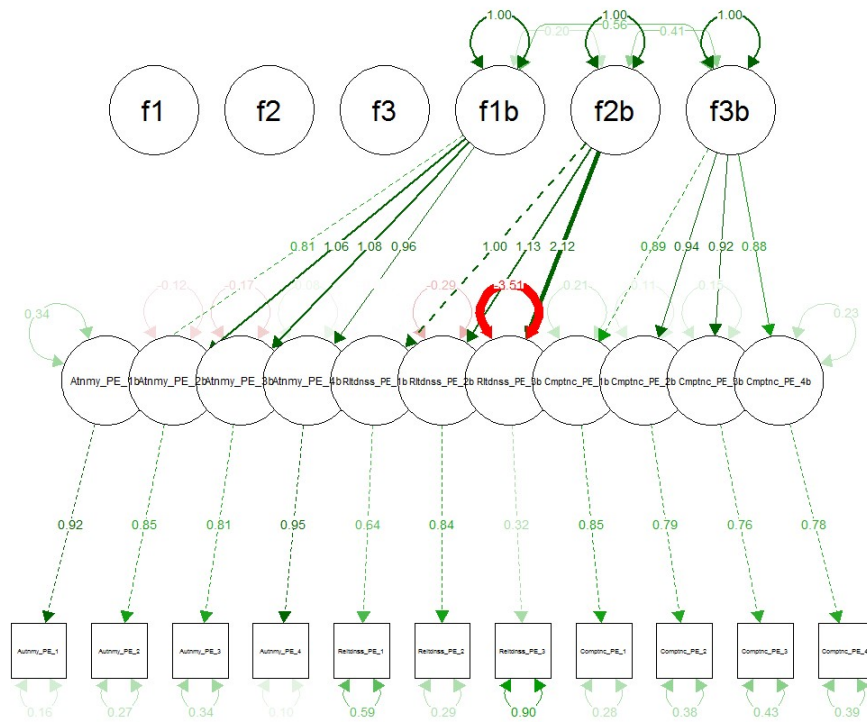
```
## Warning in qgraph::qgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

```
## Warning in qgraph::qgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

1



2



3x3, separate, manifest variances fixed where necessary

Model C


```

mod_3x3_sep_var <- '
f1 =~ c(1,0)*Autonomy_PE_1 + c(NA,0)*Autonomy_PE_2 + c(NA,0)*Autonomy_PE_3 + c(NA,0)*Autonomy_PE_4
f2 =~ c(1,0)*Relatedness_PE_1 + c(NA,0)*Relatedness_PE_2 + c(NA,0)*Relatedness_PE_3
f3 =~ c(1,0)*Competence_PE_1 + c(NA,0)*Competence_PE_2 + c(NA,0)*Competence_PE_3 + c(NA,0)*Competence_PE_4
Autonomy_PE_1 ~~ c(j,j)*Autonomy_PE_1
Autonomy_PE_2 ~~ c(NA,0)*Autonomy_PE_2
Autonomy_PE_3 ~~ c(NA,0)*Autonomy_PE_3
Autonomy_PE_4 ~~ c(m,m)*Autonomy_PE_4
Relatedness_PE_1 ~~ c(NA,0)*Relatedness_PE_1
Relatedness_PE_2 ~~ c(NA,0)*Relatedness_PE_2
Relatedness_PE_3 ~~ c(NA,0)*Relatedness_PE_3
Competence_PE_1 ~~ c(r,r)*Competence_PE_1
Competence_PE_2 ~~ c(s,s)*Competence_PE_2
Competence_PE_3 ~~ c(t,t)*Competence_PE_3
Competence_PE_4 ~~ c(u,u)*Competence_PE_4
f1 ~~ c(NA,0)*f1
f2 ~~ c(NA,0)*f2
f3 ~~ c(NA,0)*f3
f1 ~~ c(NA,0)*f2
f1 ~~ c(NA,0)*f3
f2 ~~ c(NA,0)*f3
Autonomy_PE_1b =~ c(0,x$sqc)*Autonomy_PE_1
Autonomy_PE_1b ~~ c(0,NA)*Autonomy_PE_1b
Autonomy_PE_2b =~ c(0,x$sqc)*Autonomy_PE_2
Autonomy_PE_2b ~~ c(0,NA)*Autonomy_PE_2b
Autonomy_PE_3b =~ c(0,x$sqc)*Autonomy_PE_3
Autonomy_PE_3b ~~ c(0,NA)*Autonomy_PE_3b
Autonomy_PE_4b =~ c(0,x$sqc)*Autonomy_PE_4
Autonomy_PE_4b ~~ c(0,NA)*Autonomy_PE_4b
Relatedness_PE_1b =~ c(0,x$sqc)*Relatedness_PE_1
Relatedness_PE_1b ~~ c(0,NA)*Relatedness_PE_1b
Relatedness_PE_2b =~ c(0,x$sqc)*Relatedness_PE_2
Relatedness_PE_2b ~~ c(0,NA)*Relatedness_PE_2b
Relatedness_PE_3b =~ c(0,x$sqc)*Relatedness_PE_3
Relatedness_PE_3b ~~ c(0,NA)*Relatedness_PE_3b
Competence_PE_1b =~ c(0,x$sqc)*Competence_PE_1
Competence_PE_1b ~~ c(0,NA)*Competence_PE_1b
Competence_PE_2b =~ c(0,x$sqc)*Competence_PE_2
Competence_PE_2b ~~ c(0,NA)*Competence_PE_2b
Competence_PE_3b =~ c(0,x$sqc)*Competence_PE_3
Competence_PE_3b ~~ c(0,NA)*Competence_PE_3b
Competence_PE_4b =~ c(0,x$sqc)*Competence_PE_4
Competence_PE_4b ~~ c(0,NA)*Competence_PE_4b
f1b =~ c(0,1)*Autonomy_PE_1b + c(0,NA)*Autonomy_PE_2b + c(0,NA)*Autonomy_PE_3b + c(0,NA)*Autonomy_PE_4b
f2b =~ c(0,1)*Relatedness_PE_1b + c(0,NA)*Relatedness_PE_2b + c(0,NA)*Relatedness_PE_3b
f3b =~ c(0,1)*Competence_PE_1b + c(0,NA)*Competence_PE_2b + c(0,NA)*Competence_PE_3b + c(0,NA)*Competence_PE_4b
f1b ~~ c(0,NA)*f1b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f2b + c(0,NA)*f3b
f2b ~~ c(0,NA)*f2b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3 + c(0,NA)*f3b
f3b ~~ c(0,NA)*f3b + c(0,0)*f1 + c(0,0)*f2 + c(0,0)*f3
'

# Fit hypothesized model
models$mod_3x3_sep_var_fit<- cfa(mod_3x3_sep_var, sample.cov = combined.cov, sample.nobs = combined.n, orthogonal = T)
# Summary
summary(models$mod_3x3_sep_var_fit, fit.measures = T, standardized = T)

```

```

## lavaan 0.6-3 ended normally after 86 iterations
##
## Optimization method NLMINB
## Number of free parameters 56
## Number of equality constraints 6
##
## Number of observations per group
## within 400
## between 33
##
## Estimator ML
## Model Fit Test Statistic 186.377
## Degrees of freedom 82
## P-value (Chi-square) 0.000
##
## Chi-square for each group:
##
## within 124.159
## between 62.218
##
## Model test baseline model:
##
## Minimum Function Test Statistic 2130.224
## Degrees of freedom 110
## P-value 0.000
##
## User model versus baseline model:
##
## Comparative Fit Index (CFI) 0.948
## Tucker-Lewis Index (TLI) 0.931
##
## Loglikelihood and Information Criteria:
##
## Loglikelihood user model (H0) -5960.555
## Loglikelihood unrestricted model (H1) -5867.367
##
## Number of free parameters 50
## Akaike (AIC) 12021.111
## Bayesian (BIC) 12224.647
## Sample-size adjusted Bayesian (BIC) 12065.975
##
## Root Mean Square Error of Approximation:
##
## RMSEA 0.077
## 90 Percent Confidence Interval 0.062 0.091
## P-value RMSEA <= 0.05 0.002
##
## Standardized Root Mean Square Residual:
##
## SRMR 0.058
##
## Parameter Estimates:
##
## Information Expected
## Information saturated (h1) model Structured
## Standard Errors Standard
##
##
## Group 1 [within]:
##

```

```

## Latent Variables:
##
##           Estimate   Std.Err   z-value   P(>|z|)   Std.lv
## f1 =~
##   Atnmy_PE_1         1.000
##   Atnmy_PE_2         1.545     0.157     9.842     0.000     0.745
##   Atnmy_PE_3         1.514     0.165     9.155     0.000     0.730
##   Atnmy_PE_4         1.815     0.174    10.446     0.000     0.876
## f2 =~
##   Rltdn_PE_1         1.000
##   Rltdn_PE_2         1.642     0.148    11.120     0.000     0.966
##   Rltdn_PE_3         1.466     0.130    11.258     0.000     0.863
## f3 =~
##   Cmptn_PE_1         1.000
##   Cmptn_PE_2         1.102     0.063    17.612     0.000     0.894
##   Cmptn_PE_3         0.829     0.058    14.299     0.000     0.672
##   Cmptn_PE_4         0.922     0.055    16.662     0.000     0.748
## Autonomy_PE_1b =~
##   Atnmy_PE_1 (x)         1.000
## Autonomy_PE_2b =~
##   Atnmy_PE_2 (x)         1.000
## Autonomy_PE_3b =~
##   Atnmy_PE_3 (x)         1.000
## Autonomy_PE_4b =~
##   Atnmy_PE_4 (x)         1.000
## Relatedness_PE_1b =~
##   Rltdn_PE_1 (x)         1.000
## Relatedness_PE_2b =~
##   Rltdn_PE_2 (x)         1.000
## Relatedness_PE_3b =~
##   Rltdn_PE_3 (x)         1.000
## Competence_PE_1b =~
##   Cmptn_PE_1 (x)         1.000
## Competence_PE_2b =~
##   Cmptn_PE_2 (x)         1.000
## Competence_PE_3b =~
##   Cmptn_PE_3 (x)         1.000
## Competence_PE_4b =~
##   Cmptn_PE_4 (x)         1.000
## f1b =~
##   Atnmy_PE_1         0.000
##   Atnmy_PE_2         0.000
##   Atnmy_PE_3         0.000
##   Atnmy_PE_4         0.000
## f2b =~
##   Rltdn_PE_1         0.000
##   Rltdn_PE_2         0.000
##   Rltdn_PE_3         0.000
## f3b =~
##   Cmptn_PE_1         0.000
##   Cmptn_PE_2         0.000
##   Cmptn_PE_3         0.000
##   Cmptn_PE_4         0.000
## Std.all
##
##   0.538
##   0.720
##   0.633
##   0.871
##
##   0.587

```

```

##      0.896
##      0.773
##
##      0.847
##      0.801
##      0.677
##      0.765
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      0.000
##
##      NaN
##      NaN
##      NaN
##      NaN
##
##      NaN
##      NaN
##      NaN
##
##      NaN
##      NaN
##      NaN
##      NaN
##
## Covariances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      f1 ~~
##      f2      0.104   0.021   4.924   0.000   0.366   0.366
##      f3      0.233   0.033   7.057   0.000   0.595   0.595
##      f2 ~~
##      f3      0.199   0.034   5.923   0.000   0.416   0.416
##      f1 ~~
##      f1b     0.000                NaN      NaN
##      f2 ~~
##      f1b     0.000                NaN      NaN
##      f3 ~~
##      f1b     0.000                NaN      NaN
##      f1b ~~
##      f2b     0.000                NaN      NaN
##      f3b     0.000                NaN      NaN

```

```

##      f1 ~~
##      f2b          0.000                      NaN      NaN
##      f2 ~~
##      f2b          0.000                      NaN      NaN
##      f3 ~~
##      f2b          0.000                      NaN      NaN
##      f2b ~~
##      f3b          0.000                      NaN      NaN
##      f1 ~~
##      f3b          0.000                      NaN      NaN
##      f2 ~~
##      f3b          0.000                      NaN      NaN
##      f3 ~~
##      f3b          0.000                      NaN      NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)    0.570   0.044  13.090   0.000   0.570   0.710
##      .Atnmy_PE_2        0.517   0.047  11.079   0.000   0.517   0.482
##      .Atnmy_PE_3        0.797   0.065  12.352   0.000   0.797   0.599
##      .Atnmy_PE_4 (m)    0.244   0.040   6.091   0.000   0.244   0.242
##      .Rltdn_PE_1        0.658   0.052  12.736   0.000   0.658   0.655
##      .Rltdn_PE_2        0.229   0.057   4.049   0.000   0.229   0.197
##      .Rltdn_PE_3        0.500   0.056   8.879   0.000   0.500   0.402
##      .Cmptn_PE_1 (r)    0.259   0.029   8.850   0.000   0.259   0.283
##      .Cmptn_PE_2 (s)    0.446   0.043  10.376   0.000   0.446   0.358
##      .Cmptn_PE_3 (t)    0.534   0.043  12.416   0.000   0.534   0.541
##      .Cmptn_PE_4 (u)    0.397   0.035  11.213   0.000   0.397   0.415
##      f1                0.233   0.043   5.383   0.000   1.000   1.000
##      f2                0.346   0.058   5.955   0.000   1.000   1.000
##      f3                0.658   0.066   9.928   0.000   1.000   1.000
##      Atnmy_PE_1        0.000                      NaN      NaN
##      Atnmy_PE_2        0.000                      NaN      NaN
##      Atnmy_PE_3        0.000                      NaN      NaN
##      Atnmy_PE_4        0.000                      NaN      NaN
##      Rltdn_PE_1        0.000                      NaN      NaN
##      Rltdn_PE_2        0.000                      NaN      NaN
##      Rltdn_PE_3        0.000                      NaN      NaN
##      Cmptn_PE_1        0.000                      NaN      NaN
##      Cmptn_PE_2        0.000                      NaN      NaN
##      Cmptn_PE_3        0.000                      NaN      NaN
##      Cmptn_PE_4        0.000                      NaN      NaN
##      f1b                0.000                      NaN      NaN
##      f2b                0.000                      NaN      NaN
##      f3b                0.000                      NaN      NaN
##
##
## Group 2 [between]:
##
## Latent Variables:
##      Estimate Std.Err z-value P(>|z|) Std.lv
##      f1 =~
##      Atn_PE_1          0.000          0.000
##      Atn_PE_2          0.000          0.000
##      Atn_PE_3          0.000          0.000
##      Atn_PE_4          0.000          0.000
##      f2 =~
##      Rlt_PE_1          0.000          0.000
##      Rlt_PE_2          0.000          0.000
##      Rlt_PE_3          0.000          0.000

```

##	f3 =~				
##	Cmp_PE_1	0.000			0.000
##	Cmp_PE_2	0.000			0.000
##	Cmp_PE_3	0.000			0.000
##	Cmp_PE_4	0.000			0.000
##	Autonomy_PE_1b =~				
##	Atn_PE_1 (sqc)	1.000			1.750
##	Autonomy_PE_2b =~				
##	Atn_PE_2 (sqc)	1.000			1.375
##	Autonomy_PE_3b =~				
##	Atn_PE_3 (sqc)	1.000			1.539
##	Autonomy_PE_4b =~				
##	Atn_PE_4 (sqc)	1.000			1.490
##	Relatedness_PE_1b =~				
##	Rlt_PE_1 (sqc)	1.000			1.057
##	Relatedness_PE_2b =~				
##	Rlt_PE_2 (sqc)	1.000			0.893
##	Relatedness_PE_3b =~				
##	Rlt_PE_3 (sqc)	1.000			0.745
##	Competence_PE_1b =~				
##	Cmp_PE_1 (sqc)	1.000			0.825
##	Competence_PE_2b =~				
##	Cmp_PE_2 (sqc)	1.000			0.853
##	Competence_PE_3b =~				
##	Cmp_PE_3 (sqc)	1.000			0.844
##	Competence_PE_4b =~				
##	Cmp_PE_4 (sqc)	1.000			0.781
##	f1b =~				
##	Atn_PE_1	1.000			0.809
##	Atn_PE_2	0.878	0.163	5.381	0.000
##	Atn_PE_3	0.956	0.183	5.228	0.000
##	Atn_PE_4	1.010	0.186	5.429	0.000
##	f2b =~				
##	Rlt_PE_1	1.000			0.644
##	Rlt_PE_2	1.256	0.369	3.401	0.001
##	Rlt_PE_3	0.734	0.217	3.386	0.001
##	f3b =~				
##	Cmp_PE_1	1.000			0.890
##	Cmp_PE_2	1.095	0.283	3.873	0.000
##	Cmp_PE_3	1.058	0.289	3.658	0.000
##	Cmp_PE_4	0.931	0.259	3.590	0.000
##	Std.all				
##					
##	0.000				
##	0.000				
##	0.000				
##	0.000				
##					
##	0.000				
##	0.000				
##	0.000				
##					
##	0.000				
##	0.000				
##	0.000				
##	0.000				
##					
##	0.918				
##					
##	1.000				

```

##
##      1.000
##
##      0.949
##
##      1.000
##
##      1.000
##
##      1.000
##
##      0.851
##
##      0.787
##
##      0.756
##
##      0.778
##
##      0.809
##      0.904
##      0.880
##      0.961
##
##      0.644
##      0.957
##      0.670
##
##      0.890
##      0.942
##      0.920
##      0.876
##
## Covariances:
##      Estimate   Std.Err   z-value   P(>|z|)   Std.lv   Std.all
##      f1 ~~
##      f2          0.000                NaN      NaN
##      f3          0.000                NaN      NaN
##      f2 ~~
##      f3          0.000                NaN      NaN
##      f1 ~~
##      f1b         0.000                NaN      NaN
##      f2 ~~
##      f1b         0.000                NaN      NaN
##      f3 ~~
##      f1b         0.000                NaN      NaN
##      f1b ~~
##      f2b         0.192      0.193      0.993      0.321      0.199      0.199
##      f3b         0.584      0.263      2.219      0.027      0.561      0.561
##      f1 ~~
##      f2b         0.000                NaN      NaN
##      f2 ~~
##      f2b         0.000                NaN      NaN
##      f3 ~~
##      f2b         0.000                NaN      NaN
##      f2b ~~
##      f3b         0.206      0.124      1.665      0.096      0.413      0.413
##      f1 ~~
##      f3b         0.000                NaN      NaN
##      f2 ~~

```

```
##      f3b          0.000          NaN          NaN
##      f3 ~~
##      f3b          0.000          NaN          NaN
##
## Variances:
##      Estimate Std.Err z-value P(>|z|) Std.lv Std.all
##      .Atnmy_PE_1 (j)  0.570   0.044  13.090   0.000   0.570   0.157
##      .Atnmy_PE_2      0.000          0.000   0.000
##      .Atnmy_PE_3      0.000          0.000   0.000
##      .Atnmy_PE_4 (m)  0.244   0.040   6.091   0.000   0.244   0.099
##      .Rltdn_PE_1      0.000          0.000   0.000
##      .Rltdn_PE_2      0.000          0.000   0.000
##      .Rltdn_PE_3      0.000          0.000   0.000
##      .Cmptn_PE_1 (r)  0.259   0.029   8.850   0.000   0.259   0.276
##      .Cmptn_PE_2 (s)  0.446   0.043  10.376   0.000   0.446   0.380
##      .Cmptn_PE_3 (t)  0.534   0.043  12.416   0.000   0.534   0.428
##      .Cmptn_PE_4 (u)  0.397   0.035  11.213   0.000   0.397   0.394
##      f1          0.000          NaN          NaN
##      f2          0.000          NaN          NaN
##      f3          0.000          NaN          NaN
##      Atnmy_PE_1      1.056   0.441   2.396   0.017   0.345   0.345
##      Atnmy_PE_2      0.345   0.128   2.707   0.007   0.183   0.183
##      Atnmy_PE_3      0.534   0.176   3.037   0.002   0.226   0.226
##      Atnmy_PE_4      0.170   0.166   1.025   0.305   0.077   0.077
##      Rltdn_PE_1      0.654   0.189   3.458   0.001   0.585   0.585
##      Rltdn_PE_2      0.067   0.153   0.440   0.660   0.085   0.085
##      Rltdn_PE_3      0.306   0.092   3.319   0.001   0.551   0.551
##      Cmptn_PE_1      0.142   0.140   1.013   0.311   0.208   0.208
##      Cmptn_PE_2      0.081   0.179   0.454   0.650   0.112   0.112
##      Cmptn_PE_3      0.109   0.201   0.545   0.586   0.153   0.153
##      Cmptn_PE_4      0.141   0.165   0.856   0.392   0.232   0.232
##      f1b          2.007   0.820   2.448   0.014   1.000   1.000
##      f2b          0.463   0.244   1.898   0.058   1.000   1.000
##      f3b          0.539   0.230   2.347   0.019   1.000   1.000
```

see fit indices of model C in table 2 ** Factor loadings in table 3**

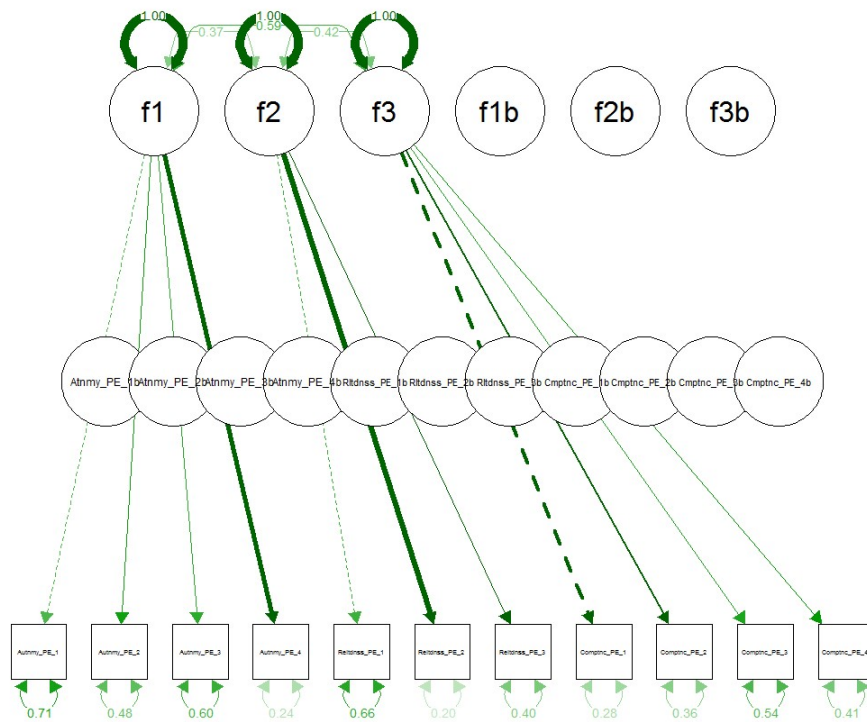
Path diagramm

```
semPlot::semPaths(models$mod_3x3_sep_var_fit,"std",edge.label.cex=0.5, curvePivot = TRUE)
```

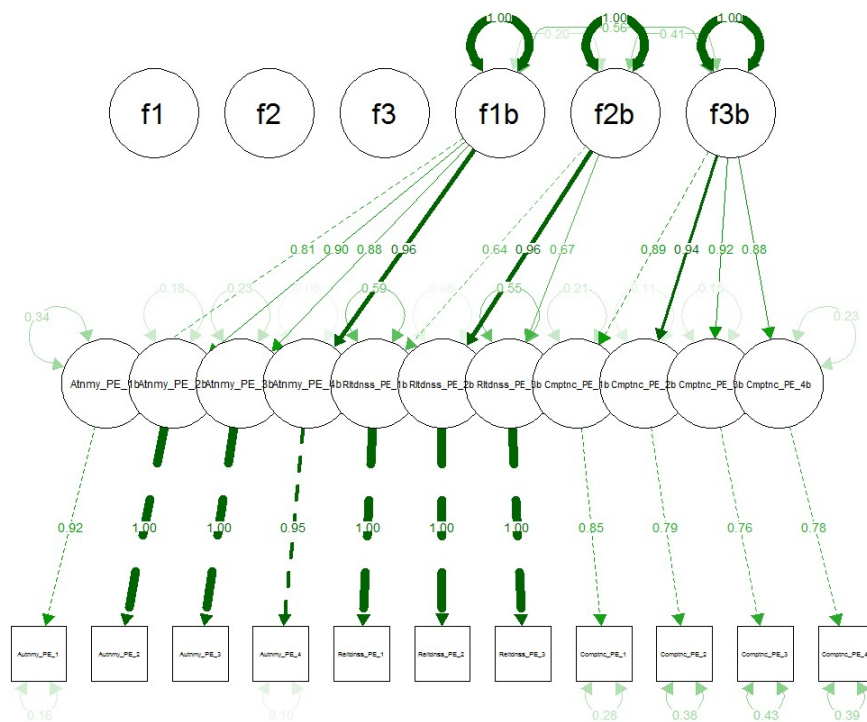
```
## Warning in qgraph::qgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```

```
## Warning in qgraph::qgraph(Edgelist, labels = nLab, bidirectional = Bidir, :
## Non-finite weights are omitted
```


1



2



Combine all converging models into table and see a subset of fit measures to compare the indices

```
overview <- round(sapply(models, function(X) fitmeasures(X, c("npar", "chisq", "df", "cfi",
"tli", "rmsea", "rmsea.ci.lower", "rmsea.ci.upper", "srmr", "aic"))),3)
overview
```

```

##          mod_one_fac mod_three_fac nullmodel_fit mod_ind_fit
## npar          22.000          25.000          25.000          35.000
## chisq          650.536          124.159          273.515          244.328
## df            44.000          41.000          107.000          97.000
## cfi            0.667          0.954          0.918          0.927
## tli            0.584          0.939          0.915          0.917
## rmsea          0.186          0.071          0.085          0.084
## rmsea.ci.lower  0.173          0.057          0.072          0.071
## rmsea.ci.upper  0.198          0.086          0.097          0.097
## srmr           0.117          0.054          0.091          0.136
## aic           11541.438          11021.062          12058.249          12049.061
##          mod_sat_fit mod_3x1_fit mod_3x1_var_fit
## npar          90.000          46.000          46.000
## chisq          142.171          209.600          209.600
## df            42.000          86.000          86.000
## cfi            0.950          0.939          0.939
## tli            0.870          0.922          0.922
## rmsea          0.105          0.081          0.081
## rmsea.ci.lower  0.086          0.068          0.068
## rmsea.ci.upper  0.124          0.096          0.096
## srmr           0.104          0.119          0.119
## aic           12056.904          12036.333          12036.333
##          mod_3x1_free_vareq_fit mod_3x1_free_vareq_var_fit
## npar          61.000          61.000
## chisq          157.964          157.964
## df            71.000          71.000
## cfi            0.957          0.957
## tli            0.933          0.933
## rmsea          0.075          0.075
## rmsea.ci.lower  0.059          0.059
## rmsea.ci.upper  0.091          0.091
## srmr           0.055          0.055
## aic           12014.698          12014.698
##          mod_3x1_sep_fit mod_3x1_sep_var_fit mod_3x3_fit
## npar          45.000          45.000          49.000
## chisq          253.129          253.129          189.720
## df            87.000          87.000          83.000
## cfi            0.918          0.918          0.947
## tli            0.896          0.896          0.930
## rmsea          0.094          0.094          0.077
## rmsea.ci.lower  0.081          0.081          0.063
## rmsea.ci.upper  0.107          0.107          0.092
## srmr           0.065          0.065          0.118
## aic           12077.862          12077.862          12022.453
##          mod_3x3_var_fit mod_3x3_free_vareq_fit
## npar          49.000          64.000
## chisq          189.720          146.746
## df            83.000          68.000
## cfi            0.947          0.961
## tli            0.930          0.937
## rmsea          0.077          0.073
## rmsea.ci.lower  0.063          0.057
## rmsea.ci.upper  0.092          0.089
## srmr           0.118          0.056
## aic           12022.453          12009.480
##          mod_3x3_free_vareq_var_fit mod_3x3_sep_fit
## npar          64.000          50.000
## chisq          146.746          186.377
## df            68.000          82.000
## cfi            0.961          0.948

```

```
## tli 0.937 0.931
## rmsea 0.073 0.077
## rmsea.ci.lower 0.057 0.062
## rmsea.ci.upper 0.089 0.091
## srmr 0.056 0.058
## aic 12009.480 12021.111
## mod_3x3_sep_var_fit
## npar 50.000
## chisq 186.377
## df 82.000
## cfi 0.948
## tli 0.931
## rmsea 0.077
## rmsea.ci.lower 0.062
## rmsea.ci.upper 0.091
## srmr 0.058
## aic 12021.111
```

Test differences of model fits

```
# Chi Square Difference Test
anova(models$nullmodel_fit, models$mod_ind_fit)
```

	Df <int>	AIC <dbl>	BIC <dbl>	Chisq <dbl>	Chisq diff <dbl>	Df diff <int>	Pr(>Chisq) <dbl>
models\$mod_ind_fit	97	12049.06	12191.54	244.3276	NA	NA	NA
models\$nullmodel_fit	107	12058.25	12160.02	273.5153	29.18766	10	0.001161778

2 rows

```
anova(models$mod_ind_fit, models$mod_sat_fit)
```

	Df <int>	AIC <dbl>	BIC <dbl>	Chisq <dbl>	Chisq diff <dbl>	Df diff <int>	Pr(>Chisq) <dbl>
models\$mod_sat_fit	42	12056.90	12423.27	142.1710	NA	NA	NA
models\$mod_ind_fit	97	12049.06	12191.54	244.3276	102.1566	55	0.0001167777

2 rows

```
anova(models$mod_three_fac, models$mod_3x3_sep_var_fit)
```

	Df <int>	AIC <dbl>	BIC <dbl>	Chisq <dbl>	Chisq diff <dbl>	Df diff <int>	Pr(>Chisq) <dbl>
models\$mod_three_fac	41	11021.06	11120.85	124.1593	NA	NA	NA
models\$mod_3x3_sep_var_fit	82	12021.11	12224.65	186.3772	62.21789	41	0.01785366

2 rows

```
anova(models$mod_3x1_var_fit, models$mod_3x3_sep_var_fit)
```

Df <int>	AIC <dbl>	BIC <dbl>	Chisq <dbl>	Chisq diff <dbl>	Df diff <int>	Pr(>Chisq) <dbl>
-------------	--------------	--------------	----------------	---------------------	------------------	---------------------

	Df <int>	AIC <dbl>	BIC <dbl>	Chisq <dbl>	Chisq diff <dbl>	Df diff <int>	Pr(>Chisq) <dbl>
models\$mod_3x3_sep_var_fit	82	12021.11	12224.65	186.3772	NA	NA	NA
models\$mod_3x1_var_fit	86	12036.33	12223.59	209.5997	23.22259	4	0.000114298

2 rows

```
anova(models$mod_3x1_sep_var_fit, models$mod_3x3_sep_var_fit)
```

	Df <int>	AIC <dbl>	BIC <dbl>	Chisq <dbl>	Chisq diff <dbl>	Df diff <int>	Pr(>Chisq) <dbl>
models\$mod_3x3_sep_var_fit	82	12021.11	12224.65	186.3772	NA	NA	NA
models\$mod_3x1_sep_var_fit	87	12077.86	12261.05	253.1289	66.75172	5	4.85208e-13

2 rows

Reliability

```
x$ab.cov
```

```

##          Autonomy_PE_1 Autonomy_PE_2 Autonomy_PE_3 Autonomy_PE_4
## Autonomy_PE_1      0.2254660370    0.110041888    0.129882792    0.125317946
## Autonomy_PE_2      0.1100418876    0.067123572    0.092198916    0.091947551
## Autonomy_PE_3      0.1298827917    0.092198916    0.084881247    0.103989004
## Autonomy_PE_4      0.1253179459    0.091947551    0.103989004    0.117008386
## Relatedness_PE_1    0.0004557546    0.011154914    0.013058193    0.008440437
## Relatedness_PE_2   -0.0215688141    0.001286220    0.007795585   -0.007891732
## Relatedness_PE_3   -0.0155121325   -0.003668756   -0.009609168   -0.011968075
## Competence_PE_1     0.0207874610    0.003979269    0.023246469   -0.008261176
## Competence_PE_2     0.0287635700    0.024944084    0.022987399    0.015401268
## Competence_PE_3     0.0209655811    0.037019698    0.037187500    0.036701265
## Competence_PE_4    -0.0052223562    0.003691356    0.013155642    0.004594645
##
##          Relatedness_PE_1 Relatedness_PE_2 Relatedness_PE_3
## Autonomy_PE_1      0.0004557546    -0.021568814   -0.015512132
## Autonomy_PE_2      0.0111549142     0.001286220   -0.003668756
## Autonomy_PE_3      0.0130581933     0.007795585   -0.009609168
## Autonomy_PE_4      0.0084404374    -0.007891732   -0.011968075
## Relatedness_PE_1    0.0110719214     0.001738461   -0.010398825
## Relatedness_PE_2    0.0017384607    -0.026341136   -0.030565812
## Relatedness_PE_3   -0.0103988253    -0.030565812   -0.051696955
## Competence_PE_1    -0.0041897644    -0.006816801   -0.016217660
## Competence_PE_2    -0.0134527685    -0.014032045   -0.010806001
## Competence_PE_3     0.0384777481     0.017494043   -0.003063422
## Competence_PE_4    -0.0145234439    -0.003085762   -0.009944725
##
##          Competence_PE_1 Competence_PE_2 Competence_PE_3
## Autonomy_PE_1      0.0207874610     0.028763570    0.0209655811
## Autonomy_PE_2      0.0039792690     0.024944084    0.0370196982
## Autonomy_PE_3      0.0232464687     0.022987399    0.0371874996
## Autonomy_PE_4     -0.0082611760     0.015401268    0.0367012652
## Relatedness_PE_1   -0.0041897644    -0.013452768    0.0384777481
## Relatedness_PE_2   -0.0068168011    -0.014032045    0.0174940433
## Relatedness_PE_3   -0.0162176599    -0.010806001   -0.0030634223
## Competence_PE_1     0.0038339171    -0.002428686    0.0008792136
## Competence_PE_2    -0.0024286857    -0.002926074   -0.0079702029
## Competence_PE_3     0.0008792136    -0.007970203    0.0227905380
## Competence_PE_4    -0.0069076756    -0.004585732    0.0049245767
##
##          Competence_PE_4
## Autonomy_PE_1     -0.005222356
## Autonomy_PE_2      0.003691356
## Autonomy_PE_3      0.013155642
## Autonomy_PE_4      0.004594645
## Relatedness_PE_1   -0.014523444
## Relatedness_PE_2   -0.003085762
## Relatedness_PE_3   -0.009944725
## Competence_PE_1    -0.006907676
## Competence_PE_2    -0.004585732
## Competence_PE_3     0.004924577
## Competence_PE_4     0.006037650

```

x\$pw.cov

```
## Autonomy_PE_1 Autonomy_PE_2 Autonomy_PE_3 Autonomy_PE_4
## Autonomy_PE_1 0.80503267 0.4275278 0.3438085 0.4098760
## Autonomy_PE_2 0.42752784 1.0750267 0.4778976 0.6658384
## Autonomy_PE_3 0.34380854 0.4778976 1.3335666 0.6409524
## Autonomy_PE_4 0.40987601 0.6658384 0.6409524 1.0140446
## Relatedness_PE_1 0.10565606 0.1773651 0.1644968 0.1927337
## Relatedness_PE_2 0.09208792 0.2032998 0.2986302 0.2923553
## Relatedness_PE_3 0.15243330 0.2248915 0.4111192 0.3547002
## Competence_PE_1 0.21328195 0.3492620 0.4217084 0.3964246
## Competence_PE_2 0.16498056 0.3521735 0.5657179 0.4406246
## Competence_PE_3 0.25023771 0.3161776 0.4881670 0.4411432
## Competence_PE_4 0.17408258 0.2597811 0.3481657 0.3708210
## Relatedness_PE_1 Relatedness_PE_2 Relatedness_PE_3
## Autonomy_PE_1 0.1056561 0.09208792 0.1524333
## Autonomy_PE_2 0.1773651 0.20329984 0.2248915
## Autonomy_PE_3 0.1644968 0.29863022 0.4111192
## Autonomy_PE_4 0.1927337 0.29235528 0.3547002
## Relatedness_PE_1 1.0070472 0.57598628 0.4701164
## Relatedness_PE_2 0.5759863 1.16610226 0.8409045
## Relatedness_PE_3 0.4701164 0.84090453 1.2474591
## Competence_PE_1 0.3203346 0.31994410 0.2641034
## Competence_PE_2 0.3221775 0.32151851 0.3153799
## Competence_PE_3 0.2190911 0.34112304 0.3701932
## Competence_PE_4 0.2687741 0.23473665 0.1945566
## Competence_PE_1 Competence_PE_2 Competence_PE_3
## Autonomy_PE_1 0.2132820 0.1649806 0.2502377
## Autonomy_PE_2 0.3492620 0.3521735 0.3161776
## Autonomy_PE_3 0.4217084 0.5657179 0.4881670
## Autonomy_PE_4 0.3964246 0.4406246 0.4411432
## Relatedness_PE_1 0.3203346 0.3221775 0.2190911
## Relatedness_PE_2 0.3199441 0.3215185 0.3411230
## Relatedness_PE_3 0.2641034 0.3153799 0.3701932
## Competence_PE_1 0.9198146 0.7405328 0.5170700
## Competence_PE_2 0.7405328 1.2493319 0.5849585
## Competence_PE_3 0.5170700 0.5849585 0.9884608
## Competence_PE_4 0.6180336 0.6683458 0.5179660
## Competence_PE_4
## Autonomy_PE_1 0.1740826
## Autonomy_PE_2 0.2597811
## Autonomy_PE_3 0.3481657
## Autonomy_PE_4 0.3708210
## Relatedness_PE_1 0.2687741
## Relatedness_PE_2 0.2347367
## Relatedness_PE_3 0.1945566
## Competence_PE_1 0.6180336
## Competence_PE_2 0.6683458
## Competence_PE_3 0.5179660
## Competence_PE_4 0.9589129
```

```
y_ab <- sqrt(x$ab.cov^2)
```

```
# Calculate the nearest positive definite matrices
pw_mat <- data.matrix(nearPD(x$pw.cov)$mat)
ab_mat <- data.matrix(nearPD(x$ab.cov)$mat)

# Combined
## Within
psych::alpha(pw_mat)
```

```
##
## Reliability analysis
## Call: psych::alpha(x = pw_mat)
##
##   raw_alpha std.alpha G6(smc) average_r S/N median_r
##       0.85      0.85      0.88      0.34 5.8      0.32
##
## Reliability if an item is dropped:
##           raw_alpha std.alpha G6(smc) average_r S/N var.r med.r
## Autonomy_PE_1      0.85      0.85      0.88      0.37 5.8 0.022 0.32
## Autonomy_PE_2      0.84      0.84      0.87      0.35 5.4 0.024 0.32
## Autonomy_PE_3      0.84      0.84      0.87      0.34 5.2 0.025 0.31
## Autonomy_PE_4      0.83      0.83      0.86      0.33 5.0 0.024 0.31
## Relatedness_PE_1    0.85      0.85      0.88      0.36 5.7 0.023 0.32
## Relatedness_PE_2    0.84      0.84      0.86      0.35 5.4 0.022 0.33
## Relatedness_PE_3    0.84      0.84      0.87      0.35 5.4 0.023 0.32
## Competence_PE_1     0.83      0.83      0.86      0.33 4.9 0.021 0.31
## Competence_PE_2     0.83      0.83      0.86      0.33 5.0 0.021 0.32
## Competence_PE_3     0.83      0.83      0.87      0.33 5.0 0.025 0.31
## Competence_PE_4     0.84      0.84      0.87      0.34 5.2 0.022 0.32
##
## Item statistics
##           r r.cor r.drop
## Autonomy_PE_1    0.50 0.42 0.38
## Autonomy_PE_2    0.61 0.57 0.50
## Autonomy_PE_3    0.65 0.60 0.55
## Autonomy_PE_4    0.72 0.70 0.64
## Relatedness_PE_1 0.53 0.46 0.42
## Relatedness_PE_2 0.59 0.56 0.49
## Relatedness_PE_3 0.59 0.55 0.49
## Competence_PE_1 0.74 0.73 0.66
## Competence_PE_2 0.71 0.68 0.62
## Competence_PE_3 0.70 0.67 0.62
## Competence_PE_4 0.66 0.63 0.56
```

```
## Between
psych::alpha(ab_mat, check.keys = TRUE)
```

```
## Warning in psych::alpha(ab_mat, check.keys = TRUE): Some items were negatively correlated
with total scale and were automatically reversed.
## This is indicated by a negative sign for the variable name.
```

```
##
## Reliability analysis
## Call: psych::alpha(x = ab_mat, check.keys = TRUE)
##
##      raw_alpha std.alpha G6(smc) average_r S/N median_r
##      0.84      0.83      1      0.31 4.9      0.27
##
## Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N var.r med.r
## Autonomy_PE_1      0.82      0.81      1      0.30 4.2  0.14 0.26
## Autonomy_PE_2      0.77      0.78      1      0.26 3.6  0.15 0.23
## Autonomy_PE_3      0.77      0.78      1      0.26 3.5  0.15 0.23
## Autonomy_PE_4      0.78      0.80      1      0.28 3.9  0.15 0.26
## Relatedness_PE_1    0.84      0.84      1      0.34 5.2  0.14 0.35
## Relatedness_PE_2    0.85      0.85      1      0.36 5.6  0.13 0.35
## Relatedness_PE_3-   0.83      0.79      1      0.27 3.7  0.17 0.22
## Competence_PE_1     0.84      0.84      1      0.34 5.2  0.17 0.38
## Competence_PE_2     0.83      0.84      1      0.35 5.4  0.13 0.31
## Competence_PE_3     0.82      0.80      1      0.29 4.1  0.15 0.26
## Competence_PE_4     0.85      0.85      1      0.36 5.7  0.16 0.45
##
## Item statistics
##      r r.cor r.drop
## Autonomy_PE_1    0.70 0.70 0.724
## Autonomy_PE_2    0.92 0.92 0.973
## Autonomy_PE_3    0.96 0.96 0.988
## Autonomy_PE_4    0.80 0.80 0.860
## Relatedness_PE_1 0.40 0.40 0.226
## Relatedness_PE_2 0.29 0.29 -0.011
## Relatedness_PE_3- 0.90 0.90 0.739
## Competence_PE_1 0.41 0.41 0.238
## Competence_PE_2 0.35 0.35 0.441
## Competence_PE_3 0.75 0.75 0.570
## Competence_PE_4 0.26 0.26 0.075
```

Autonomy subscale

```
## Within
psych::alpha(pw_mat[c(1:4), c(1:4)])
```



```
##
## Reliability analysis
## Call: psych::alpha(x = pw_mat[c(1:4), c(1:4)])
##
##   raw_alpha std.alpha G6(smc) average_r S/N median_r
##      0.78      0.78    0.75      0.47 3.6      0.46
##
## Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N var.r med.r
## Autonomy_PE_1    0.77    0.77    0.71      0.53 3.4 0.0146 0.55
## Autonomy_PE_2    0.70    0.71    0.63      0.45 2.4 0.0121 0.45
## Autonomy_PE_3    0.76    0.76    0.69      0.52 3.2 0.0109 0.46
## Autonomy_PE_4    0.66    0.66    0.57      0.40 2.0 0.0041 0.40
##
## Item statistics
##      r r.cor r.drop
## Autonomy_PE_1 0.72 0.56 0.50
## Autonomy_PE_2 0.80 0.72 0.62
## Autonomy_PE_3 0.73 0.59 0.52
## Autonomy_PE_4 0.85 0.81 0.71
```

```
## Between
psych::alpha(ab_mat[c(1:4), c(1:4)])
```

```
##
## Reliability analysis
## Call: psych::alpha(x = ab_mat[c(1:4), c(1:4)])
##
##   raw_alpha std.alpha G6(smc) average_r S/N median_r
##      0.95      0.97    0.97      0.88 29      0.87
##
## Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N var.r med.r
## Autonomy_PE_1    0.97    0.98    0.99      0.94 49 0.0018 0.95
## Autonomy_PE_2    0.92    0.94    0.92      0.84 15 0.0042 0.85
## Autonomy_PE_3    0.91    0.94    0.94      0.85 17 0.0089 0.82
## Autonomy_PE_4    0.92    0.96    0.96      0.88 23 0.0071 0.85
##
## Item statistics
##      r r.cor r.drop
## Autonomy_PE_1 0.90 0.84 0.83
## Autonomy_PE_2 0.98 0.99 0.96
## Autonomy_PE_3 0.98 0.98 0.95
## Autonomy_PE_4 0.95 0.94 0.89
```

Relatedness subscale

```
## Within
psych::alpha(pw_mat[c(5:7), c(5:7)], check.keys = T)
```

```
##
## Reliability analysis
## Call: psych::alpha(x = pw_mat[c(5:7), c(5:7)], check.keys = T)
##
##      raw_alpha std.alpha G6(smc) average_r S/N median_r
##      0.79      0.79      0.74      0.55 3.7      0.53
##
## Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N var.r med.r
## Relatedness_PE_1      0.82      0.82      0.70      0.70 4.6      NA 0.70
## Relatedness_PE_2      0.59      0.59      0.42      0.42 1.4      NA 0.42
## Relatedness_PE_3      0.69      0.69      0.53      0.53 2.3      NA 0.53
##
## Item statistics
##      r r.cor r.drop
## Relatedness_PE_1 0.78 0.58 0.52
## Relatedness_PE_2 0.89 0.83 0.73
## Relatedness_PE_3 0.84 0.75 0.64
```

```
## Between
psych::alpha(ab_mat[c(5:7), c(5:7)], check.keys = T)
```

```
## Warning in psych::alpha(ab_mat[c(5:7), c(5:7)], check.keys = T): Some items were negative
ly correlated with total scale and were automatically reversed.
## This is indicated by a negative sign for the variable name.
```

```
##
## Reliability analysis
## Call: psych::alpha(x = ab_mat[c(5:7), c(5:7)], check.keys = T)
##
##      raw_alpha std.alpha G6(smc) average_r S/N median_r
##      0.65      0.75      0.69      0.5 3      0.48
##
## Reliability if an item is dropped:
##      raw_alpha std.alpha G6(smc) average_r S/N var.r med.r
## Relatedness_PE_1      0.60      0.65      0.48      0.48 1.9      NA 0.48
## Relatedness_PE_2      0.35      0.55      0.38      0.38 1.2      NA 0.38
## Relatedness_PE_3-      0.68      0.79      0.65      0.65 3.7      NA 0.65
##
## Item statistics
##      r r.cor r.drop
## Relatedness_PE_1 0.83 0.71 0.63
## Relatedness_PE_2 0.87 0.79 0.69
## Relatedness_PE_3- 0.76 0.54 0.45
```

Competence subscale

```
## Within
psych::alpha(pw_mat[c(8:11), c(8:11)], check.keys = T)
```

```
##
## Reliability analysis
## Call: psych::alpha(x = pw_mat[c(8:11), c(8:11)], check.keys = T)
##
##   raw_alpha std.alpha G6(smc) average_r S/N median_r
##      0.85      0.85      0.82      0.59 5.8      0.58
##
## Reliability if an item is dropped:
##           raw_alpha std.alpha G6(smc) average_r S/N  var.r med.r
## Competence_PE_1      0.79      0.79      0.72      0.56 3.8 0.0022 0.53
## Competence_PE_2      0.80      0.80      0.74      0.58 4.1 0.0049 0.54
## Competence_PE_3      0.85      0.85      0.79      0.65 5.6 0.0016 0.66
## Competence_PE_4      0.81      0.81      0.75      0.59 4.3 0.0082 0.54
##
## Item statistics
##           r r.cor r.drop
## Competence_PE_1 0.87 0.82 0.75
## Competence_PE_2 0.85 0.78 0.72
## Competence_PE_3 0.78 0.65 0.61
## Competence_PE_4 0.84 0.76 0.70
```

```
## Between
psych::alpha(ab_mat[c(8:11), c(8:11)], check.keys = T)
```

```
## Warning in psych::alpha(ab_mat[c(8:11), c(8:11)], check.keys = T): Some items were negatively correlated with total scale and were automatically reversed.
## This is indicated by a negative sign for the variable name.
```

```
##
## Reliability analysis
## Call: psych::alpha(x = ab_mat[c(8:11), c(8:11)], check.keys = T)
##
##   raw_alpha std.alpha G6(smc) average_r S/N median_r
##      0.18      0.22      0.22      0.065 0.28      0.019
##
## Reliability if an item is dropped:
##           raw_alpha std.alpha G6(smc) average_r S/N  var.r
## Competence_PE_1      0.21      0.24      0.20      0.094 0.31 0.02116
## Competence_PE_2     -0.13     -0.16     -0.10     -0.048 -0.14 0.00041
## Competence_PE_3-      0.18      0.19      0.16      0.071 0.23 0.01982
## Competence_PE_4      0.27      0.33      0.28      0.142 0.50 0.02357
##
##           med.r
## Competence_PE_1 0.072
## Competence_PE_2 -0.039
## Competence_PE_3- 0.072
## Competence_PE_4 0.210
##
## Item statistics
##           r r.cor r.drop
## Competence_PE_1 0.51 0.162 0.027
## Competence_PE_2 0.70 0.636 0.335
## Competence_PE_3- 0.54 0.246 0.086
## Competence_PE_4 0.44 -0.019 -0.030
```

Criterion validity