

IRTPRO™

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Analysis of Quality of Life data

1. Exploratory Factor Analysis (EFA)

To illustrate the implementation of exploratory factor analysis for graded response data, the "Quality of Life Interview for the Chronically Mentally Ill" (Lehman, 1988) was analyzed based on the item responses of 586 chronically mentally ill patients. The scale consists of seven subdomains (Family, Finance, Health, Leisure, Living, Safety, and Social), each with 4 to 6 items for a total of 34 items. In addition, there is one global life satisfaction item, yielding a total of 35 items. Each item is rated on a 7-point scale with the following response categories: 1 = terrible; 2 = unhappy; 3 = mostly dissatisfied; 4 = mixed, about equally satisfied and dissatisfied; 5 = mostly satisfied; 6 = pleased; and 7 = delighted. The table below provides a brief description of each of the 35 items.

Table 7.1: Description of items in the Lehman (1988) Quality-of-Life Rating Scale Data (N =586)

| | | |
|--|---|--|
| <p>Global Item1: Global life satisfaction as a whole</p> <p>Family Item2: Family Item3: Amount of family contact Item4: Family with interaction Item5: General family stuff</p> <p>Finance Item6: Total money you get Item7: Amount pay for basic needs Item8: Financial well-being Item9: Money for fun</p> | <p>Health Item10: Health in general Item11: Medical care Item12: How often see doctor Item13: Talk to therapist Item14: Physical condition Item15: Emotional well-being</p> <p>Leisure Item16: Way spend free time Item17: Amount of free time Item18: Chance to enjoy time Item19: Amount of fun Item20: Amount of relaxation Item21: Pleasure from TV</p> | <p>Living Item22: Living arrangements Item23: Food Item24: Privacy Item25: Amount of freedom Item26: Prospect of staying</p> <p>Safety Item27: Neighborhood safety Item28: Safe at home Item29: Police access Item30: Protect robbed/attack Item31: Personal safety</p> <p>Social Item32: Do things with others Item33: Time with others Item34: Social interactions Item35: People in general</p> |
|--|---|--|

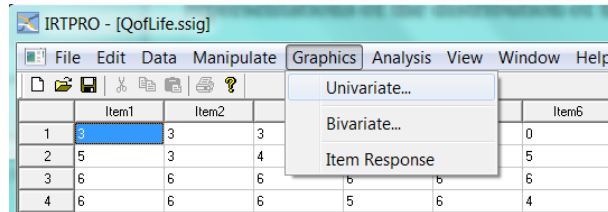
To open the data file, select the file **QoLife.ssig** from the **IRTPRO Examples\By Data Set\Quality of Life** folder. The first 15 cases for Item1 to Item9 are displayed below in spreadsheet format. Each of the items has seven categories and therefore the available models are graded, general partial credit and nominal.

The screenshot shows the IRTPRO software window titled "IRTPRO - [QofLife.ssig]". The menu bar includes File, Edit, Data, Manipulate, Graphics, Analysis, View, Window, and Help. The spreadsheet displays the following data:

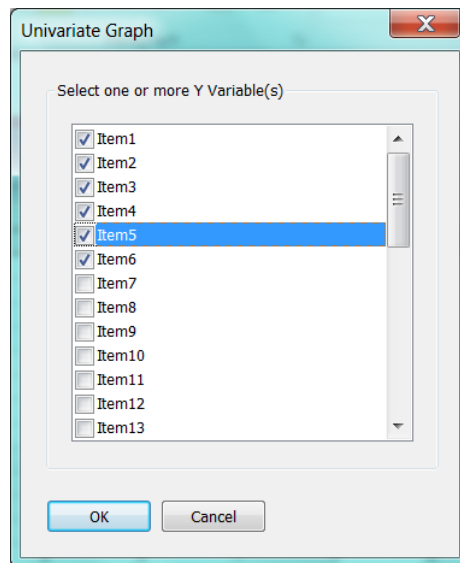
| | Item1 | Item2 | Item3 | Item4 | Item5 | Item6 | Item7 | Item8 | Item9 |
|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 1 | 3 | 3 | 3 | 4 | 4 | 0 | 0 | 3 | 3 |
| 2 | 5 | 3 | 4 | 5 | 4 | 5 | 5 | 6 | 5 |
| 3 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 4 | 6 |
| 4 | 6 | 6 | 6 | 5 | 6 | 4 | 5 | 4 | 5 |
| 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| 6 | 5 | 6 | 4 | 4 | 4 | 5 | 5 | 5 | 4 |
| 7 | 5 | 5 | 4 | 5 | 5 | 5 | 5 | 5 | 4 |
| 8 | 4 | 5 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 9 | 3 | 6 | 2 | 4 | 4 | 1 | 1 | 1 | 1 |
| 10 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 2 |
| 11 | 5 | 6 | 6 | 6 | 6 | 5 | 5 | 5 | 5 |
| 12 | 5 | 5 | 5 | 5 | 5 | 4 | 5 | 4 | 4 |
| 13 | 4 | 6 | 4 | 6 | 6 | 0 | 1 | 0 | 0 |
| 14 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 6 |
| 15 | 2 | 1 | 0 | 0 | 2 | 5 | 6 | 4 | 5 |

The status bar at the bottom of the window shows "Ready".

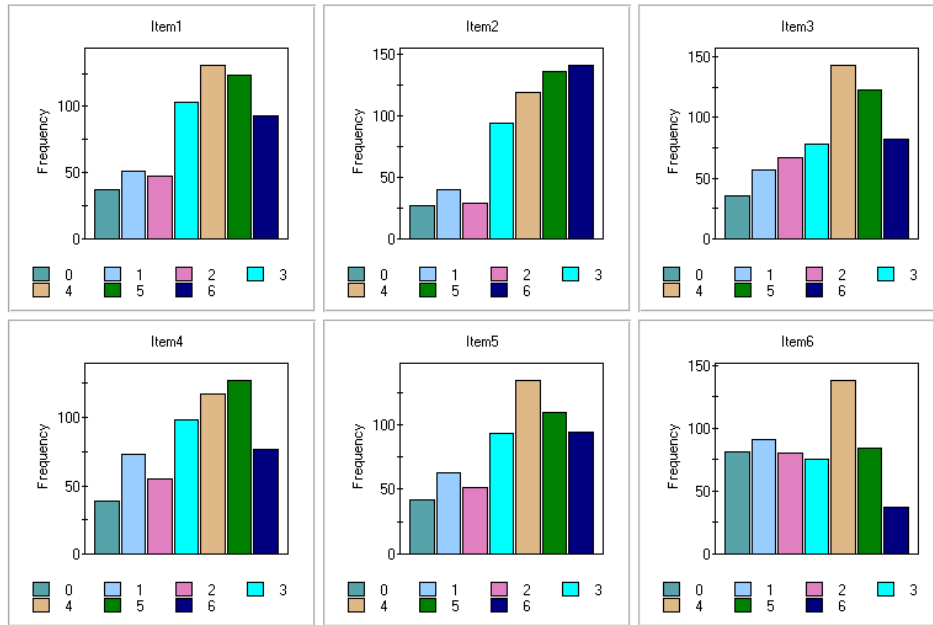
From the main menu bar, select the **Graphics, Univariate...** option to obtain bar chart representations of the distribution of the items over category values.



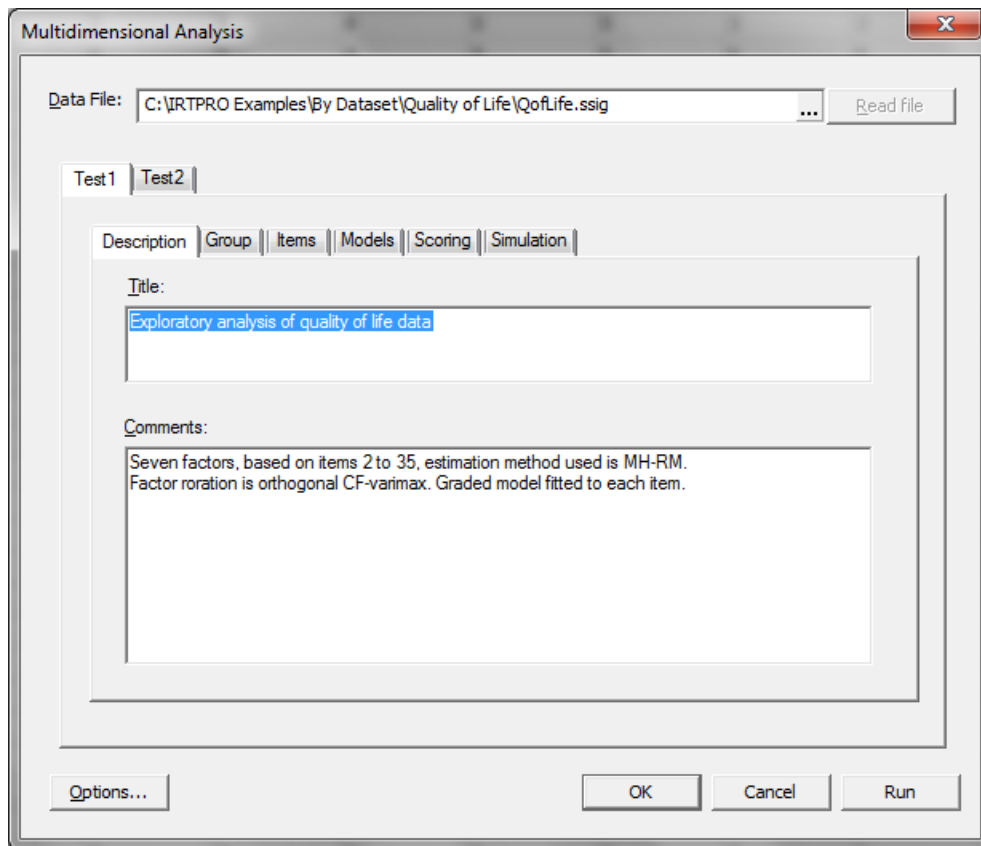
By selecting this option, the **Univariate Graph** window is displayed enabling one to select a list of items to be displayed graphically. To illustrate, the first six items are selected as shown.



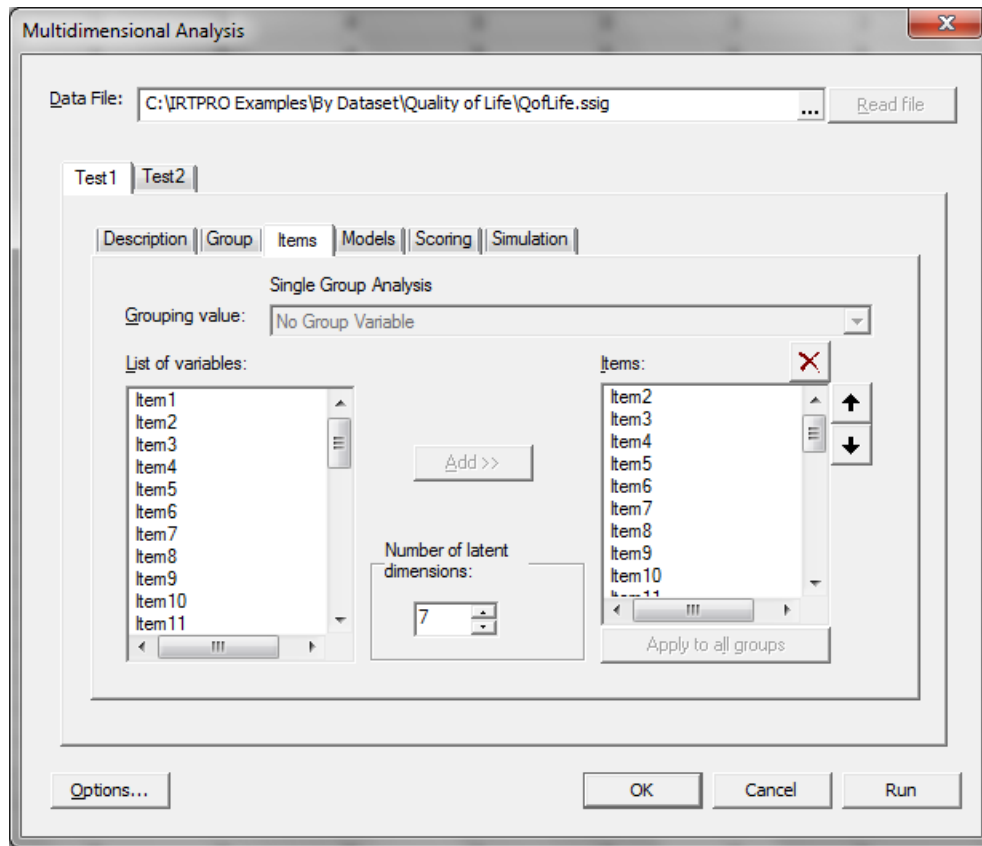
Next, click the **OK** button to obtain the bar charts. Each chart presents the distributions of responses over the seven categories.



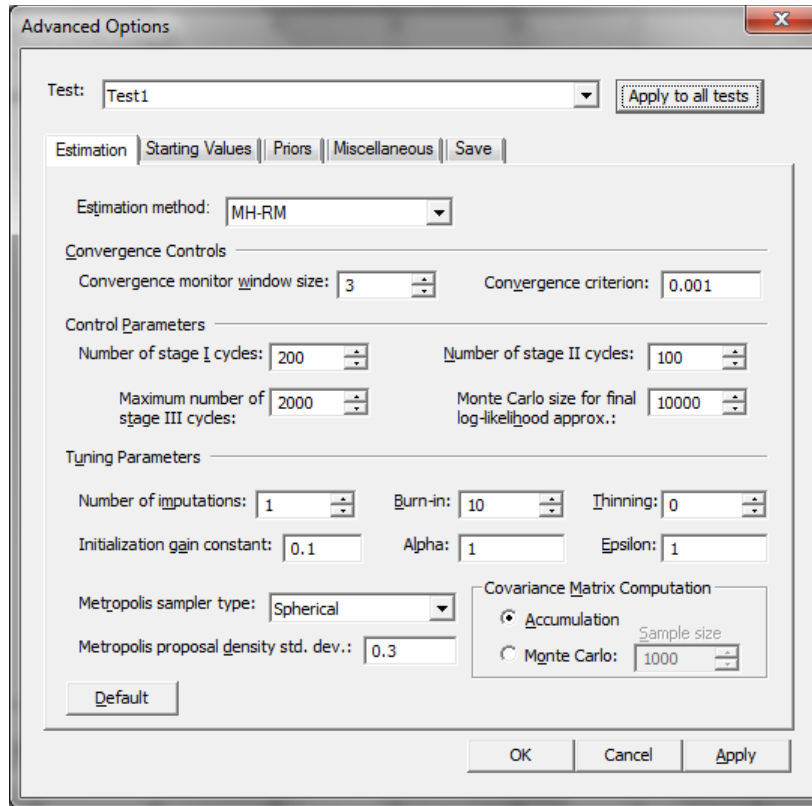
To start the exploratory factor analysis (EFA), select the **Analysis, Multidimensional...** option from the main menu bar and use the **Title** and **Comments** text boxes to describe the analysis.



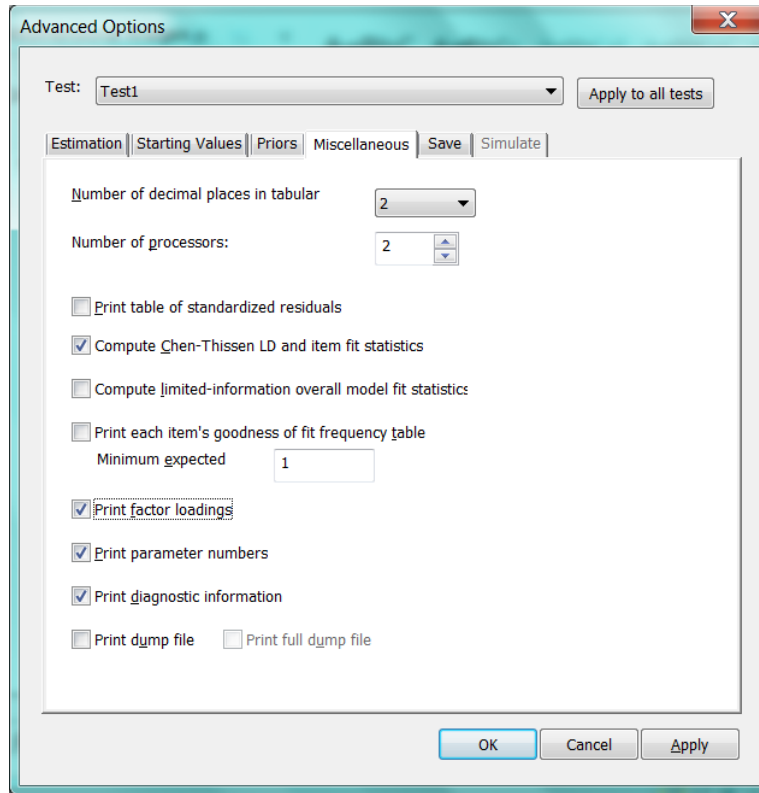
Since the dataset consists of a single group, the **Group** tab is not used and we skip to the **Items** tab to select Item2 to Item35. In the **Number of latent dimensions:** field enter "7".



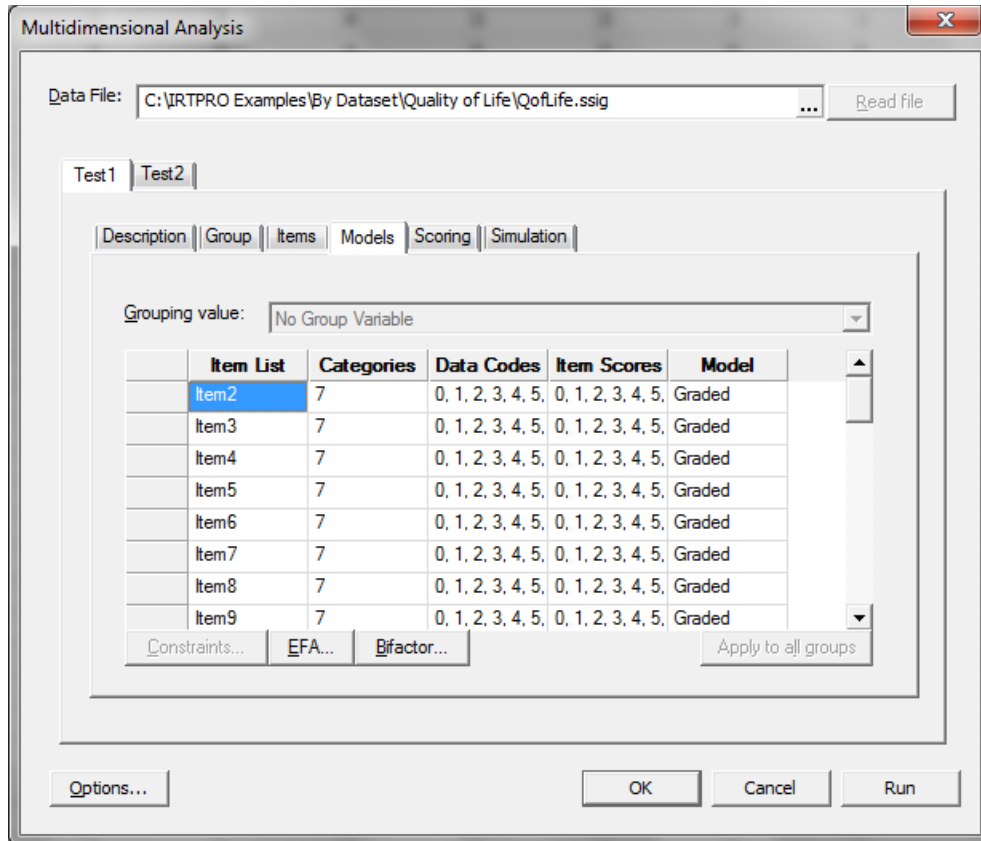
To change the estimation method from the default (Bock-Aitkin) to MH-RM, check the **Options** button (bottom-left on screen displayed above).



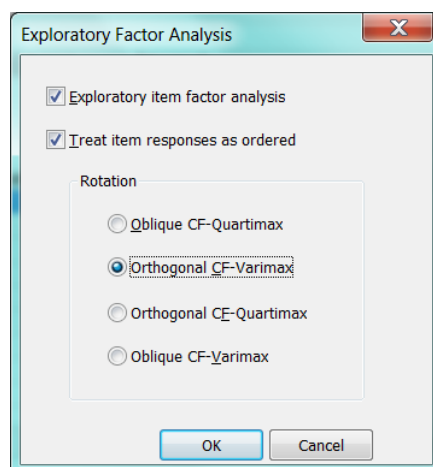
To obtain a listing of factor loading in the output file, select the **Miscellaneous** tab in the **Advanced Options** window and click the **Print Factor Loadings** check box.



Next, proceed to the **Models** tab. Click the **EFA** button to continue.



To confirm that you intend to do an exploratory item factor analysis, click the appropriate check box. In doing so, IRTPRO automatically sets up the EFA parameter constraints and the **Constraints** button, **Models** tab, is disabled. There are four rotation types available as shown in the dialogue below. For this analysis, the **Orthogonal CF-Varimax** method is selected.



Portion of the output, listing the rotated factor loadings of the first five factors for item2 to item20, is displayed below.

Orthogonal CF-Variimax Rotated Loadings for Group 1 (Back to TOC)

| Item | Label | λ_1 | s.e. | λ_2 | s.e. | λ_3 | s.e. | λ_4 | s.e. | λ_5 | s.e. |
|------|--------|-------------|------|-------------|------|-------------|------|-------------|------|-------------|------|
| 1 | Item2 | -0.79 | 0.00 | 0.11 | 0.02 | 0.13 | 0.02 | -0.08 | 0.02 | -0.14 | 0.02 |
| 2 | Item3 | -0.69 | 0.01 | 0.12 | 0.02 | 0.18 | 0.04 | -0.18 | 0.04 | -0.15 | 0.02 |
| 3 | Item4 | -0.83 | 0.01 | 0.13 | 0.02 | 0.20 | 0.04 | -0.16 | 0.04 | -0.18 | 0.03 |
| 4 | Item5 | -0.83 | 0.02 | 0.16 | 0.02 | 0.18 | 0.04 | -0.19 | 0.04 | -0.20 | 0.03 |
| 5 | Item6 | -0.14 | 0.04 | 0.10 | 0.04 | 0.18 | 0.05 | -0.83 | 0.03 | -0.10 | 0.04 |
| 6 | Item7 | -0.13 | 0.06 | 0.14 | 0.04 | 0.12 | 0.06 | -0.67 | 0.04 | -0.13 | 0.06 |
| 7 | Item8 | -0.15 | 0.04 | 0.14 | 0.05 | 0.14 | 0.05 | -0.84 | 0.02 | -0.14 | 0.05 |
| 8 | Item9 | -0.14 | 0.05 | 0.17 | 0.06 | 0.13 | 0.05 | -0.81 | 0.03 | -0.11 | 0.05 |
| 9 | Item10 | -0.13 | 0.07 | 0.23 | 0.07 | 0.21 | 0.07 | -0.11 | 0.07 | -0.30 | 0.07 |
| 10 | Item11 | -0.19 | 0.06 | 0.15 | 0.06 | 0.16 | 0.06 | -0.18 | 0.06 | -0.17 | 0.06 |
| 11 | Item12 | -0.19 | 0.06 | 0.18 | 0.07 | 0.07 | 0.06 | -0.16 | 0.06 | -0.17 | 0.06 |
| 12 | Item13 | -0.18 | 0.06 | 0.10 | 0.07 | 0.21 | 0.06 | -0.17 | 0.06 | -0.22 | 0.06 |
| 13 | Item14 | -0.22 | 0.06 | 0.24 | 0.07 | 0.18 | 0.06 | -0.19 | 0.06 | -0.26 | 0.06 |
| 14 | Item15 | -0.27 | 0.06 | 0.30 | 0.07 | 0.07 | 0.06 | -0.21 | 0.06 | -0.30 | 0.06 |
| 15 | Item16 | -0.19 | 0.05 | 0.53 | 0.05 | 0.13 | 0.06 | -0.26 | 0.05 | -0.30 | 0.05 |
| 16 | Item17 | -0.19 | 0.06 | 0.59 | 0.06 | 0.15 | 0.06 | -0.16 | 0.06 | -0.19 | 0.06 |
| 17 | Item18 | -0.19 | 0.05 | 0.62 | 0.05 | 0.18 | 0.06 | -0.21 | 0.06 | -0.21 | 0.06 |
| 18 | Item19 | -0.19 | 0.05 | 0.70 | 0.05 | 0.14 | 0.07 | -0.26 | 0.05 | -0.17 | 0.06 |
| 19 | Item20 | -0.23 | 0.06 | 0.61 | 0.05 | 0.19 | 0.07 | -0.22 | 0.06 | -0.11 | 0.06 |

By looking at all factor loadings that exceed 0.40 in absolute value, the EFA confirms the presence of seven subdomains (F1 = Family, F2 = Leisure, F3 = Living, F4 = Finance, F5 = Safety, F6 = Social and F7 = Health) listed in the table at the beginning of this section.

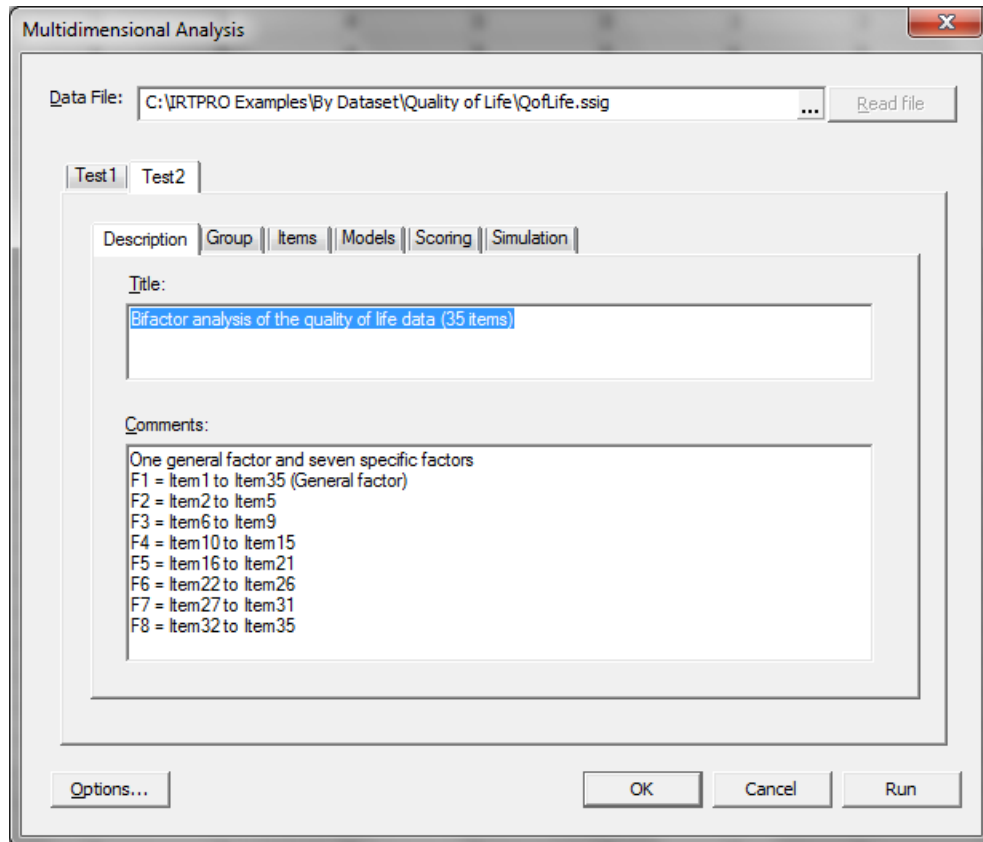
2. Bifactor Analysis

A plausible factorial structure for many types of psychological and educational tests exhibits a general factor and one or more group or method factors. A bifactor model can represent this type of factorial structure. The bifactor structure results from the constraint that each item has a nonzero loading on the primary dimension and, at most, one of the group factors. Using maximum marginal likelihood estimation of item parameters, the bifactor restriction leads to a major simplification of the likelihood equations and (a) permits analysis of models with large numbers of group factors, (b) permits conditional dependence within identified subsets of items, and (c) provides more parsimonious factor solutions than an unrestricted full-information item factor analysis in some cases. Analysis of data obtained from 586 chronically mentally ill patients, described in the previous section, reveals a clear bifactor structure, partially demonstrated by fitting an EFA model to the data with orthogonal rotation of the factors.

The bifactor model was originally introduced to extend the Spearman one-factor model for intelligence tests to include so-called "group" factors. Including these mutually uncorrelated factors enables the researcher to explain departures from the common (general) factor. The mutually uncorrelated factors assumption makes it possible to do numerical quadrature in

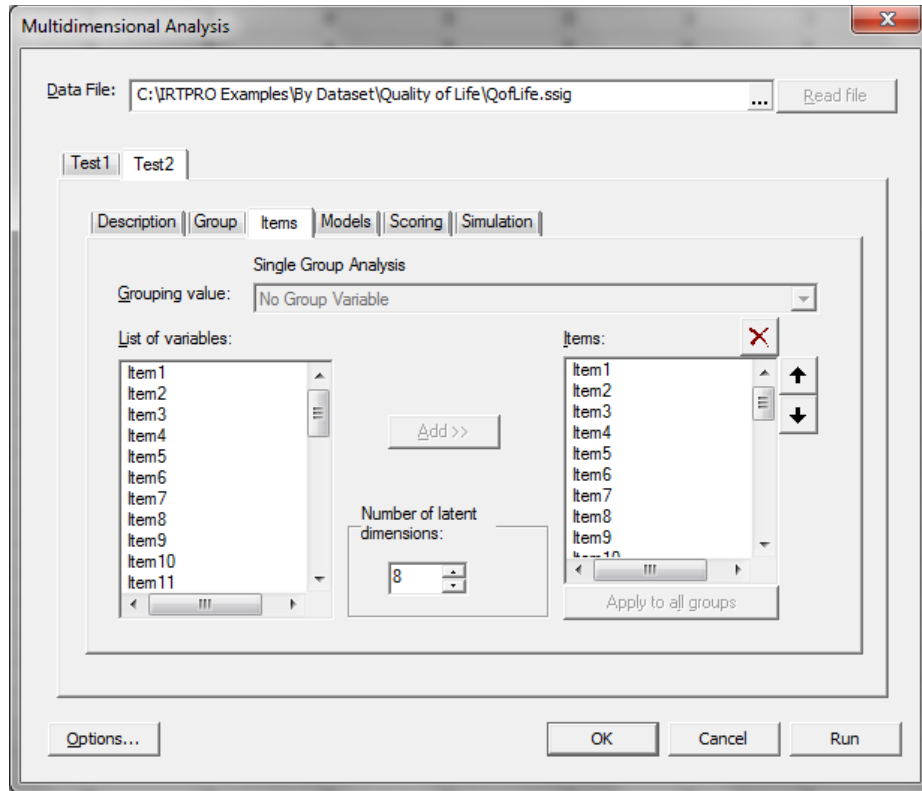
two dimensions.

To define the analysis using the user's interface, select the **Analysis, Multidimensional IRT...** option from the main menu bar. For this analysis, we assume a total of eight factors, these being a general factor and seven additional mutually uncorrelated factors.

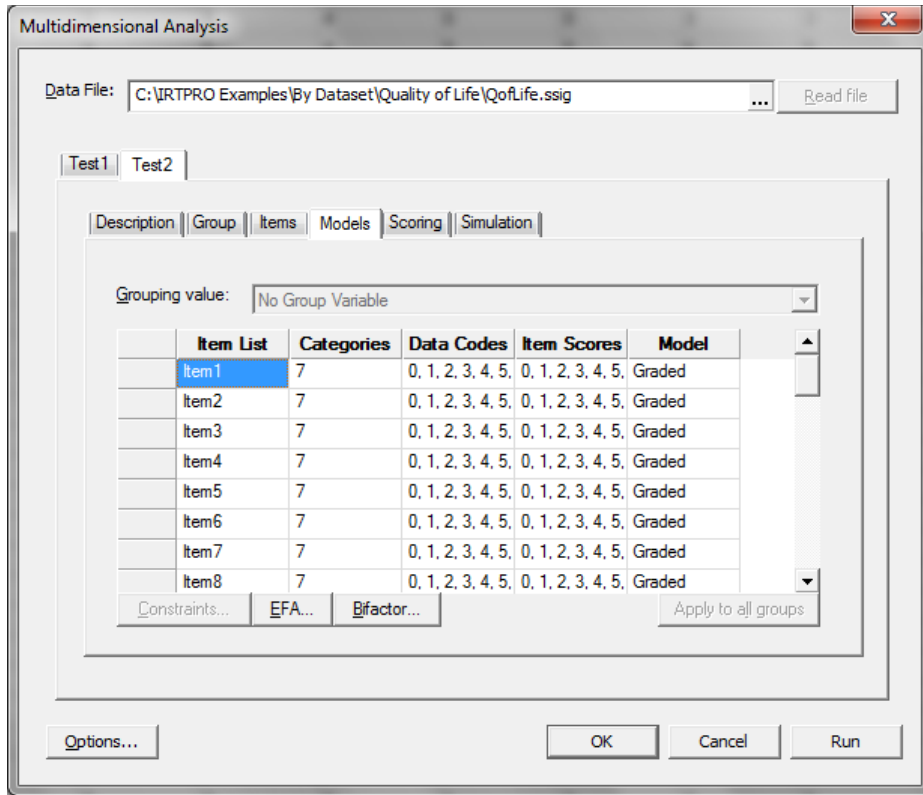


The **Description** tab shows the assignment of items to the group factors. Note that the mutually uncorrelated factors assumption implies that any given item can be assigned to only one group factor. Also, note that one or more of the 35 items do not have to be assigned to any group factor. In this illustration, item1 is not assigned to any one of the additional factors. Since the dataset consists of a single group, the **Groups** tab is skipped and under the **Items** tab all 35 items are selected.

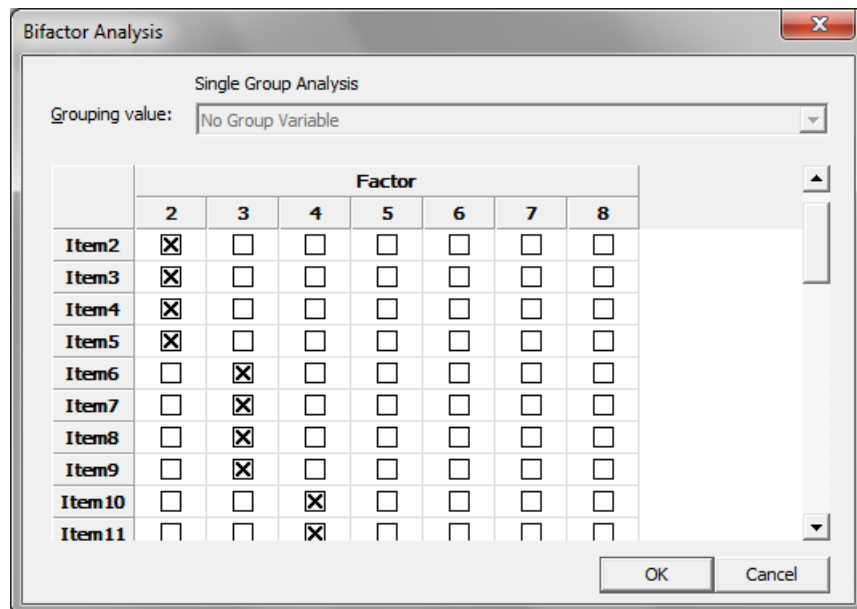
In the case of a multidimensional analysis, the **Items** tab contains a field for the number of latent dimensions, the number to be entered being 8 in the present example.



The graded model (the default model when the number of categories for an item is greater than two) is used for each item and hence we click the **Bifactor** button to assign items to the additional factors.



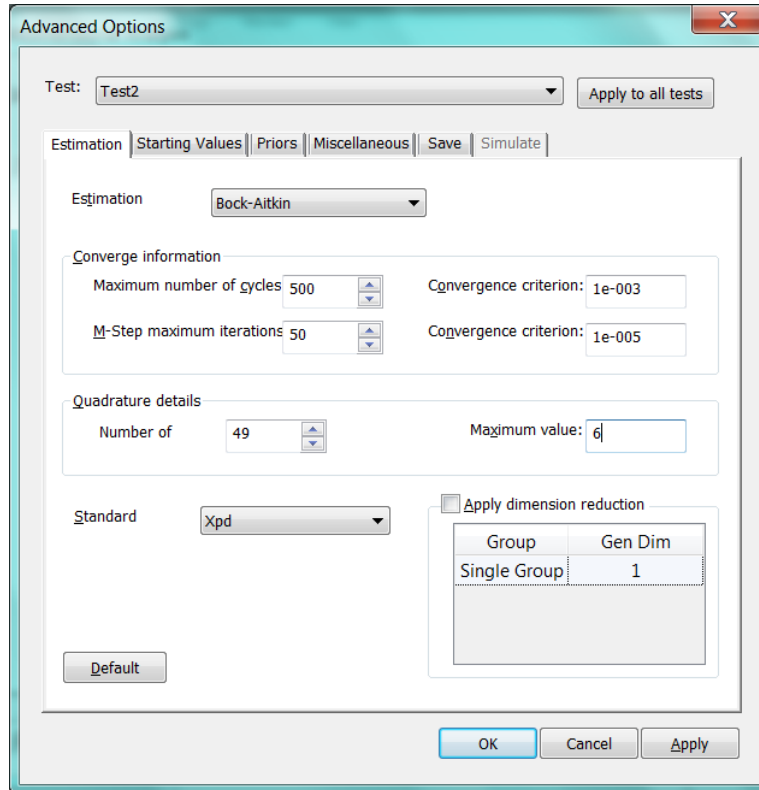
Selection of the **Bifactor** option activates a **Bifactor Analysis** window, allowing one to select items from the **List of variables** for each additional factor. Below, Factor 2 is selected and Item2 to Item5 are assigned to this factor.



Note that when either an **EFA** or **Bifactor** analysis is specified, the **Constraints** option is no

longer available since parameter constraints are, in these cases, generated by the user's interface.

Access to the **Advanced Options** window is obtained by clicking the **Options** button on the **Multidimensional Analysis** window. For the current analysis, the Bock-Aitkin estimation method is selected and the **Convergence information**, **Quadrature details**, and method to be used to calculate the standard errors are specified.



A portion of the output is shown below. Note that all the slope parameters (a_1) for the general factor are estimated. In the case of the additional factors, slopes are only estimated for the list of items assigned to a group factor.

IRTPRO - [QofLife.Test2-irt.htm]

File Edit View Analysis Window Help

Likelihood-based Values and Goodness of Fit Statistics

Summary of the Data and Control Parameters

Graded Model Item Parameter Estimates for Group 1, logit: $a\theta + c$ (Back to TOC)

| Item | Label | a_1 | s.e. | a_2 | s.e. | a_3 | s.e. | a_4 | s.e. | a_5 | s.e. |
|------|--------|-------|------|-------|------|-------|------|-------|------|-------|------|
| 1 | Item1 | 7 | 2.39 | 0.25 | 0.00 | ---- | 0.00 | ---- | 0.00 | ---- | 0.00 |
| 2 | Item2 | 14 | 1.70 | 0.21 | 15 | 1.93 | 0.20 | 0.00 | ---- | 0.00 | ---- |
| 3 | Item3 | 22 | 1.58 | 0.20 | 23 | 1.45 | 0.15 | 0.00 | ---- | 0.00 | ---- |
| 4 | Item4 | 30 | 2.79 | 0.34 | 31 | 3.27 | 0.35 | 0.00 | ---- | 0.00 | ---- |
| 5 | Item5 | 38 | 2.83 | 0.33 | 39 | 2.84 | 0.27 | 0.00 | ---- | 0.00 | ---- |
| 6 | Item6 | 46 | 1.73 | 0.23 | 0.00 | ---- | 47 | 2.49 | 0.26 | 0.00 | ---- |
| 7 | Item7 | 54 | 1.09 | 0.16 | 0.00 | ---- | 55 | 1.38 | 0.17 | 0.00 | ---- |
| 8 | Item8 | 62 | 2.15 | 0.26 | 0.00 | ---- | 63 | 2.74 | 0.30 | 0.00 | ---- |
| 9 | Item9 | 70 | 1.95 | 0.26 | 0.00 | ---- | 71 | 2.52 | 0.28 | 0.00 | ---- |
| 10 | Item10 | 78 | 1.25 | 0.16 | 0.00 | ---- | 0.00 | ---- | 79 | 0.37 | 0.15 |
| 11 | Item11 | 86 | 1.61 | 0.20 | 0.00 | ---- | 0.00 | ---- | 87 | 1.55 | 0.24 |
| 12 | Item12 | 94 | 1.41 | 0.20 | 0.00 | ---- | 0.00 | ---- | 95 | 1.49 | 0.22 |
| 13 | Item13 | 102 | 1.66 | 0.22 | 0.00 | ---- | 0.00 | ---- | 103 | 1.68 | 0.26 |
| 14 | Item14 | 110 | 1.68 | 0.18 | 0.00 | ---- | 0.00 | ---- | 111 | 0.54 | 0.17 |
| 15 | Item15 | 118 | 1.83 | 0.19 | 0.00 | ---- | 0.00 | ---- | 119 | 0.27 | 0.14 |

Done

In many practical applications, the bifactor model provides a natural alternative to the traditional conditionally independent unidimensional IRT model. When conditional dependence is likely, as in the case of paragraph comprehension tests, tests in which there are two or more methods of item presentation, or personality or other items that have a two-level structure with an underlying general factor, the item bifactor solution provides an excellent alternative. An attractive by-product of this model is that it requires only the evaluation of a two-dimensional integral, regardless of the number of subtests, paragraphs, or content areas.

In the ordinal response case, the bifactor model provides a very general multidimensional model for graded response data. In mental health measurement, rating scales are typically constructed by sampling items from domains related to a single underlying construct, as in the quality-of-life scale analyzed in the illustration. In these cases, a priori knowledge of which item belongs to which subdomain is available, and the bifactor model is a natural choice. Similarly, in educational measurement problems, tests are often constructed by creating a series of subtests or so-called "testlets" (Wainer & Kiely, 1987) within which items have similar content or focus, and these testlets are then combined to form a test. In this case, item groupings are also known in advance, and the bifactor model applies. Regardless of the number of testlets, the relevant integrals in the full-information maximum marginal likelihood solution always reduce to 2 and can be approximated to any practical degree of accuracy.