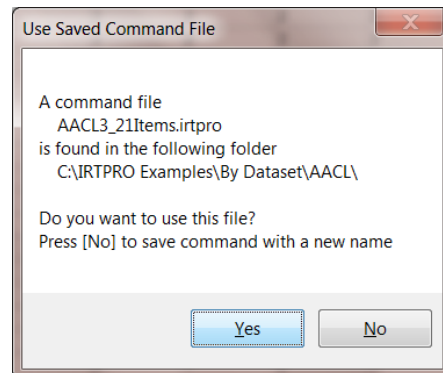# IRTPRO™

## Multidimensional analysis of the Affect Adjective Check List (AACL)

To obtain a better fit than was obtained with a unidimensional model, we consider a two-dimensional model that fits one factor (latent variable) for the "anxiety-plus" items and a second (correlated) factor for the "anxiety-minus" items. See elsewhere for a description of the data and the recoding of item scores. Open the file **AACL_21Items.ssig** stored in the folder **C:\IRTPRO Examples\by DataSet\AACL**, and then select **Multidimensional IRT …** under the **Analysis** menu. A **Use Saved Command File** dialog appears. Click the **Yes** button and insert a second test by right-clicking on the right-hand side of the **UniDallItems** tab.

Use Saved Command File

A command file
    AACL3_21Items.irtpro
is found in the following folder
    C:\IRTPRO Examples\By Dataset\AACL\

Do you want to use this file?
Press [No] to save command with a new name

Yes   No

Rename the **Test2** tab to **TwoFactor**, enter a title and comments and select all 21 items. Change the number of dimensions to two as shown below.

The particular two-dimensional model to be fitted to these data is a "simple structure" confirmatory factor analysis (CFA) model, which has non-zero slopes (or factor loadings) for the first eleven "anxiety-plus" adjectives on the first factor, non-zero slopes (or factor loadings) for the final ten "anxiety-minus" adjectives on the second factor, and zero slopes (or loadings) for the other combinations.

In addition, the correlation between the two latent variables (for the "anxiety-plus" adjectives and the "anxiety-minus" adjectives) is estimated.
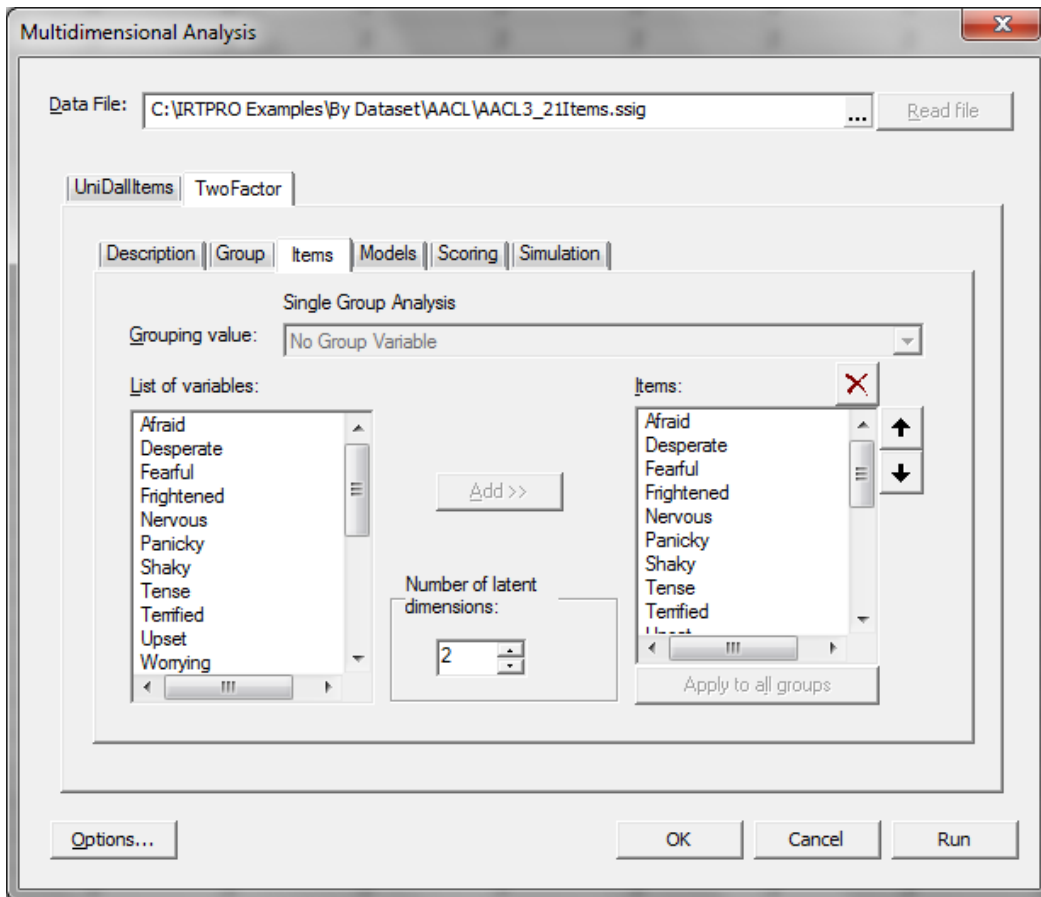
To set up the constraints in the IRTPRO graphical user interface (GUI), we click on the **Models** tab. Recode item scores of the first eleven items.
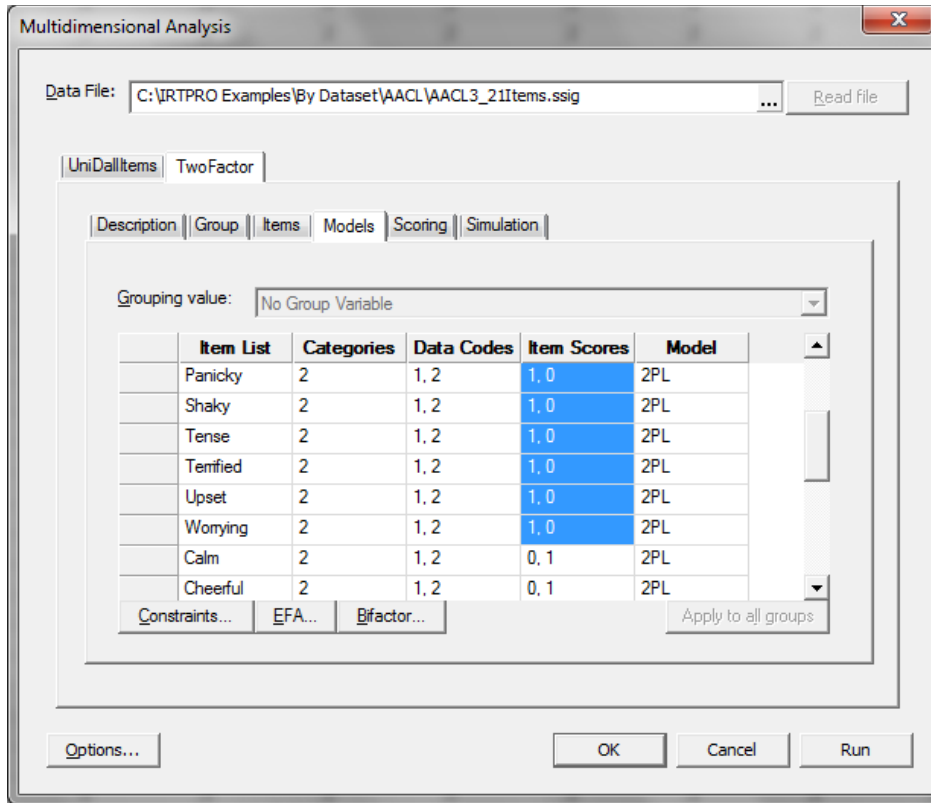
Once done, click on the **Constraints** button beneath the item list, and that shows the **Item Parameter Constraints** window:
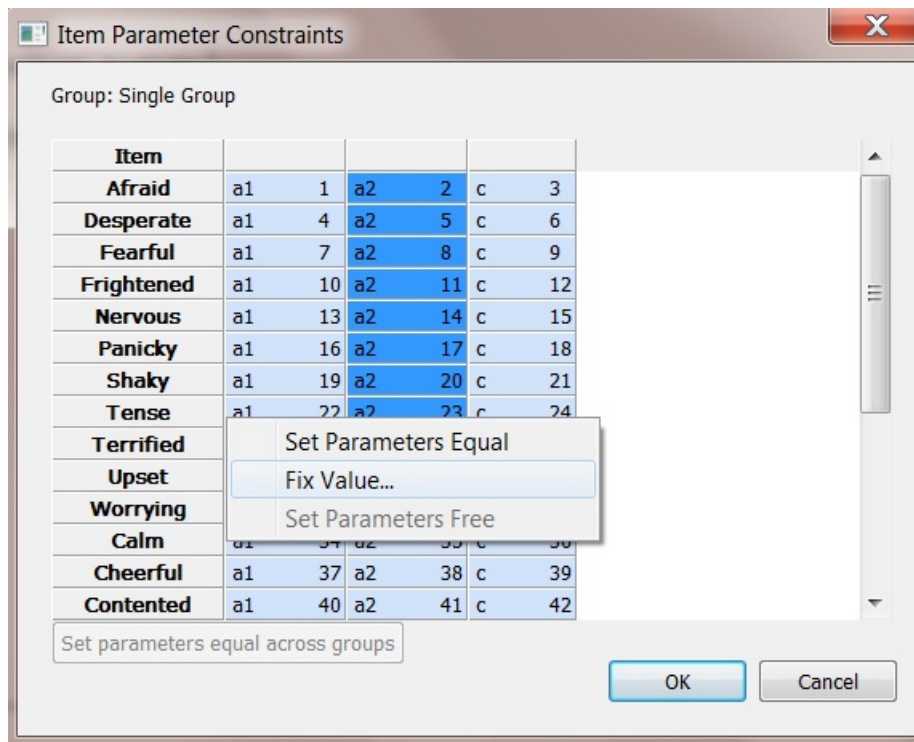
The **Item Parameter Constraints** window lists the items in the left-most column, and then, for each item, the model parameters are indicated symbolically (a for slopes, and c for intercepts).

Select the a_2 cells for items Afraid to Worrying and right-click to invoke the dialog for setting parameters equal, to free parameters or to fix parameter values. Select the **Fix Value...** option and since the default value is 0.0, click the **OK** button. For convenience, blocks of item parameters may be selected using standard conventions, such as shift-clicking, so that constraints may be applied to several parameters at a time.
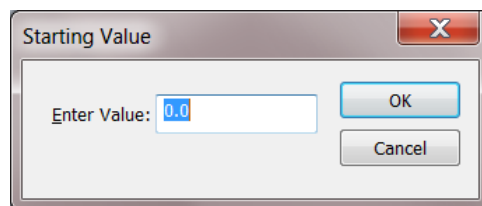
Next, select the a_1 cells for items Calm to Thoughtful and right-click to invoke the dialog for setting parameters equal, to free parameters or to fix parameter values. Select the **Fix Value...** option and click the **OK** button.

Finally, select the covariance cell (σ_{21}) and right-click to select the **Set Parameters Free** option. Integers in blue cells with the parameter symbol indicate the numbers for parameters that will be estimated. Real values in the red cells indicate fixed parameter values as shown below.

The elements of the mean vector and covariance matrix of the latent variables are also model parameters; they are shown at the bottom of the **Item Parameter Constraints** window. In this example, the means and variances are fixed (at 0.0 and 1.0, respectively) to standardize the two latent variables. The covariance between those two standardized variables (σ_{21}) is estimated – that is the correlation between the two latent variables.

Item						
Afraid	a1	1	a2	0.0	c	3
Desperate	a1	4	a2	0.0	c	6
Fearful	a1	7	a2	0.0	c	9
Frightened	a1	10	a2	0.0	c	12
Nervous	a1	13	a2	0.0	c	15
Panicky	a1	16	a2	0.0	c	18
Shaky	a1	19	a2	0.0	c	21
Tense	a1	22	a2	0.0	c	24
Terrified	a1	25	a2	0.0	c	27
Upset	a1	28	a2	0.0	c	30
Worrying	a1	31	a2	0.0	c	33
Calm	a1	0.0	a2	35	c	36
Cheerful	a1	0.0	a2	38	c	39
Contended	a1	0.0	a2	41	c	42
Happy	a1	0.0	a2	44	c	45
Joyful	a1	0.0	a2	47	c	48
Loving	a1	0.0	a2	50	c	51
Pleasant	a1	0.0	a2	53	c	54
Secure	a1	0.0	a2	56	c	57
Steady	a1	0.0	a2	59	c	60
Thoughtful	a1	0.0	a2	62	c	63
Means	μ1	0.0	μ2	0.0		
Covariances	σ1 1	1.0				
	σ2 1	64	σ2 2	1.0		

When the parameters are as desired, we click **OK** in the **Item Parameter Constraints** window, then **Run** in the **Multidimensional Analysis** dialog box, and wait… longer than for the unidimensional run, because multidimensional runs take more time.

When the parameters have been estimated, the output appears. We note that among the item parameter estimates, there are two columns of slopes, labeled a_1 and a_2 — those are slopes on the two latent dimensions. We also note that there are c (intercept) parameters, but no b (threshold) parameters, because the latter do not have meaning for multidimensional models.

2PL Model Item Parameter Estimates for Group 1, logit: aθ + c

Item	Label	a1		s.e.	a2		s.e.	c		s.e.
1	Afraid	2	3.47	0.69		0.00	-----	1	-4.33	0.75
2	Desperate	4	3.28	0.62		0.00	-----	3	-3.97	0.65
3	Fearful	6	5.08	1.21		0.00	-----	5	-5.76	1.26
4	Frightened	8	8.16	3.02		0.00	-----	7	-10.35	3.63
5	Nervous	10	3.14	0.52		0.00	-----	9	-1.69	0.35
6	Panicky	12	2.68	0.45		0.00	-----	11	-2.76	0.41
7	Shaky	14	2.27	0.40		0.00	-----	13	-2.92	0.40
8	Tense	16	2.93	0.46		0.00	-----	15	-0.71	0.27
9	Terrified	18	4.88	1.82		0.00	-----	17	-9.49	3.14
10	Upset	20	2.06	0.34		0.00	-----	19	-2.31	0.32
11	Worrying	22	3.71	0.76		0.00	-----	21	0.16	0.31
12	Calm		0.00	-----	24	1.51	0.25	23	-1.17	0.20
13	Cheerful		0.00	-----	26	2.16	0.35	25	-1.04	0.24
14	Contended		0.00	-----	28	2.94	0.49	27	-1.26	0.30
15	Happy		0.00	-----	30	3.60	0.70	29	-1.93	0.43
16	Joyful		0.00	-----	32	2.68	0.48	31	1.01	0.27
17	Loving		0.00	-----	34	1.50	0.24	33	-0.66	0.18
18	Pleasant		0.00	-----	36	2.66	0.49	35	-2.99	0.46
19	Secure		0.00	-----	38	2.13	0.34	37	-1.00	0.23
20	Steady		0.00	-----	40	2.01	0.34	39	-1.63	0.26
21	Thoughtful		0.00	-----	42	1.48	0.27	41	-1.90	0.24

To see the estimated correlation between the two latent variables, we click on the entry **Group Latent Variable Means** in the table of contents; below the means, IRTPRO lists the latent variable variance-covariance matrix:

Latent Variable Variance-Covariance Matrix for Group 1,

θ_1	s.e.	θ_2	s.e.
1.00	-----		
4 3 0.55	0.06	1.00	-----

We observe that the correlation between the latent variables that account for the covariation among the "anxiety-plus" and "anxiety-minus" adjectives is only 0.55. That value would have needed to be 1.0 for a unidimensional model to fit, which explains why a unidimensional model does not appear to fit well.

The M_2 statistic for this model suggests much better fit:

Statistics based on one- and two-way marginal tables			
M_2	Degrees of freedom	Probability	RMSEA
463.91	188	0.0001	0.07
Note: M_2 is based on full marginal tables.			
Note: Model-based weight matrix is used.			

The difference between the values of -2 log likelihood for the unidimensional model (5058.51) and for this two-dimensional model (4748.47) may be interpreted as a χ^2-distributed statistic on 1 degree of freedom (because the unidimensional model is nested within this two-dimensional model, and the two-dimensional model uses one more fitted parameter. That difference is 310.1, which is incredibly significant. There is strong evidence that these data need a two dimensional model to be fitted.

With the two-dimensional model, the standardized LD χ^2 statistics no longer suggests strong residual covariance. There are few extremely large values and no obvious red clusters:

Marginal fit (X2) and Standardized LD X2 Statistics for Group 1

Item	Marginal X^2	1	2	3	4	5	6	7	8	9	10
1	0.0										
2	0.0	0.9									
3	0.0	0.4	-0.3								
4	0.0	-0.7	1.1	1.1							
5	0.0	0.2	-0.7	-0.6	-0.6						
6	0.0	-0.5	-0.7	1.8	5.0	-0.3					
7	0.0	0.1	0.6	-0.1	-0.7	-0.7	0.1				
8	0.0	0.2	-0.5	1.6	----	0.0	-0.0	-0.7			
9	0.1	0.0	-0.6	----	----	----	0.0	0.7	----		
10	0.0	0.3	0.1	0.2	0.1	-0.7	-0.7	0.1	-0.3	-0.5	
11	0.0	-0.2	0.4	----	----	-0.2	1.2	-0.6	0.4	----	-0.1
12	0.0	0.3	9.6	2.8	3.3	3.7	11.4	4.2	9.1	0.1	2.0
13	0.0	3.0	-0.6	2.1	1.1	2.2	-0.7	-0.3	0.2	0.1	-0.3
14	0.0	-0.7	0.6	-0.6	-0.7	-0.7	-0.5	-0.5	-0.2	0.6	-0.7
15	0.0	-0.2	-0.5	-0.5	-0.7	0.1	-0.6	-0.7	-0.1	-0.5	-0.7
16	0.0	-0.4	-0.7	-0.5	-0.2	0.6	-0.4	-0.6	1.5	----	-0.7
17	0.0	8.5	1.1	5.2	5.7	5.5	0.2	0.1	4.5	1.0	0.2
18	0.0	2.5	2.3	-0.7	-0.6	-0.1	0.7	0.0	-0.7	-0.6	-0.6
19	0.0	-0.5	0.7	1.6	1.0	-0.2	0.5	1.8	0.1	-0.6	0.5
20	0.0	1.4	3.1	3.4	3.6	-0.6	2.2	4.0	0.8	0.1	0.2
21	0.0	0.3	-0.6	-0.7	-0.7	0.6	-0.6	-0.6	1.1	-0.6	0.0

Item	Marginal X^2	11	12	13	14	15	16	17	18	19	20
11	0.0										
12	0.0	5.5									
13	0.0	1.8	0.5								
14	0.0	-0.1	3.1	1.2							
15	0.0	-0.4	-0.1	3.9	-0.6						
16	0.0	3.7	0.5	1.9	-0.7	1.3					
17	0.0	6.3	2.6	0.1	1.1	-0.7	5.7				
18	0.0	-0.4	-0.7	0.6	0.8	1.8	-0.6	-0.5			
19	0.0	1.1	-0.7	5.9	-0.2	1.0	2.3	-0.2	-0.7		
20	0.0	1.5	0.4	4.5	-0.7	2.6	1.6	3.8	-0.7	9.8	
21	0.0	0.6	1.8	-0.7	1.4	-0.2	-0.5	2.0	-0.4	-0.6	-0.0

One value of the pairwise LD statistics that stands out is the 11.4 for items 6 and 12; those adjectives are "panicky" and "calm" (the latter reverse scored). It is likely that there is additional un-modeled local dependence between those two near-antonyms. That *could* be modeled as well, but we leave that exercise to the reader.