FIML and missing data: the assessment of invariance

In practice, many multivariate data sets are observations from several groups. Examples of these groups are genders, languages, political parties, countries, faculties, colleges, schools, etc. For these data sets, it is often of interest to determine whether or not the parameters of the structural equation model for the observed variables are invariant across the groups. The statistical methods for multiple group structural equation modeling may be used to determine whether or not these parameters are invariant across the groups.

LISREL (Jöreskog & Sörbom 2006) may be used to fit multiple group structural equation models to multiple group data. Traditional statistical methods such as Maximum Likelihood (ML), Robust Maximum Likelihood (RML), Weighted Least Squares (WLS), Diagonally Weighted Least Squares (DWLS), Generalized Least Squares (GLS) and Un-weighted Least Squares (ULS) are available for complete multiple group data while the Full Information Maximum Likelihood (FIML) method is available for incomplete multiple group data. The ML, RML, WLS, DWLS, GLS and ULS methods for multiple group structural equation modeling are described in Jöreskog & Sörbom (1999) while the FIML method is described in Du Toit & Du Toit (2001).

In this example, the FIML estimation method for incomplete data of LISREL is used to fit a measurement model to a multivariate data sets consisting of the simulated scores of a sample of 1250 boys and 1250 girls on six psychological tests. The raw data are given in the LISREL System File **LIS11_MG_BOYS_GIRLS_16**.

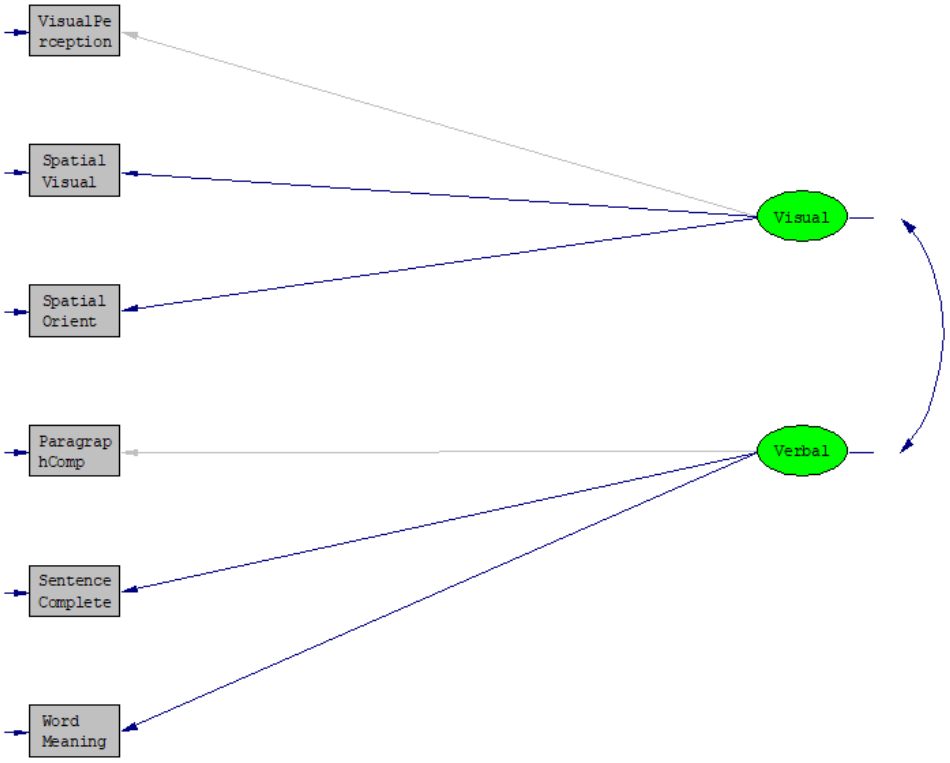
Variables of interest are:

- Visual perception scores (VisualPerception)
- Tests of spatial visualization ('Spatial Visual')
- Test of spatial orientation ('Spatial Orient')
- Paragraph completion score (ParagraphComp)
- Sentence completion score (SentenceComplete)
- Word meaning score ('Word Meaning')

The invariance of a model is often of interest if the sample data consist of data from different groups such as males and females, different political parties, freshmen, sophomores, juniors and seniors, etc. In this section, we illustrate how LISREL can be used to assess various levels of invariance across groups.

Configural invariance is achieved if the model of interest fits across the groups. Although the model is the same across groups, the unknown parameters of the model are assumed to be different across the groups. The multiple group (global) Chi-square test statistic for this multiple group model is used to assess configural invariance. The measurement model in Figure 1 will now be used to illustrate how the multiple group feature of LISREL may be used to assess the configural invariance of the measurement model in Figure 1 across gender.

Figure 1: measurement model



The syntax for this analysis is shown below (**LIS11_EX5.SPL**):

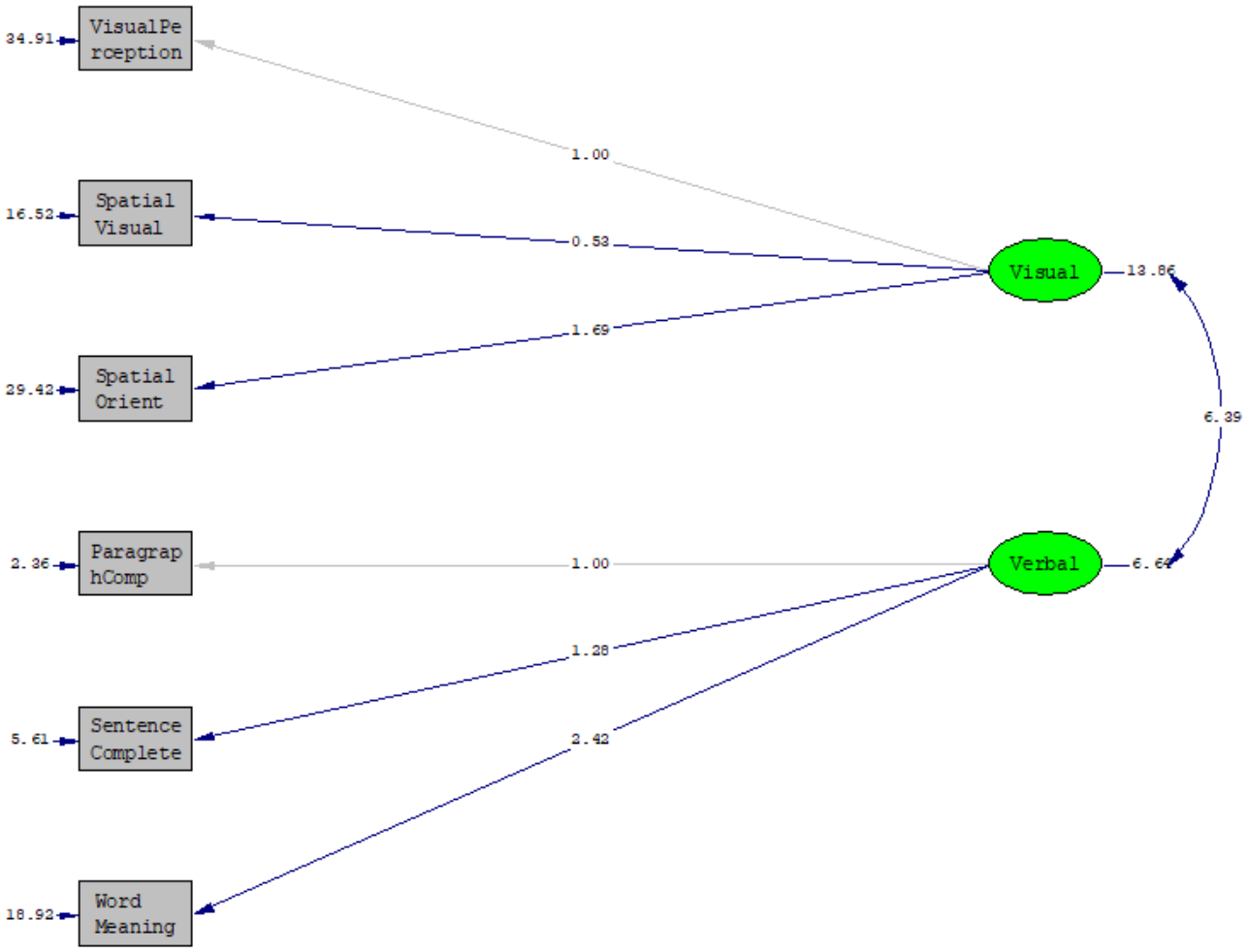
```
Group 1: Boys
$GROUPS=Gender
Raw Data from File LIS_MG_BOYS_GIRLS_16.LSF
Latent Variables: Visual Verbal
VisualPerception = 1*Visual
```

```
'Spatial Visual' 'Spatial Orient' = Visual
ParagraphComp = 1*Verbal
SentenceComplete 'Word Meaning' = Verbal

Group 2: Girls
Raw Data from File LIS_MG_BOYS_GIRLS_16.LSF
VisualPerception = 1*Visual
'Spatial Visual' 'Spatial Orient' = Visual
ParagraphComp = 1*Verbal
SentenceComplete 'Word Meaning' = Verbal
Set the Variance of Verbal Free
Set the Variance of Visual Free
Set the Covariance of Visual Verbal Free
Set the Error Variance of VisualPerception - 'Word Meaning' Free
LISREL Output: ND=3 SC
Path Diagram
End of Problem
```

Lines 11-18 specify the measurement model for boys. Lines 15-18 specify that the variance and covariance parameters of the model are different across the two groups. Line 19 requests the results in terms of the parameter matrices of the LISREL model for the measurement model in Figure 1. In addition, 3 decimal places (ND=3) and the completely standardized solutions (SC) are specified.

The path diagram and estimates obtained for this model are given below. The large *p*-value for the Chi-square test statistic value and corresponding small RMSEA value imply that the data supports the configural invariance of the measurement model in Figure 1 across boys and girls.



Chi-Square=15.57, df=16, P-value=0.48322, RMSEA=0.000