LISREL output files for measurement models

1. Introduction

In practice, the variables of interest are often latent (unobservable) variables, such as intelligence, job satisfaction, organizational commitment, socio-economic status, ambition, alienation, verbal ability, etc. These latent variables are modeled by specifying a measurement model and a structural model. The measurement model specifies the relationships between the observed indicators and the latent variables while the structural equation model specifies the relationships amongst the latent variables.

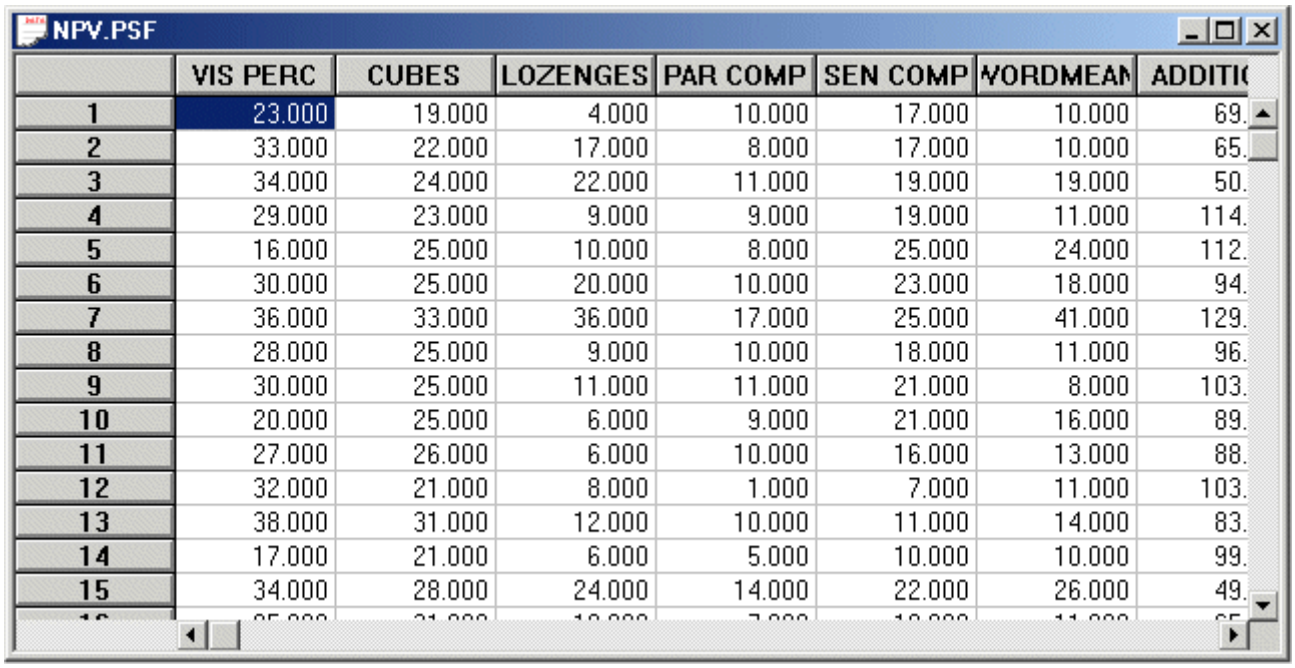
In practice, it is very convenient to refine the measurement model before the complete model is fitted to the data. In this regard, the reliability and the validity of the indicators of the latent variables are assessed even before the measurement model is fitted to the data. Thereafter, modification indices are sometimes used to refine the measurement model.

LISREL 8.80 for Windows (Jöreskog & Sörbom 2006) does not include methods to assess the reliability (internal consistency) and validity of the indicators of a measurement model. However, it does include the Maximum Likelihood (ML), Robust Maximum Likelihood (RML), Generalized Least Squares (GLS), Un-weighted Least Squares (ULS), Weighted Least Squares (WLS), Diagonally Weighted Least Squares (DWLS) and Full Information Maximum Likelihood (FIML) methods to fit measurement models to data. Each of these methods includes modification indices that may be used to refine measurement models. More information on these indices is provided in (Jöreskog & Sörbom 1999) and Du Toit & Du Toit (2001). In addition, LISREL 8.80 for Windows include methods to assess the validity of latent constructs as outlined in Steenkamp & Van Trijp (1991).

In this note, the RML method of LISREL 8.80 for Windows is used to fit and refine a measurement model to the scores of a sample of school children on nine psychological tests. This data set is described in the next section. The measurement model is described in section 3. In section 4, SIMPLIS syntax file for the measurement model is described while the results are presented in section 5. The modification indices are then used to refine the model in section 6.

2. The data

The data are the scores on nine psychological tests of 145 seventh- and eighth-grade students at the Grant-White school in Chicago. The raw data are listed in the PRELIS System File (PSF) ***NPV.PSF*** located in ***C:\LISREL 8.8 Student Examples\WORKSHOP***. The first couple of lines of this file are shown in the following PSF window.



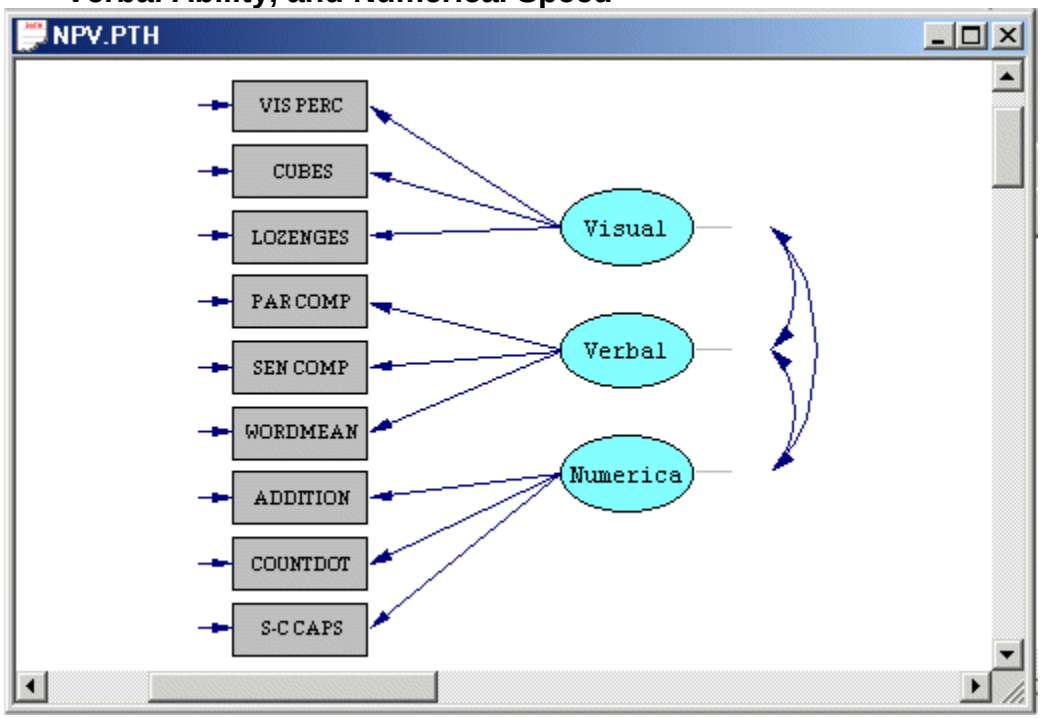
NPV.PSF

	VIS PERC	CUBES	LOZENGES	PAR COMP	SEN COMP	VORDMEAN	ADDITI
1	23.000	19.000	4.000	10.000	17.000	10.000	69.
2	33.000	22.000	17.000	8.000	17.000	10.000	65.
3	34.000	24.000	22.000	11.000	19.000	19.000	50.
4	29.000	23.000	9.000	9.000	19.000	11.000	114.
5	16.000	25.000	10.000	8.000	25.000	24.000	112.
6	30.000	25.000	20.000	10.000	23.000	18.000	94.
7	36.000	33.000	36.000	17.000	25.000	41.000	129.
8	28.000	25.000	9.000	10.000	18.000	11.000	96.
9	30.000	25.000	11.000	11.000	21.000	8.000	103.
10	20.000	25.000	6.000	9.000	21.000	16.000	89.
11	27.000	26.000	6.000	10.000	16.000	13.000	88.
12	32.000	21.000	8.000	1.000	7.000	11.000	103.
13	38.000	31.000	12.000	10.000	11.000	14.000	83.
14	17.000	21.000	6.000	5.000	10.000	10.000	99.
15	34.000	28.000	24.000	14.000	22.000	26.000	49.

3. The measurement model

We consider nine psychological tests that were administered to 145 seventh- and eighth-grade students. These nine psychological tests are theoretically constructed to measure the visual perception, verbal ability and numerical speed of seventh- and eighth-grade children. A path diagram for the corresponding measurement model for visual perception, verbal ability and numerical speed is shown in Figure 1.

Figure 1: A path diagram for a measurement model of Visual Perception, Verbal Ability, and Numerical Speed



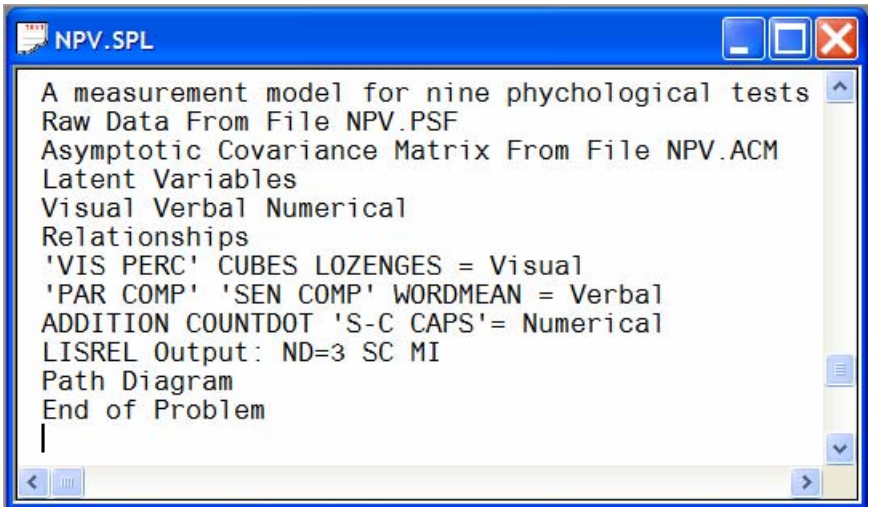
4. Fitting the measurement model to the data

Generating the estimated Asymptotic Covariance Matrix (ACM)

- Use the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the location ***C:\LISREL 8.8 Student Examples\WORKSHOP***.
- Select the ***PRELIS Data (*.psf)*** option from the ***Files of type*** dropdown list box.
- Select the file ***NPV.PSF*** by clicking on it.
- Click on the ***Open*** button to open the PSF window for ***NPV.PSF***.
- Select the ***Output Options*** option on the ***Statistics*** menu to load the ***Output*** dialog box.
- Check the ***Save to File*** checkbox in the ***Asymptotic Covariance Matrix*** section.
- Enter the name ***NPV.ACM*** in the string box in the ***Asymptotic Covariance Matrix*** section.
- Click on the ***OK*** button to run PRELIS28 to generate the text editor window containing the output file ***NPV.OUT***.

The SIMPLIS syntax file

- Use the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the location ***C:\LISREL 8.8 Student Examples\WORKSHOP***.
- Select the file ***NPV.SPL*** by clicking on it.
- Click on the ***Open*** button to open the following text editor window.

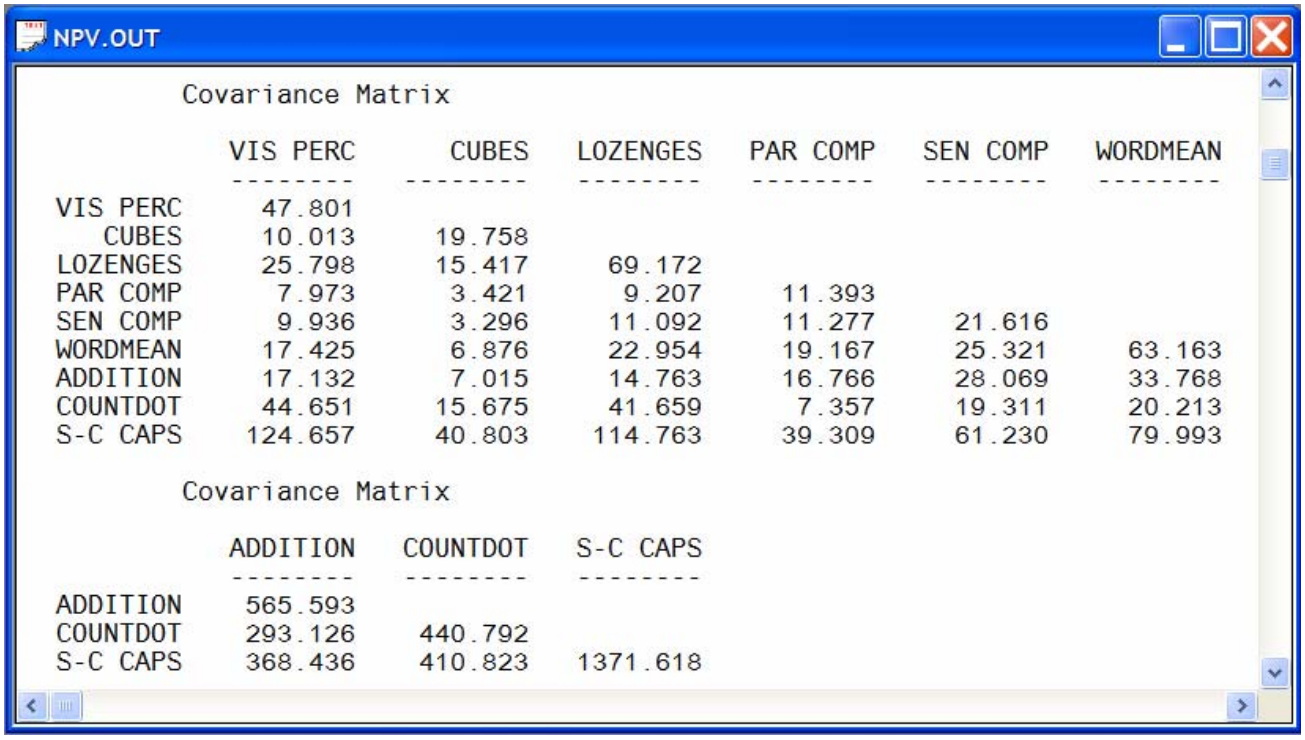


Line 1 provides a title for the analysis.
Line 2 specifies the raw data source.
Line 3 specifies the binary file containing the estimated asymptotic matrix of the sample variances and covariances.
Lines 4 and 5 specify labels for the latent variables.
Lines 6 thru 9 specify the measurement model to be fitted to the data.
Line 10 specifies that the results should be printed in terms of the LISREL model for the measurement model in Figure 1. It also requests three decimal places, the completely standardized solution and the modification indices.
Line 11 requests a path diagram of the fitted model.
Line 12 indicates no more SIMPLIS commands are to be processed.

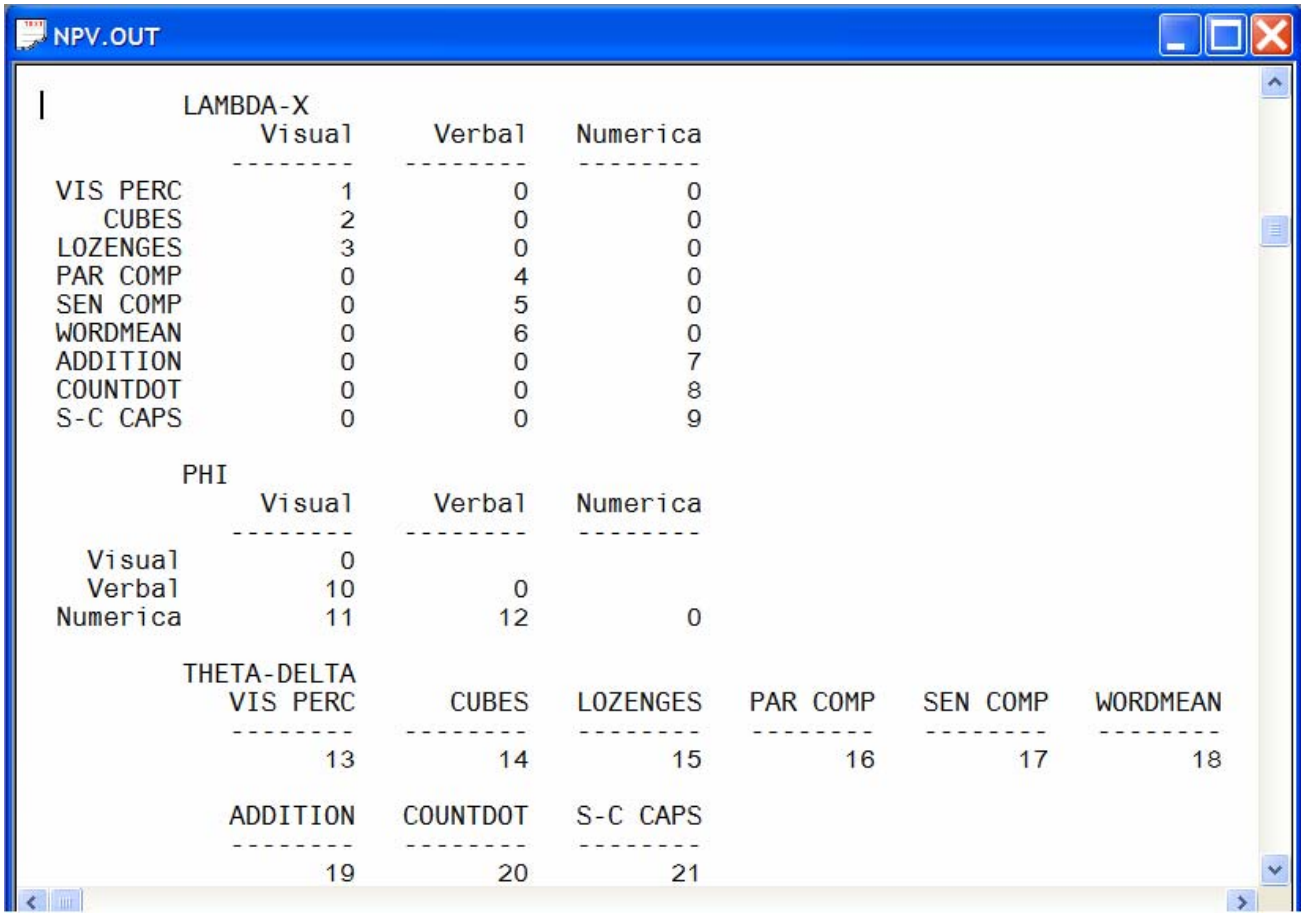
- Click on the ***Run LISREL*** icon on the main toolbar to produce the PTH window for ***NPV.PTH***.

5. The results

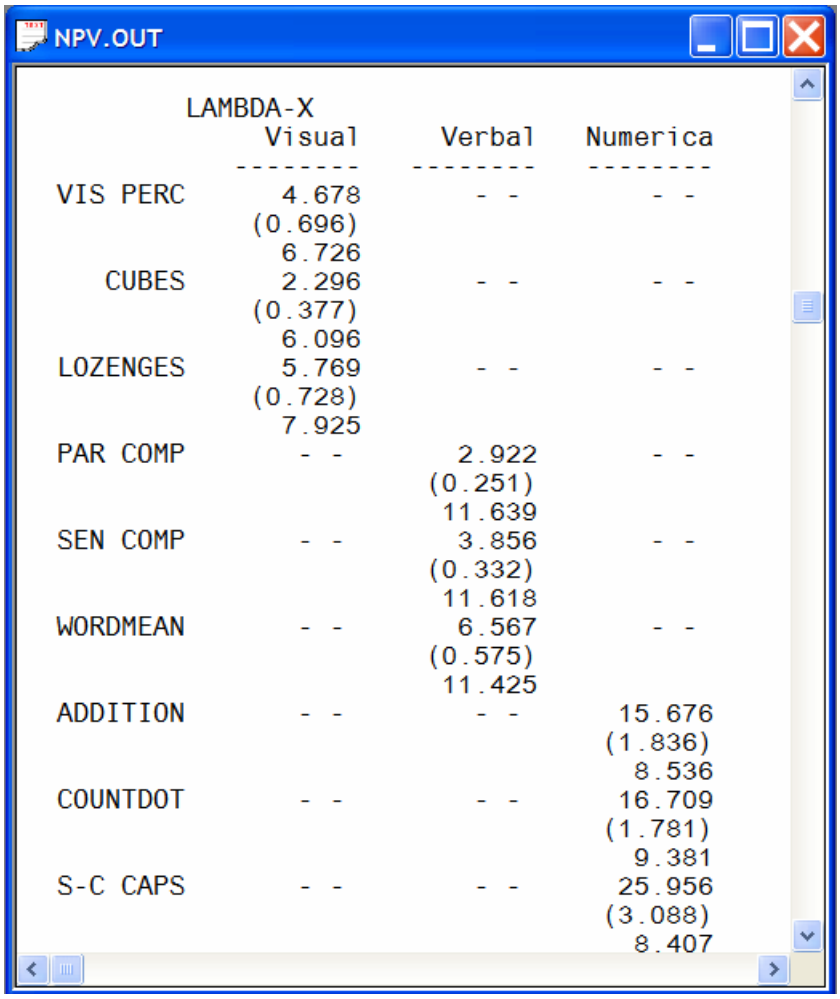
The output file, ***NPV.OUT***, consists of several sections. In this section, we will review some selections of the output file. The sample covariance matrix is shown in the following text editor window.



The parameter specifications for the LISREL model for the model in Figure 1 are listed in the following text editor window.

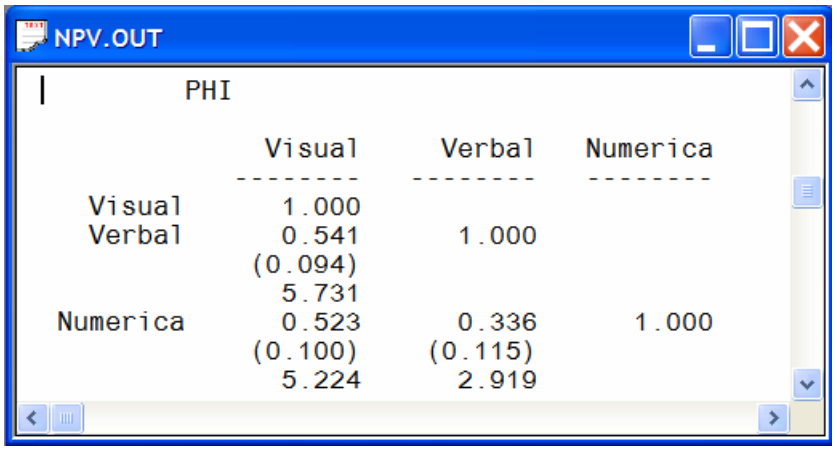


The estimated matrix of factor loadings follows.



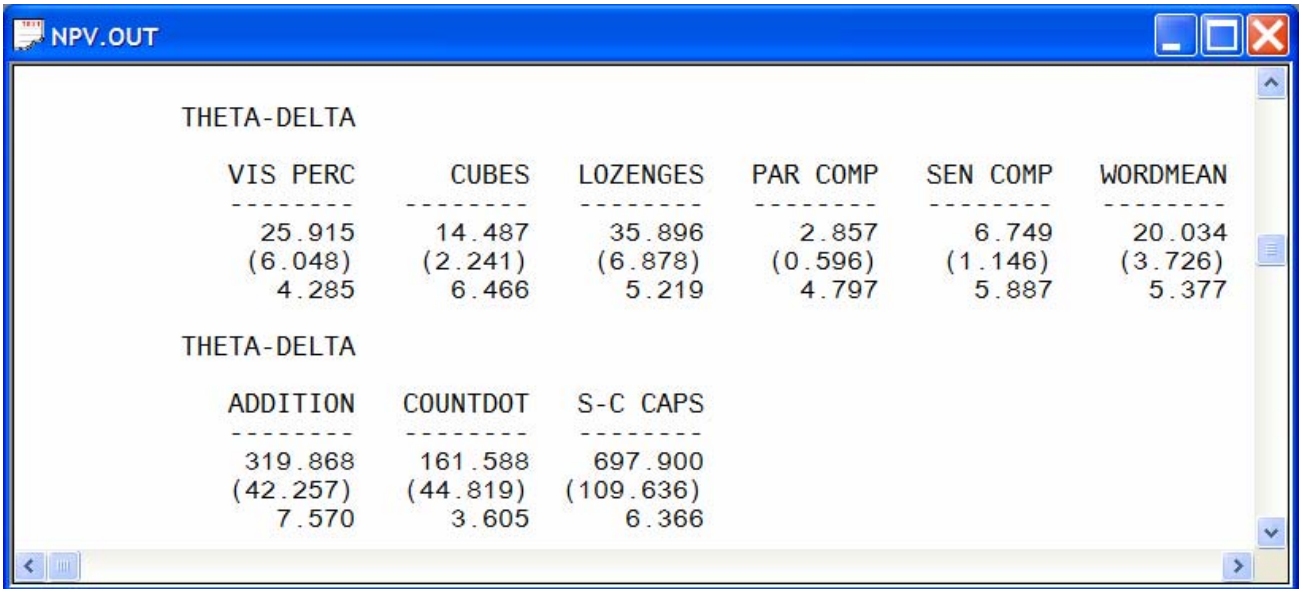
The results above indicate that all the free factor loadings are statistically significant if a significance level of 1% is used. Consequently, the construct validity of the nine psychological tests as indicators of the three latent variables appears to be at an acceptable level.

The estimated correlation matrix of the three latent variables is provided in the following text editor window.



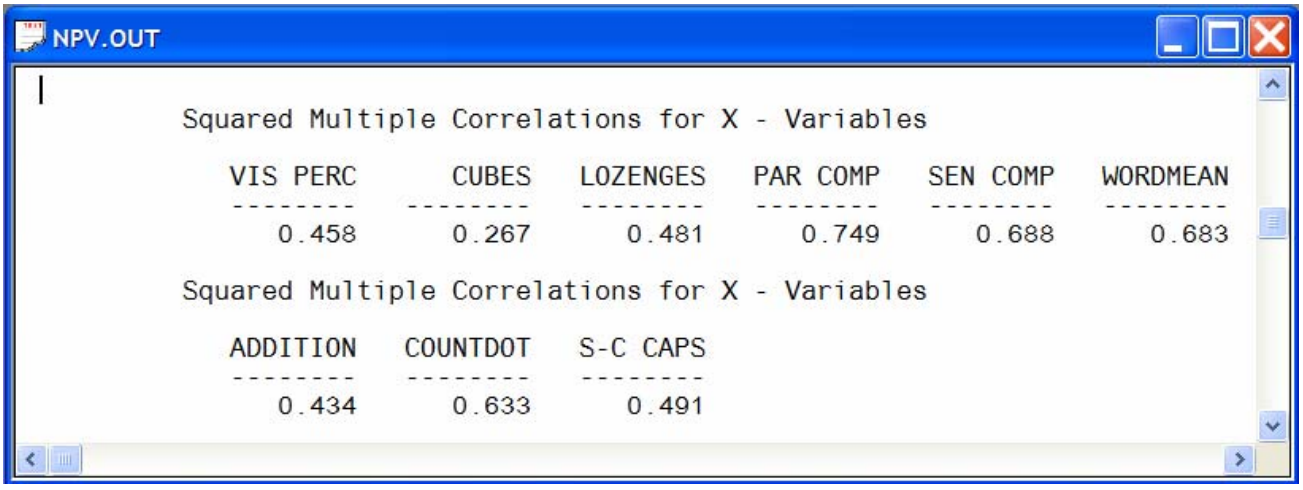
The results above indicate that all three factor correlations are statistically significant if a significance level of 1% is used. In other words, there is sufficient evidence that the three abilities are correlated.

The estimated measurement error variances are shown below.



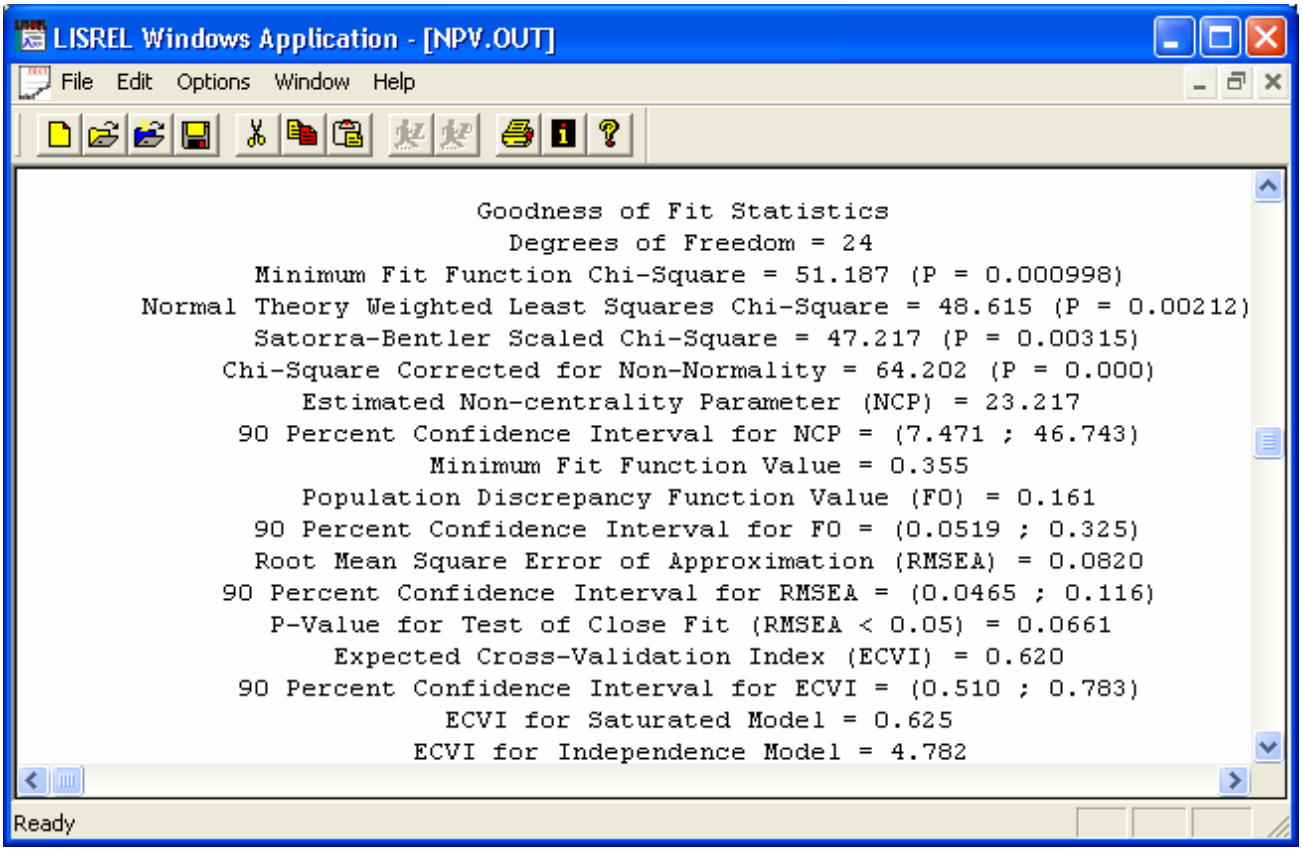
The results above indicate that all the measurement error variances are statistically significant if a significance level of 1% is used.

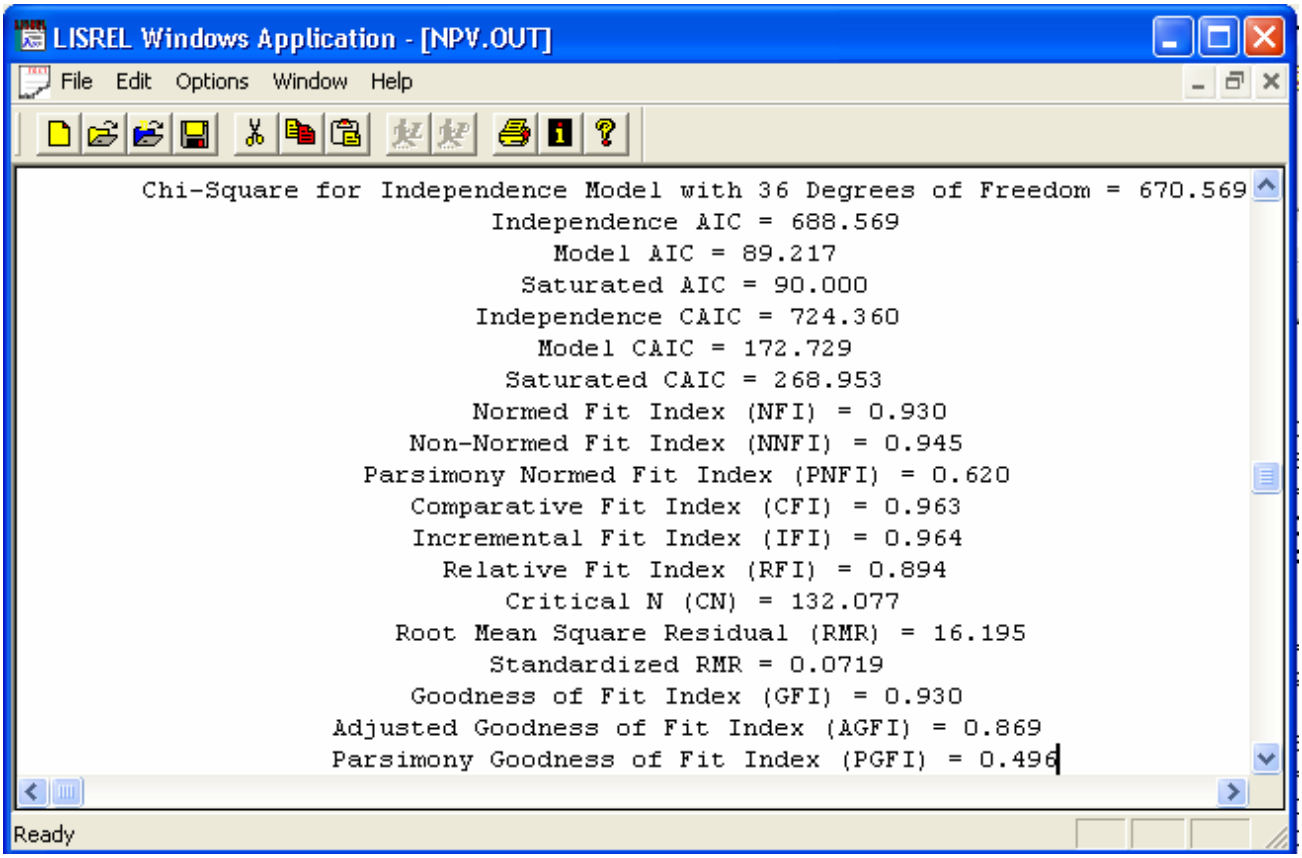
The estimated squared multiple correlations of the nine psychological tests are shown in the following text editor window.



The results above indicate that the latent variable verbal ability explain more of the variation in all three its indicators than the latent variables visual and numerical ability.

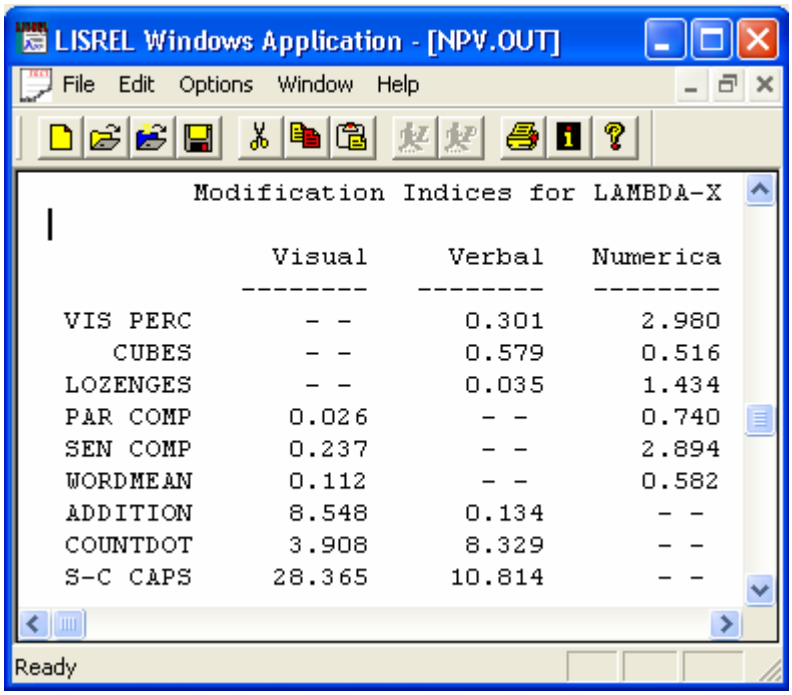
The measures of fit of the measurement model are displayed in the following two text editor windows.

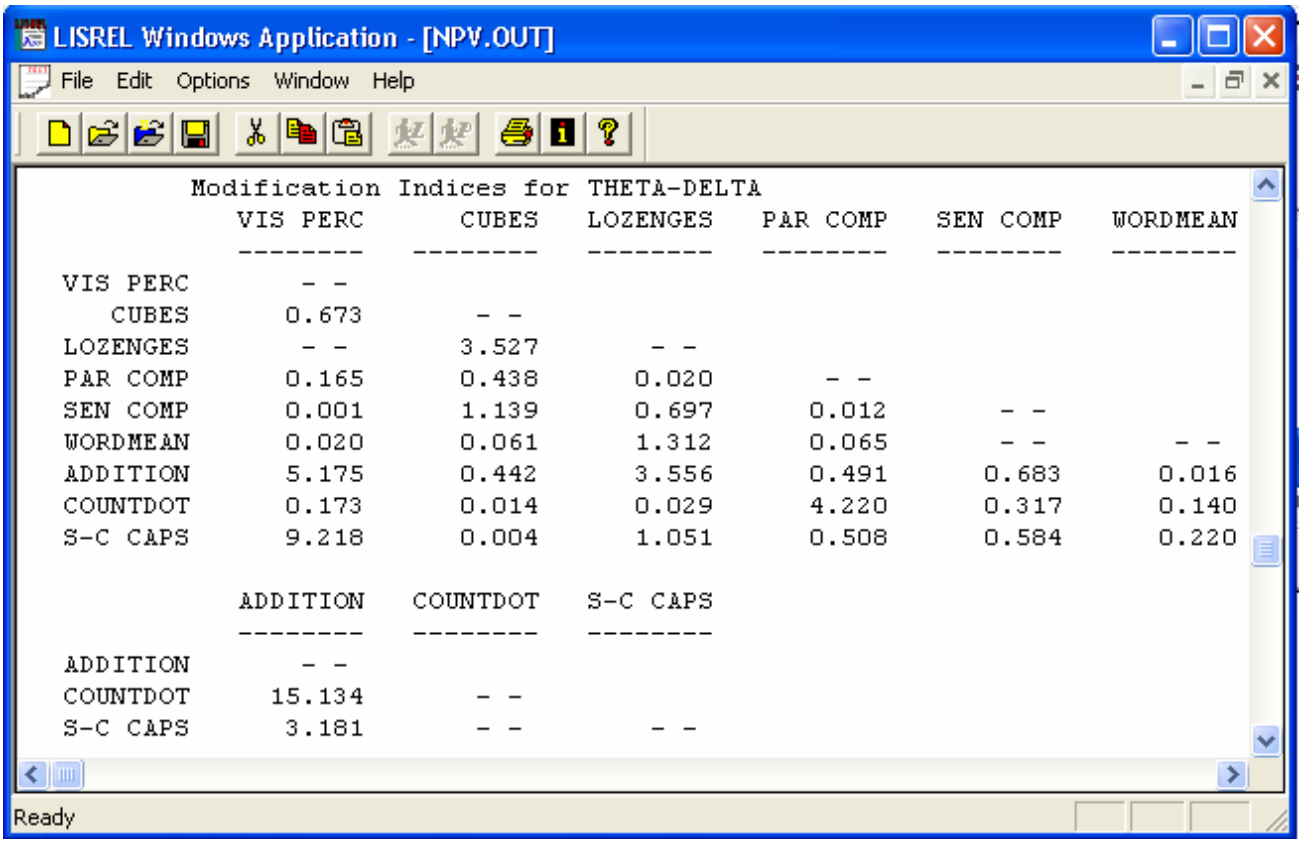




These measures of fit indicate that the model provides a poor fit to the data.

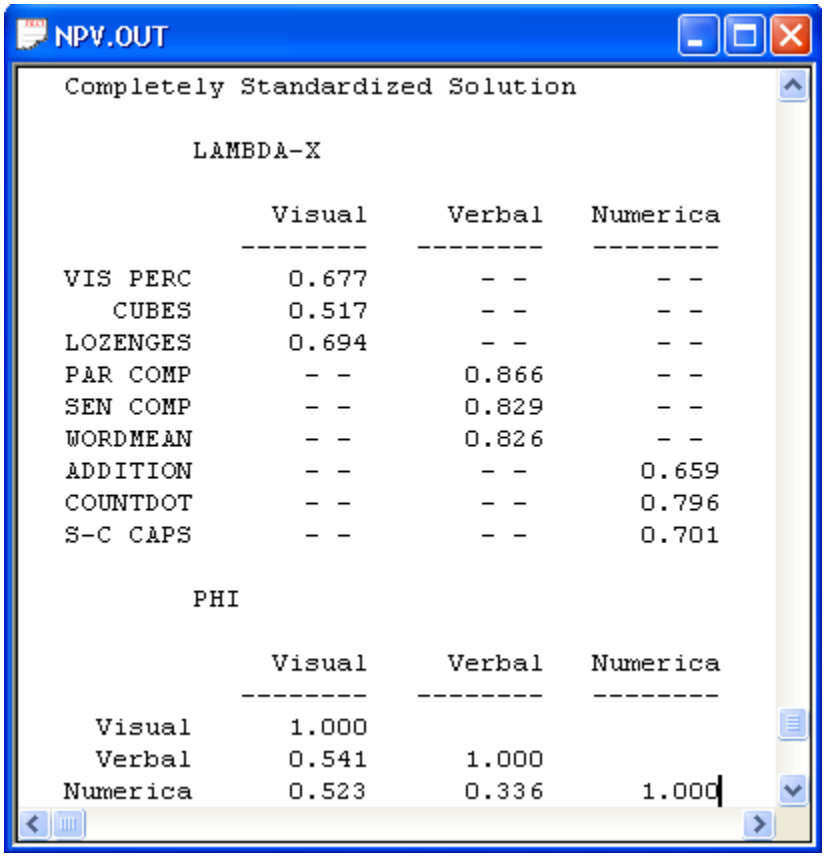
The next two text editor windows show the modification indices for the matrix of factor loadings and the measurement error covariance matrix.

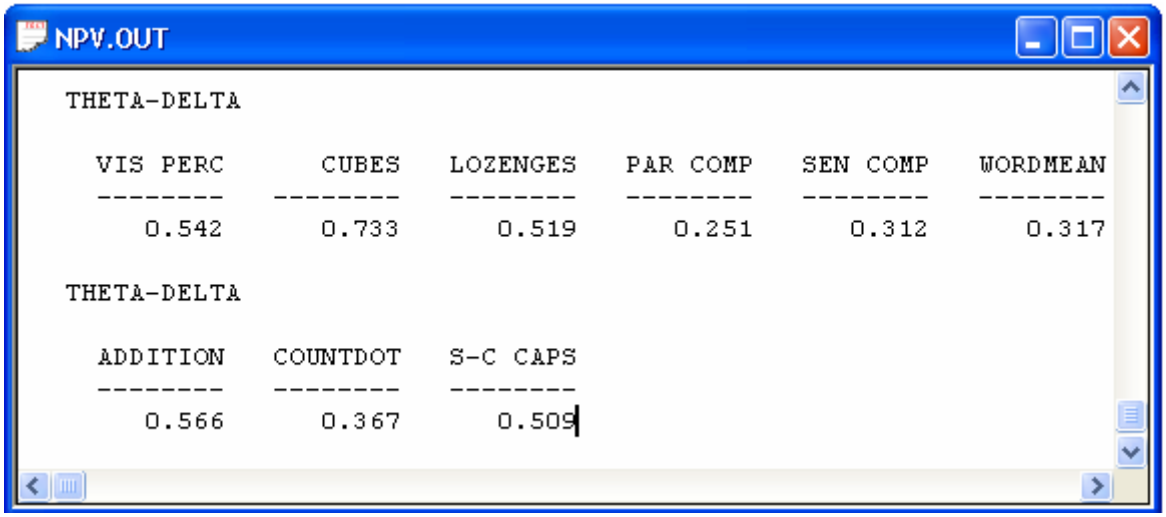




The results above indicate that the largest modification index is that for the factor loading of visual ability for the indicator S-C CAPS.

The completely standardized solution is given in the following two text editor windows.





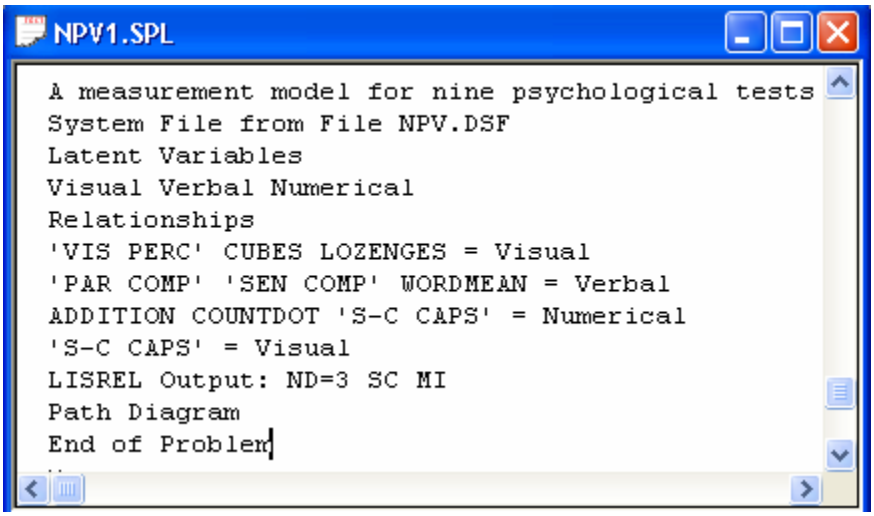
The completely standardized estimates above indicate that the solution is admissible since none of them exceeds unity in absolute value.

6. Refining the measurement model

From the results in section 5, it is evident that the largest modification index is that of the factor loading of the variable ***S-C CAPS*** as an indicator of latent variable ***Visual***. The contents of this test support this suggestion. In other words, this factor loading makes sense from a theoretical point of view. We will now demonstrate how to modify the SIMPLIS syntax file for the measurement model to accommodate this factor loading.

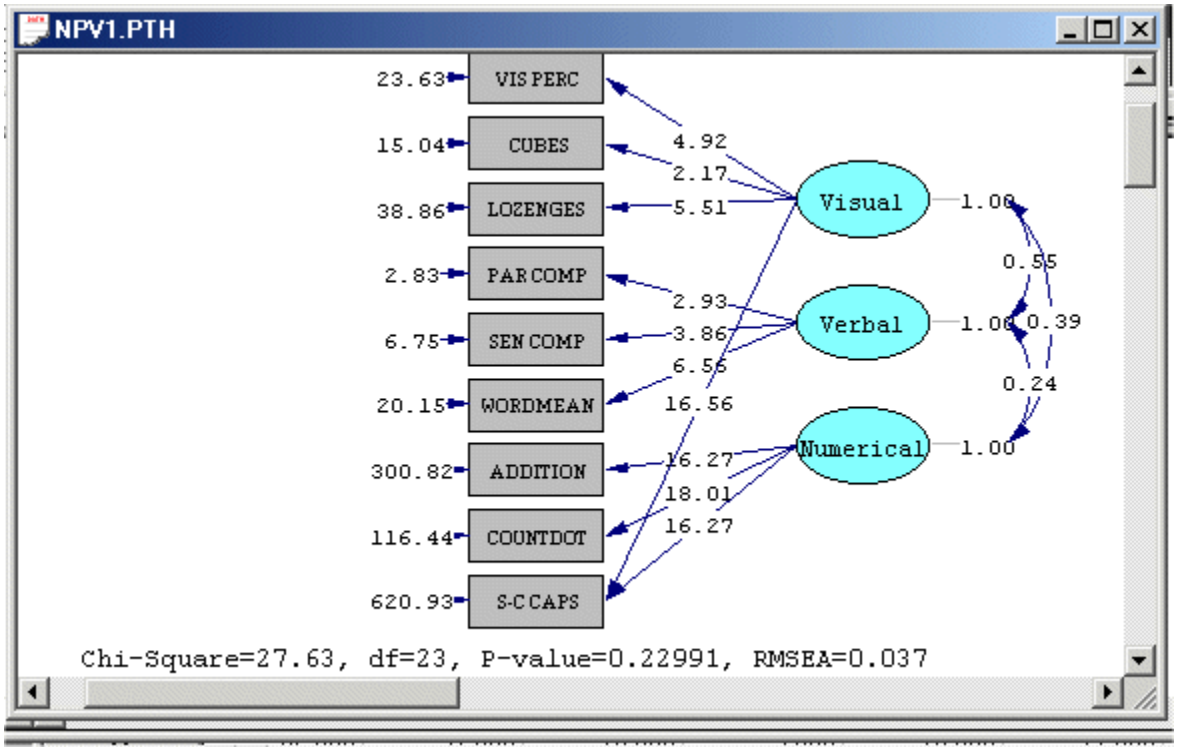
The SIMPLIS syntax file

- Use the ***Open*** option on the ***File*** menu to load the ***Open*** dialog box.
- Browse for the location ***C:\LISREL 8.8 Student Examples\WORKSHOP***.
- Select the file ***NPV1.SPL*** by clicking on it.
- Click on the ***Open*** button to open the following text editor window.

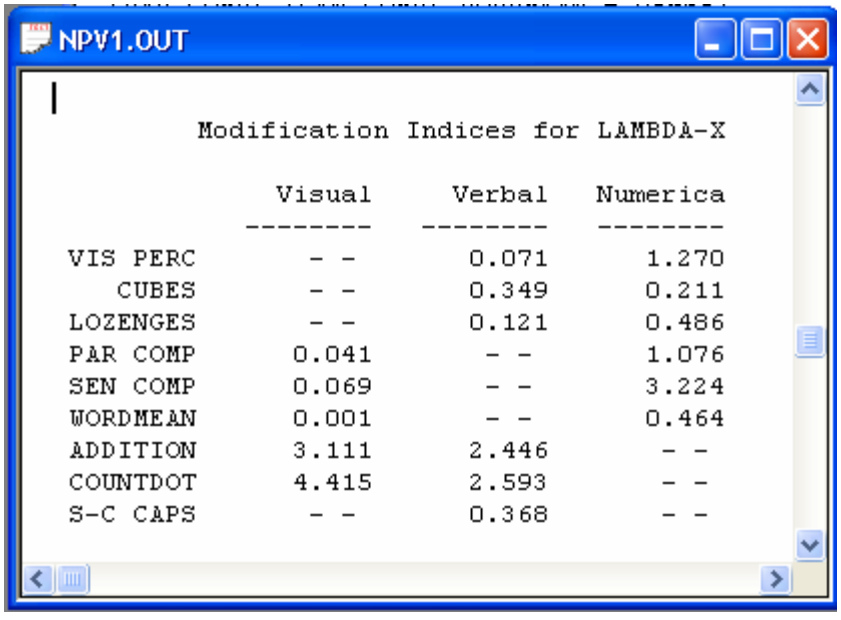


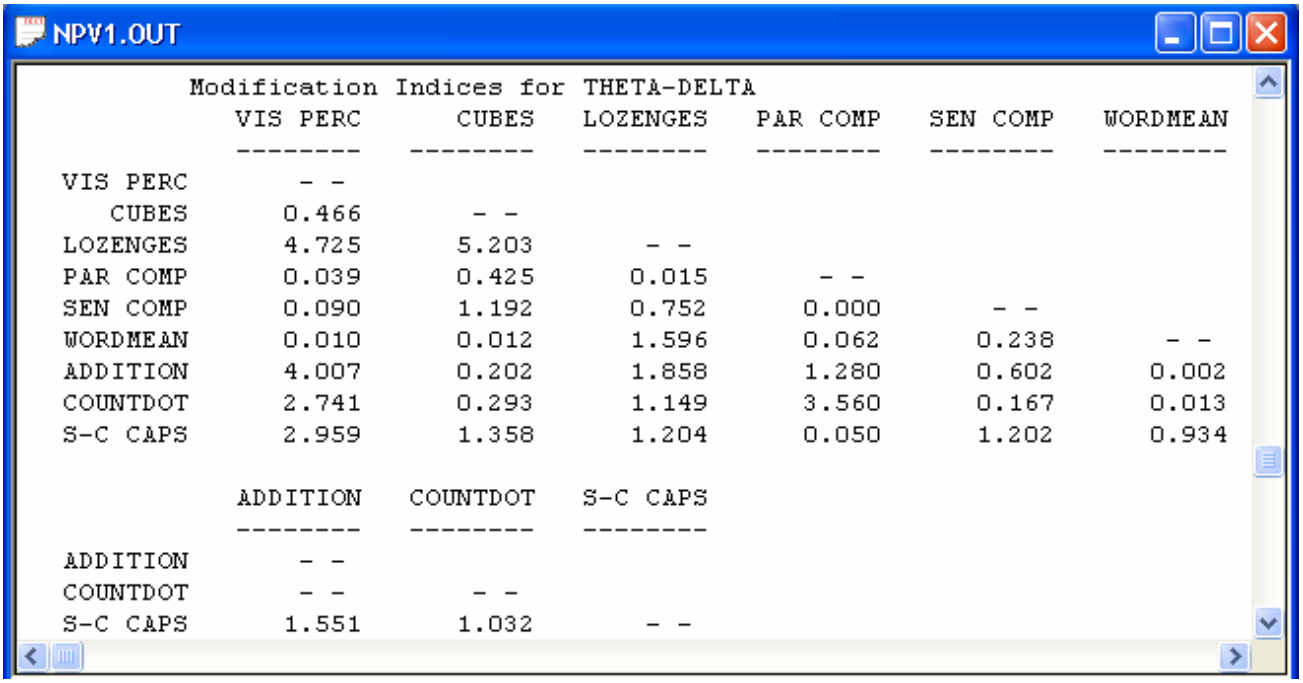
Line 1 provides a title for the analysis.
Line 2 specifies the data source.
Lines 3 to 4 specify labels for the latent variables.
Lines 5 to 9 specify the measurement model to be fitted to the data.
Line 10 specifies that the results should be printed in terms of the LISREL model for the measurement model in Figure 1. It also requests three decimal places, the completely standardized solution and modification indices.
Line 11 requests a path diagram.
Line 12 indicates no more SIMPLIS commands are to be processed.

- Click on the ***Run LISREL*** icon on the main toolbar to produce the following PTH window.



The modification indices are displayed in the following two text editor windows.




NPV1.OUT

Modification Indices for THETA-DELTA

	VIS PERC	CUBES	LOZENGES	PAR COMP	SEN COMP	WORDMEAN
VIS PERC	- -					
CUBES	0.466	- -				
LOZENGES	4.725	5.203	- -			
PAR COMP	0.039	0.425	0.015	- -		
SEN COMP	0.090	1.192	0.752	0.000	- -	
WORDMEAN	0.010	0.012	1.596	0.062	0.238	- -
ADDITION	4.007	0.202	1.858	1.280	0.602	0.002
COUNTDOT	2.741	0.293	1.149	3.560	0.167	0.013
S-C CAPS	2.959	1.358	1.204	0.050	1.202	0.934

	ADDITION	COUNTDOT	S-C CAPS
ADDITION	- -		
COUNTDOT	- -	- -	
S-C CAPS	1.551	1.032	- -

From the results above, it is evident that none of the modification indices suggests further refining of the measurement model.

References

Du Toit, M. & Du Toit, S.H.C. (2001).
Interactive LISREL: User's Guide.
Lincolnwood, IL: Scientific Software International, Inc.

Jöreskog, K.G. & Sörbom, D. (1999).
LISREL 8: User's Reference Guide.
Lincolnwood, IL: Scientific Software International, Inc.

Jöreskog, K.G. & Sörbom, D. (2006).
LISREL 8.80 for Windows [Computer Software].
Lincolnwood, IL: Scientific Software International, Inc.

Steenkamp, J.E.M. & Van Trijp, H.C.M (1991).
The use of LISREL in validating marketing constructs.
International Journal of Research in Marketing, **8**, 283-299.