CFA Example Using Forgiveness of Situations

The Forgiveness of Situation Subscale includes 6 items, 3 of which are reverse-coded, on a 7-point scale:

1. When things go wrong for reasons that can't be controlled, I get stuck in negative thoughts about it. **(R)**
2. With time I can be understanding of bad circumstances in my life.
3. If I am disappointed by uncontrollable circumstances in my life, I continue to think negatively about them. **(R)**
4. I eventually make peace with bad situations in my life.
5. It's really hard for me to accept negative situations that aren't anybody's fault. **(R)**
6. Eventually I let go of negative thoughts about bad circumstances that are beyond anyone's control.

Response Anchors:

1 = Almost Always False of Me
3 = More Often False of Me
5 = More Often True of Me
7 = Almost Always True of Me

N =1103

Observed Correlation Matrix

	R1	2	R3	4	R5	6
R1	**1.000**					
2	0.240	**1.000**				
R3	**0.647**	0.317	**1.000**			
4	0.300	**0.570**	0.369	**1.000**		
R5	**0.453**	0.255	**0.482**	0.289	**1.000**	
6	0.297	**0.457**	0.356	**0.448**	0.304	**1.000**
Means	4.547	5.289	4.896	5.359	4.860	5.321
Variances	3.049	1.903	2.543	1.967	2.945	2.341

Observed Covariance Matrix

	R1	2	R3	4	R5	6
R1	**3.049**					
2	0.577	**1.903**				
R3	1.802	0.697	**2.543**			
4	0.734	1.103	0.824	**1.967**		
R5	1.358	0.604	1.319	0.695	**2.945**	
6	0.795	0.965	0.868	0.962	0.798	**2.341**

To do CFA analysis, you only need means, variances, and either correlations or covariances among items:

Covariance = Correlation * SD(X) *SD(Y)
Correlation = Covariance / SD(X) * SD(Y)

Mplus Code to Read in Data:

```
TITLE:      CFA of Situation Factor
DATA:       FILE IS Study2.dat;          ! Don't need path if in same directory
            FORMAT IS free;              ! Default
            TYPE IS INDIVIDUAL;          ! Default

VARIABLE:   NAMES ARE Self1 Self2r Self3 Self4r Self5 Self6r
                      Other1r Other2 Other3r Other4 Other5r Other6
                      Sit1r Sit2 Sit3r Sit4 Sit5r Sit6
                      Selfsub Othsub Sitsub HFSsum;              ! Every variable in DATASET

            USEVARIABLES ARE Sit1r Sit2 Sit3r Sit4 Sit5r Sit6;   ! Every variable in MODEL
            MISSING ARE ALL (99999);

ANALYSIS:   TYPE IS GENERAL;             ! Default
            ESTIMATOR IS ML;             ! Default if TYPE=GENERAL and all continuous items

MODEL:      (model syntax goes here, to be changed for each model)
OUTPUT:     SAMPSTAT              ! Sample descriptives to verify data
            MODINDICES            ! Voodoo suggestions to improve the model
            STDYX                 ! Requests fully standardized solution
            RESIDUAL;             ! Requests normalized residuals
```

Model 1. Fully Z-Scored Factor Model Identification
(Factor Variance = 1, Factor Mean = 0, All Loadings and Intercepts Estimated)

The following code refers to EVERY model parameter for completeness:

```
!Model 1 - Fully Z-Scored Factor Identification Approach

    ! Item factor loadings --> @=fixed, *=free
       Sit BY Sit1r* Sit2* Sit3r* Sit4* Sit5r* Sit6*;

    ! Item intercepts --> [ ] indicates means or intercepts
       [Sit1r* Sit2* Sit3r* Sit4* Sit5r* Sit6*];

    ! Item error variances --> just list item by itself
       Sit1r* Sit2* Sit3r* Sit4* Sit5r* Sit6*;

    ! Factor variance --> just list factor by itself
       Sit@1;

    ! Factor mean --> [ ] indicates means or intercepts
       [Sit@0];
```

In reality, all you'd need to write to define this model is:

```
    ! Item factor loadings --> @=fixed, *=free
       Sit BY Sit1r* Sit2* Sit3r* Sit4* Sit5r* Sit6*;

    ! Factor variance --> just list factor by itself
       Sit@1;
```

All intercepts are estimated and the factor mean is fixed at 0 by default.
All residual variances for the items are estimated by default, too.
Factor variances and covariances are estimated by default unless specified otherwise.

Model 1. Fully Z-Scored Factor Model Identification
(Factor Variance = 1, Factor Mean = 0, All Loadings and Intercepts Estimated)

UNSTANDARDIZED MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
FACTOR LOADINGS (regression slopes of item response on factor)				
SIT BY				
SIT1R	1.234	0.053	23.145	0.000
SIT2	0.702	0.047	14.882	0.000
SIT3R	1.241	0.048	25.939	0.000
SIT4	0.784	0.047	16.765	0.000
SIT5R	1.023	0.052	19.667	0.000
SIT6	0.819	0.050	16.317	0.000
Means (of Factor)				
999 = "cannot be computed" - here, because the parameter is fixed to 1 already				
SIT	0.000	0.000	999.000	999.000
Intercepts (of Items) - HERE, ARE ACTUAL ITEM MEANS				
SIT1R	4.547	0.053	86.474	0.000
SIT2	5.289	0.042	127.347	0.000
SIT3R	4.896	0.048	101.959	0.000
SIT4	5.359	0.042	126.896	0.000
SIT5R	4.860	0.052	94.060	0.000
SIT6	5.321	0.046	115.493	0.000
Variances (of Factor)				
SIT	1.000	0.000	999.000	999.000
Residual Variances (variance of e's)				
SIT1R	1.526	0.094	16.165	0.000
SIT2	1.409	0.071	19.859	0.000
SIT3R	1.004	0.078	12.945	0.000
SIT4	1.352	0.071	19.118	0.000
SIT5R	1.899	0.093	20.388	0.000
SIT6	1.671	0.083	20.054	0.000

Making use of the unstandardized model estimates:

Writing out the model – individual predicted values:

$Y_1 = \mu_1 + \lambda_1 F + e_1$

$Y_1 = 4.547 + 1.234F + e_1$

Writing out the model – predicted item variances and covariances:

$Var(Y_1) = (\lambda_1^2)\, Var(F) + Var(e_1)$

$Var(Y_1) = (1.234^2)*(1) + 1.526 = 3.049$ (= original item variance)

$Cov(Y_1,Y_2) = \lambda_1 * Var(F) * \lambda_2$

$Cov(Y_1,Y_2) = (1.234)*(1)*(.702) = .866$ (actual = .577, so over-predicted)

STDYX STANDARDIZED MODEL RESULTS (FULLY STANDARDIZED WITH RESPECT TO X & Y)

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
FACTOR LOADINGS (correlations of item response with factor)				
Square these to get reliability (proportion "true variance") per item				
SIT BY				
SIT1R	0.707	0.022	32.280	0.000
SIT2	0.509	0.030	17.174	0.000
SIT3R	0.778	0.020	38.487	0.000
SIT4	0.559	0.028	20.074	0.000
SIT5R	0.596	0.023	25.419	0.000
SIT6	0.535	0.028	19.405	0.000
Means (of Factor)				
SIT	0.000	0.000	999.000	999.000
Intercepts (of Items) → is intercept / SD(Y) → not usually reported				
SIT1R	2.604	0.063	41.273	0.000
SIT2	3.834	0.087	44.067	0.000
SIT3R	3.070	0.072	42.659	0.000
SIT4	3.821	0.087	44.048	0.000
SIT5R	2.832	0.067	42.021	0.000
SIT6	3.477	0.080	43.508	0.000
Variances (of Factor) → will always be 1 in a standardized solution				
SIT	1.000	0.000	999.000	999.000
Residual Variances (variance of e's)				
SIT1R	0.500	0.031	16.168	0.000
SIT2	0.741	0.030	24.521	0.000
SIT3R	0.395	0.031	12.549	0.000
SIT4	0.687	0.031	22.047	0.000
SIT5R	0.645	0.028	23.056	0.000
SIT6	0.714	0.030	24.167	0.000
R-SQUARE (equals 1-residual variance OR standardized loading squared in standardized metric)				
SIT1R	0.500	0.031	16.140	0.000
SIT2	0.259	0.030	8.587	0.000
SIT3R	0.605	0.031	19.244	0.000
SIT4	0.313	0.031	10.037	0.000
SIT5R	0.355	0.028	12.709	0.000
SIT6	0.286	0.030	9.702	0.000

The standardized solution will look identical across methods of model identification with respect to the factor loadings, error variances, and R-square values for the items. The standardized intercepts will change because they depend on the unstandardized intercepts (but nobody reports them anyway).

Making use of the standardized model estimates:

Writing out the model – predicted item correlations:

$Corr(Y_1,Y_2) = \lambda_1 * Var(F) * \lambda_2$

$Corr(Y_1,Y_2) = (.707)*(1)*(.509) = .360$ (actual = .240, so over-predicted)

Calculating Omega Model-Based Reliability:

Omega = (sum of loadings)^2 / [(sum of loadings)^2 + sum residual variances]
Sum of loadings = (.707 + .509 + .778 + .559 + .596 + .535) = 3.684
Sum of residual variances = 3.682

Omega = 3.684^2 / (3.684^2 + 3.682) = .787

Now let's see the model parameters when using the marker item approach to model identification…
Model 2. Marker Item Loading = 1, Factor Mean = 0 (Factor Variance, All Intercepts Estimated)

```
! Model 2 -- Marker Item Loading with Factor Mean = 0
    Sit BY Sit1r@1 Sit2* Sit3r* Sit4* Sit5r* Sit6*;     ! Loadings (#1 fixed=1)
    [Sit1r* Sit2* Sit3r* Sit4* Sit5r* Sit6*];           ! Intercepts (all free)
    Sit1r* Sit2* Sit3r* Sit4* Sit5r* Sit6*;             ! Residual variances (all free)
    Sit*;                                               ! Factor variance (free)
    [Sit@0];                                            ! Factor mean (fixed=0)
```

UNSTANDARDIZED MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
FACTOR LOADINGS (regression slopes of item response on factor)				
Here, loading for SIT1R is not tested because it is fixed=1				
SIT BY				
SIT1R	1.000	0.000	999.000	999.000
SIT2	0.569	0.046	12.293	0.000
SIT3R	1.005	0.044	22.627	0.000
SIT4	0.636	0.047	13.512	0.000
SIT5R	0.829	0.049	16.890	0.000
SIT6	0.664	0.050	13.402	0.000
Means (of Factor)				
SIT	0.000	0.000	999.000	999.000
Intercepts (of Items) - EXPECTED Y WHEN FACTOR = 0				
HERE, WHICH IS WHEN ITEM 1 = MEAN				
SIT1R	4.547	0.053	86.474	0.000
SIT2	5.289	0.042	127.346	0.000
SIT3R	4.896	0.048	101.959	0.000
SIT4	5.359	0.042	126.896	0.000
SIT5R	4.860	0.052	94.060	0.000
SIT6	5.321	0.046	115.493	0.000
Variances (of Factor)				
SIT	1.523	0.132	11.573	0.000
Residual Variances (variances of e's)				
SIT1R	1.526	0.094	16.165	0.000
SIT2	1.409	0.071	19.859	0.000
SIT3R	1.004	0.078	12.945	0.000
SIT4	1.352	0.071	19.118	0.000
SIT5R	1.899	0.093	20.388	0.000
SIT6	1.671	0.083	20.054	0.000

Model 3. Marker Item Loading = 1 and Intercept = 0 (Factor Variance and Mean Estimated)

```
! Model 3 -- Marker Item Loading and Intercept
    Sit BY Sit1r@1 Sit2* Sit3r* Sit4* Sit5r* Sit6*;     ! Loadings (1 fixed=1)
    [Sit1r@0 Sit2* Sit3r* Sit4* Sit5r* Sit6*];          ! Intercepts (1 fixed=0)
    Sit1r* Sit2* Sit3r* Sit4* Sit5r* Sit6*;             ! Residual variances (all free)
    Sit*;                                               ! Factor variance (free)
    [Sit*];                                             ! Factor mean (free)
```

Means (of Factor) → Note is mean of marker item				
SIT	4.547	0.053	86.474	0.000
Intercepts (of Items) - EXPECTED Y WHEN FACTOR = 0				
HERE, WHICH IS WHEN ITEM 1 = 0 → beyond scale of item, so values are very low				
SIT1R	0.000	0.000	999.000	999.000
SIT2	2.701	0.215	12.588	0.000
SIT3R	0.325	0.208	1.567	0.117
SIT4	2.469	0.218	11.325	0.000
SIT5R	1.092	0.229	4.767	0.000
SIT6	2.304	0.230	10.026	0.000

Calculating model degrees of freedom:

Total df = [p(p+1) / 2] + p = 27
Spent by model = 18
Leftover df = 9

Model fit information for a single-factor model (same regardless of identification method):

Chi-Square Test of Model Fit (Significance is bad here)

Value	427.937
Degrees of Freedom	9 → leftover after estimating our model
P-Value	0.0000

Chi-Square Test of Model Fit for the Baseline Model (fit if no covariance modeled at all)

Value	1981.034
Degrees of Freedom	15 → leftover if just means and variances of items
P-Value	0.0000

CFI/TLI (want close to 1)

CFI	0.787
TLI	0.645

Loglikelihood (in SAS, is given as -2LL instead)

H0 Value	-11536.404
H1 Value	-11322.435

Information Criteria (smaller is better)

Number of Free Parameters	18 → actually df spent, not "free"
Akaike (AIC)	23108.808
Bayesian (BIC)	23198.912
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	23141.739

RMSEA (Root Mean Square Error Of Approximation)(want close to 0)

Estimate		0.205
90 Percent C.I.	0.189	0.222
Probability RMSEA <= .05		0.000

SRMR (Standardized Root Mean Square Residual)(want close to 0)

Value	0.086

Not so good… what do the voo-doo modification indices suggest we do to fix it?

MODEL MODIFICATION INDICES
Minimum M.I. value for printing the modification index 10.000
EPC = EXPECTED PARAMETER CHANGE

WITH Statements (SUGGESTED ERROR COVARIANCES)

		M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
SIT2	WITH SIT1R	68.990	-0.464	-0.464	-0.316
SIT3R	**WITH SIT1R**	**199.696**	**1.023**	**1.023**	**0.827**
SIT3R	WITH SIT2	48.510	-0.357	-0.357	-0.300
SIT4	WITH SIT1R	50.443	-0.403	-0.403	-0.280
SIT4	**WITH SIT2**	**224.292**	**0.702**	**0.702**	**0.509**
SIT4	WITH SIT3R	40.618	-0.336	-0.336	-0.288
SIT6	WITH SIT1R	33.475	-0.358	-0.358	-0.224
SIT6	**WITH SIT2**	**88.831**	**0.486**	**0.486**	**0.317**
SIT6	WITH SIT3R	31.132	-0.319	-0.319	-0.246
SIT6	WITH SIT4	64.705	0.415	0.415	0.276

Another approach – how about we examine local fit and see where the problems seem to be?
The means and variances of the items will be perfectly reproduced, so that's not an issue…
misfit boils down to the difference between the observed and model-predicted covariances.

Although Mplus gives us the residual (defined as observed – predicted) covariance matrix, it is scale dependent and thus not so helpful. We can calculate the residual correlation matrix instead:

Residual Correlation Matrix	R1	2	R3	4	R5	6
R1						
2	-0.120					
R3	0.097	-0.079				
4	-0.095	**0.285**	-0.066			
R5	0.032	-0.048	0.018	-0.044		
6	-0.081	**0.185**	-0.060	**0.149**	-0.015	

Mplus also gives us "normalized" residuals, which can be thought of as z-scores for how large the residual is in absolute terms. Because the denominator decreases with sample size, however, these values may be inflated in large samples.

"Normalized" Residuals = (obs – exp) / SD(obs)

Normalized Residuals for Covariances/Correlations/Residual Correlations

	SIT1R	SIT2	SIT3R	SIT4	SIT5R	SIT6
SIT1R	0.000					
SIT2	-3.887	0.000				
SIT3R	2.713	-2.506	0.000			
SIT4	-3.043	**8.229**	-2.075	0.000		
SIT5R	0.966	-1.555	0.545	-1.429	0.000	
SIT6	-2.575	**5.579**	-1.904	**4.510**	-0.479	0.000

NEGATIVE NORMALIZED RESIDUAL → Less related than you predicted
POSITIVE NORMALIZED RESIDUAL → More related than you predicted

Why might the normalized residuals (residual correlations) for the positive-worded items be larger than for the negatively-worded items?

These results suggest that wording valence is playing a larger role than what the one-factor model predicts. Rather than adding voo-doo error covariances, how about a two-factor model instead?

Model 4. Fully Z-Scored, 2-Factor Model

```
! Model 4 -- Fully Z-Scored 2-Factor Model
    SitP BY Sit2*  Sit4*  Sit6*;              ! SitP loadings (all free)
    SitN BY Sit1r* Sit3r* Sit5r*;            ! SitN loadings (all free)
    [Sit2*  Sit4*  Sit6];                    ! SitP intercepts (all free)
    [Sit1r* Sit3r* Sit5r*];                  ! SitN intercepts (all free)
    Sit2*   Sit4*  Sit6;                     ! SitP residual variances (all free)
    Sit1r*  Sit3r* Sit5r*;                   ! SitN residual variances (all free)
    SitP@1; SitN@1;                          ! Factor variances (fixed=1)
    SitP WITH SitN*;                         ! Factor covariance (free)
    [SitP@0 SitN@0];                         ! Factor means (fixed=0)
```

Chi-Square Test of Model Fit

Value	35.410
Degrees of Freedom	8
P-Value	0.0000

CFI/TLI

CFI	0.986
TLI	0.974

Information Criteria

Number of Free Parameters	19
Akaike (AIC)	22718.281
Bayesian (BIC)	22813.391
Sample-Size Adjusted BIC (n* = (n + 2) / 24)	22753.042

RMSEA (Root Mean Square Error Of Approximation)

Estimate		0.056
90 Percent C.I.	0.038	0.075
Probability RMSEA <= .05		0.277

SRMR (Standardized Root Mean Square Residual)

Value	0.029

Is the 2-factor model better than the 1-factor model? How do we know?

UNSTANDARDIZED RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
SITP BY				
SIT2	1.007	0.042	24.075	0.000
SIT4	1.064	0.043	24.971	0.000
SIT6	0.956	0.048	19.931	0.000
SITN BY				
SIT1R	1.325	0.051	26.124	0.000
SIT3R	1.349	0.046	29.386	0.000
SIT5R	1.009	0.052	19.280	0.000
SITP WITH SITN = Covariance between factors (= correlation if variances=1)				
	0.564	**0.030**	**18.976**	**0.000**
Means				
SITP	0.000	0.000	999.000	999.000
SITN	0.000	0.000	999.000	999.000
Intercepts				
SIT1R	4.547	0.053	86.474	0.000
SIT2	5.289	0.042	127.346	0.000
SIT3R	4.896	0.048	101.959	0.000
SIT4	5.359	0.042	126.896	0.000
SIT5R	4.860	0.052	94.060	0.000
SIT6	5.321	0.046	115.493	0.000
Variances				
SITP	1.000	0.000	999.000	999.000
SITN	1.000	0.000	999.000	999.000
Residual Variances				
SIT1R	1.294	0.085	15.187	0.000
SIT2	0.888	0.058	15.231	0.000
SIT3R	0.724	0.074	9.766	0.000
SIT4	0.835	0.061	13.669	0.000
SIT5R	1.926	0.094	20.419	0.000
SIT6	1.428	0.077	18.660	0.000

STDYX STANDARDIZED RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
SITP BY				
SIT2	0.730	0.021	34.325	0.000
SIT4	0.759	0.021	36.144	0.000
SIT6	0.625	0.024	25.724	0.000
SITN BY				
SIT1R	0.759	0.019	39.934	0.000
SIT3R	0.846	0.018	47.325	0.000
SIT5R	0.588	0.024	24.663	0.000
Residual Variances				
SIT1R	0.425	0.029	14.729	0.000
SIT2	0.467	0.031	15.023	0.000
SIT3R	0.285	0.030	9.421	0.000
SIT4	0.425	0.032	13.333	0.000
SIT5R	0.654	0.028	23.313	0.000
SIT6	0.610	0.030	20.107	0.000
R-SQUARE				
SIT1R	0.575	0.029	19.967	0.000
SIT2	0.533	0.031	17.162	0.000
SIT3R	0.715	0.030	23.662	0.000
SIT4	0.575	0.032	18.072	0.000
SIT5R	0.346	0.028	12.332	0.000
SIT6	0.390	0.030	12.862	0.000

Omega for Positive Factor = .58

Omega for Negative Factor = .57

Any more local fit problems? Maybe…

Residuals of covariance matrix (so unstandardized):

	SIT1R	SIT2	SIT3R	SIT4	SIT5R	SIT6
SIT1R	0.000					
SIT2	-0.176	0.000				
SIT3R	0.016	-0.069	0.000			
SIT4	-0.062	0.031	0.015	0.000		
SIT5R	0.021	0.030	-0.042	0.089	0.000	
SIT6	0.080	0.003	0.140	-0.055	0.254	0.000

"Normalized" residuals

	SIT1R	SIT2	SIT3R	SIT4	SIT5R	SIT6
SIT1R	0.000					
SIT2	**-2.358**	0.000				
SIT3R	0.157	-0.997	0.000			
SIT4	-0.799	0.464	0.203	0.000		
SIT5R	0.214	0.414	-0.462	1.175	0.000	
SIT6	0.955	0.036	1.797	-0.777	**3.071**	0.000

Any suggested voo-doo?

MODEL MODIFICATION INDICES

Minimum M.I. value for printing the modification index 10.000

		M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
BY Statements - these are cross-loadings					
SITN	BY SIT2	13.888	-0.224	-0.224	-0.162
SITN	BY SIT6	15.383	0.245	0.245	0.160
WITH Statements - these are error covariances					
SIT4	WITH SIT2	15.386	0.332	0.332	0.386
SIT6	WITH SIT4	13.884	-0.273	-0.273	-0.250

Because we have no real reason to fit any of these suggested parameters, we will not add any new parameters. This will be about as good as it gets.

One last example: Formal Tests of CTT Assumptions

We first test the CTT assumption of tau-equivalence (equal factor loadings):

```
! Model 5 -- Tau-Equivalent Items 2-Factor Model
    SitP BY Sit2*  Sit4*  Sit6*   (1);          ! SitP loadings (all held equal)
    SitN BY Sit1r* Sit3r* Sit5r*  (2);          ! SitN loadings (all held equal)
    [Sit2*  Sit4*  Sit6];                       ! SitP intercepts (all free)
    [Sit1r* Sit3r* Sit5r*];                     ! SitN intercepts (all free)
    Sit2*  Sit4*  Sit6;                         ! SitP residual variances (all free)
    Sit1r* Sit3r* Sit5r*;                       ! SitN residual variances (all free)
    SitP@1; SitN@1;                             ! Factor variances (fixed=1)
    SitP WITH SitN*;                            ! Factor covariance (free)
    [SitP@0 SitN@0];                            ! Factor means (fixed=0)
```

UNSTANDARDIZED MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
SITP BY				
SIT2	1.014	0.029	34.721	0.000
SIT4	1.014	0.029	34.721	0.000
SIT6	1.014	0.029	34.721	0.000
SITN BY				
SIT1R	1.254	0.035	36.261	0.000
SIT3R	1.254	0.035	36.261	0.000
SIT5R	1.254	0.035	36.261	0.000
Residual Variances				
SIT1R	1.335	0.075	17.866	0.000
SIT2	0.882	0.052	16.867	0.000
SIT3R	0.857	0.059	14.582	0.000
SIT4	0.887	0.052	16.973	0.000
SIT5R	1.805	0.094	19.148	0.000
SIT6	1.382	0.071	19.358	0.000

STANDARDIZED STYDX MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
SITP BY				
SIT2	0.734	0.015	49.347	0.000
SIT4	0.733	0.015	49.041	0.000
SIT6	0.653	0.015	44.691	0.000
SITN BY				
SIT1R	0.735	0.014	52.318	0.000
SIT3R	0.804	0.014	58.783	0.000
SIT5R	0.682	0.013	51.054	0.000
Residual Variances				
SIT1R	0.459	0.021	22.218	0.000
SIT2	0.462	0.022	21.166	0.000
SIT3R	0.353	0.022	16.025	0.000
SIT4	0.463	0.022	21.158	0.000
SIT5R	0.534	0.018	29.308	0.000
SIT6	0.573	0.019	30.044	0.000

Why are the standardized loadings not held equal like the unstandardized loadings are?

Fit of previous 2-factor model:

Chi-Square Test of Model Fit

Value		35.410
Degrees of Freedom		8
P-Value		0.0000

CFI/TLI

CFI		0.986
TLI		0.974

RMSEA

Estimate		0.056
90 Percent C.I.	0.038	0.075
Probability RMSEA <= .05		0.277

Fit of tau-equivalent items 2-factor model:

Chi-Square Test of Model Fit

Value		73.500
Degrees of Freedom		12
P-Value		0.0000

CFI/TLI

CFI		0.969
TLI		0.961

RMSEA

Estimate		0.068
90 Percent C.I.	0.054	0.084
Probability RMSEA <= .05		0.021

Does the assumption of tau-equivalence hold? How do we know?

The previous model tests of the assumption of tau-equivalence for both factors at once. It is possible, however, that it might hold for one factor and not the other, in which case we would be misled. Given the pattern of loadings, let's test tau-equivalence only for the positive factor instead:

```
! Model 6 -- Tau-Equivalent Items on Positive Only 2-Factor Model
    SitP BY Sit2*  Sit4*  Sit6*   (1);          ! SitP loadings (all held equal)
    SitN BY Sit1r* Sit3r* Sit5r*     ;          ! SitN loadings (all free now)
    (rest same)
```

```
Chi-Square Test of Model Fit
          Value                             38.676
          Degrees of Freedom                    10
          P-Value                           0.0000
CFI/TLI
          CFI                                0.985
          TLI                                0.978
RMSEA
          Estimate                           0.051
          90 Percent C.I.                    0.035  0.068
          Probability RMSEA <= .05           0.429
```

What do we conclude?

```
UNSTANDARDIZED MODEL RESULTS
                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
 SITP     BY
    SIT2               1.014      0.029     34.724      0.000
    SIT4               1.014      0.029     34.724      0.000
    SIT6               1.014      0.029     34.724      0.000

 SITN     BY
    SIT1R              1.325      0.051     26.132      0.000
    SIT3R              1.349      0.046     29.397      0.000
    SIT5R              1.010      0.052     19.289      0.000

 Residual Variances
    SIT1R              1.295      0.085     15.206      0.000
    SIT2               0.881      0.052     16.855      0.000
    SIT3R              0.725      0.074      9.784      0.000
    SIT4               0.886      0.052     16.963      0.000
    SIT5R              1.925      0.094     20.415      0.000
    SIT6               1.384      0.072     19.359      0.000
```

```
STANDARDIZED STDYX MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value
 SITP     BY
    SIT2               0.734      0.015     49.359      0.000
    SIT4               0.733      0.015     49.051      0.000
    SIT6               0.653      0.015     44.678      0.000
 SITN     BY
    SIT1R              0.759      0.019     39.966      0.000
    SIT3R              0.846      0.018     47.375      0.000
    SIT5R              0.588      0.024     24.680      0.000
 Residual Variances
    SIT1R              0.425      0.029     14.747      0.000
    SIT2               0.461      0.022     21.149      0.000
    SIT3R              0.285      0.030      9.438      0.000
    SIT4               0.463      0.022     21.143      0.000
    SIT5R              0.654      0.028     23.301      0.000
    SIT6               0.574      0.019     30.071      0.000
```

Given that tau-equivalence held for the positive factor, we can also test the assumption of parallel items as equal residual variances:

```
! Model 7 -- Parallel Items on Positive Only 2-Factor Model
    SitP BY Sit2*  Sit4*  Sit6*   (1);          ! SitP loadings (all held equal)
    SitN BY Sit1r* Sit3r* Sit5r*     ;          ! SitN loadings (all free)
    Sit2*  Sit4*  Sit6             (3);          ! SitP residual variances (all held equal)
    Sit1r* Sit3r* Sit5r*              ;          ! SitN residual variances (all free)
    (rest same)

Chi-Square Test of Model Fit
          Value                             79.049
          Degrees of Freedom                   12
          P-Value                          0.0000
CFI/TLI
          CFI                               0.966
          TLI                               0.957
RMSEA
          Estimate                          0.071
          90 Percent C.I.               0.057  0.086
          Probability RMSEA <= .05          0.009
```

What do we conclude?

```
UNSTANDARDIZED MODEL RESULTS

                                                    Two-Tailed
                    Estimate       S.E.  Est./S.E.    P-Value

 SITP     BY
    SIT2               1.005      0.029     34.221      0.000
    SIT4               1.005      0.029     34.221      0.000
    SIT6               1.005      0.029     34.221      0.000
 Residual Variances
    SIT2               1.060      0.032     33.212      0.000
    SIT4               1.060      0.032     33.212      0.000
    SIT6               1.060      0.032     33.212      0.000

STANDARDIZED STDYX MODEL RESULTS

 SITP     BY
    SIT2               0.698      0.013     55.463      0.000
    SIT4               0.698      0.013     55.463      0.000
    SIT6               0.698      0.013     55.463      0.000
 Residual Variances
    SIT2               0.512      0.018     29.117      0.000
    SIT4               0.512      0.018     29.117      0.000
    SIT6               0.512      0.018     29.117      0.000
```