

# IRTPRO™

## Contents

1. Model-based graphics .....	1
1.1 Introduction .....	1
1.2 Trace lines .....	3
1.3 Item Information .....	5
1.4 Combined trace lines-information curves .....	9
1.5 Total Information .....	10
1.6 Test Characteristic Curves .....	12
1.7 Controlling the appearance of a graph .....	14

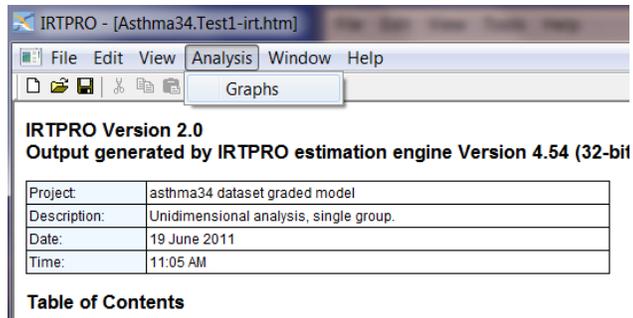
## 1. Model-based graphics

### 1.1 Introduction

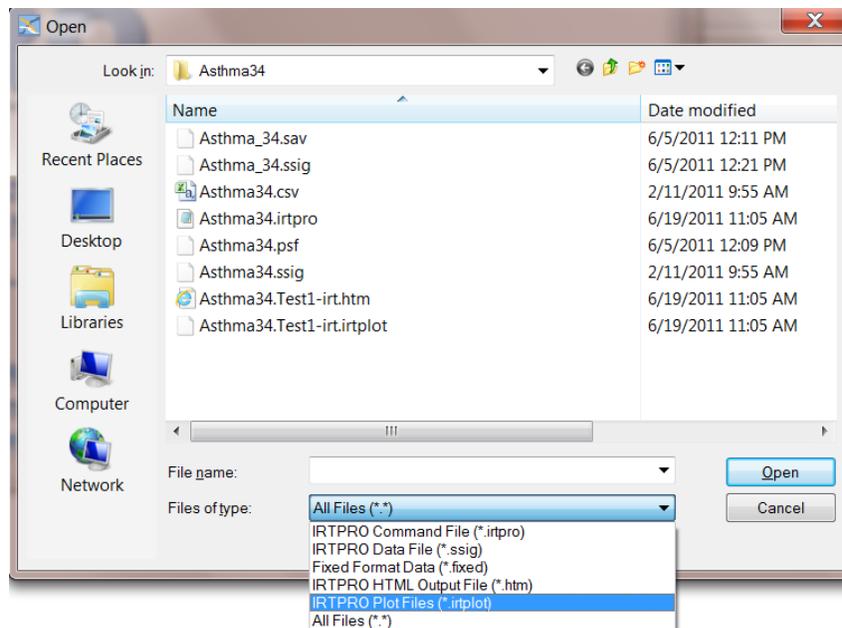
The model-based graphics option in IRTPRO is only available for unidimensional IRT models. There are five different display types available, these being:

- Trace lines (Section 1.2).
- Item information curves (Section 1.3).
- Combined display of trace lines and item information curves (Section 1.4).
- Total information curve (Section 1.5).
- Test characteristic curve (Section 1.6).

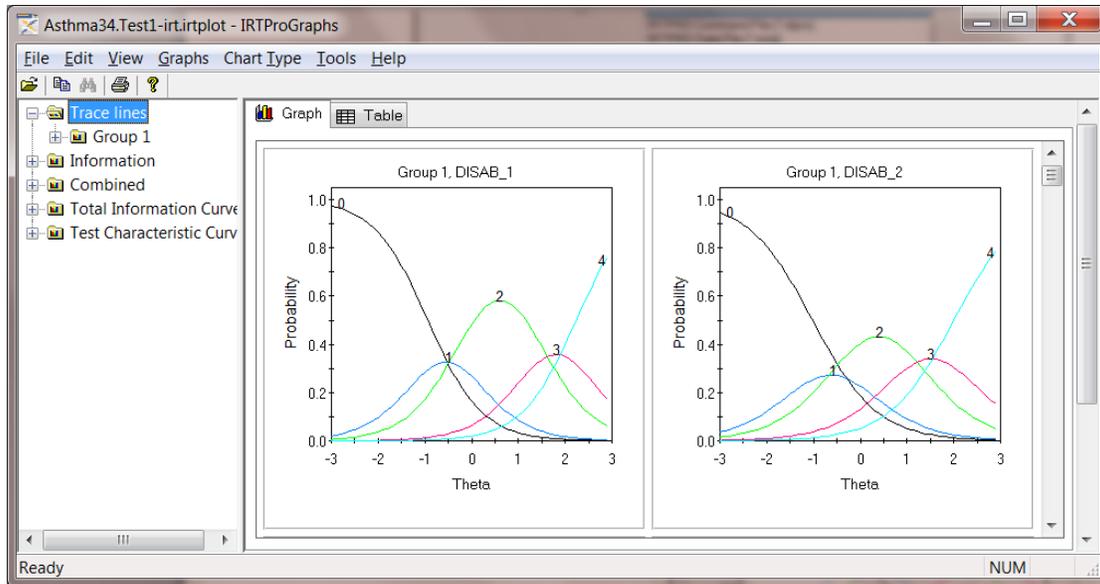
There are two ways to display IRT graphics. The first method is to run a unidimensional analysis. On successful completion of the analysis, an output file with extension **-irt.htm** is produced. With the **-irt.htm** content displayed, select **Analysis**, **Graphs** to obtain trace lines, information and test characteristic curves.



Alternatively, on successful completion of a run, IRTPRO produces a plot file with the extension **-irt.irtplot**. One can use the **File, Open** option to locate this file.



The **Graphics** window is displayed by either selecting the **Analysis, Graphs** option or by opening the plot file. By default, trace lines are displayed when this window is opened.

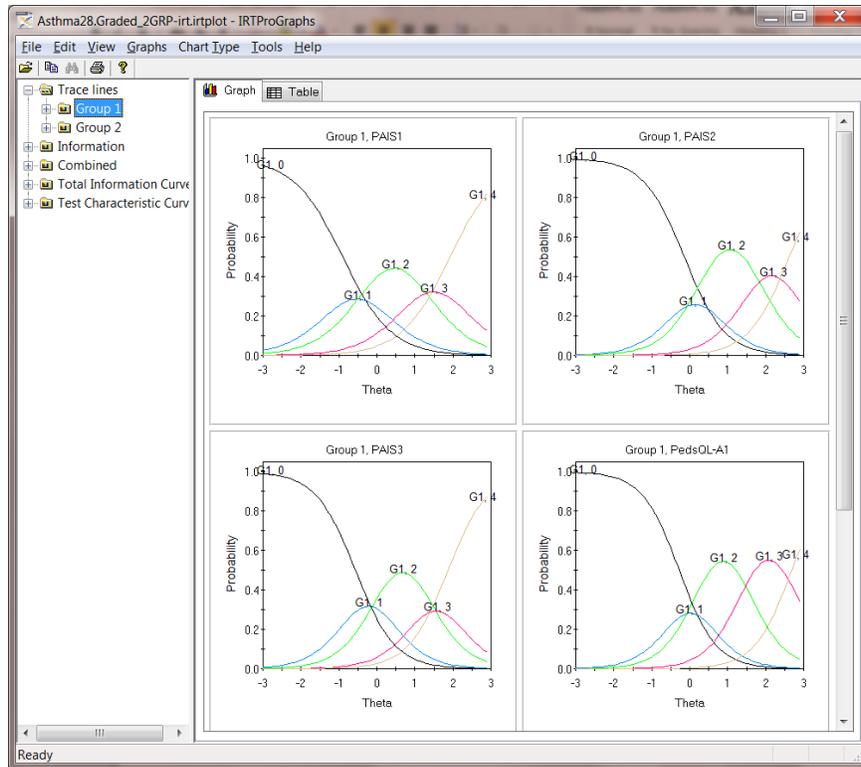


## 1.2 Trace lines

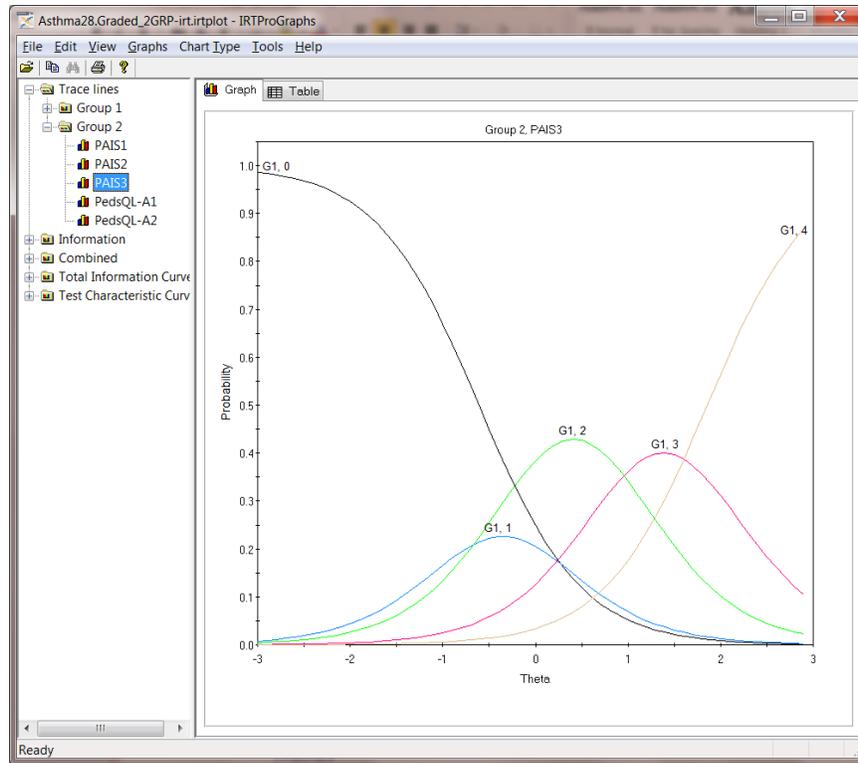
A trace line (item characteristic curve) is a nonlinear function that portrays the regression of the item score on the trait or ability measured in a test.

In the case of binary data, two trace lines are shown, one for the positive response and the other its complement. In polytomous models such as the graded response model and nominal response models, trace lines for each response category are plotted. Each curve shows the selection probability of a category of the item as a function of  $\theta$ .

By default, trace lines for all the items selected under the **Models** tab are displayed simultaneously for each group. Trace lines for the first four items of Group number 1 of a two-group analysis are shown below.



To view the trace lines for any specific item, double-click on the relevant graphics box, or, if for example the item PAIS3 of the second group is of interest, click on the **Group 2, PAIS3** link using the trace line tree expansion shown below.



### 1.3 Item Information

Item information is a function of  $\theta$ ; it provides valuable insight about the precision of measurement provided by the item. It is of particular use in test construction, where these curves can be used to ensure the inclusion of different items that maximize the precision of measurement at different levels of  $\theta$  in the test.

In the case of the 2PL model, for example, the item information function is given by (Hambleton & Swaminathan, 1985, Table 6-1)

$$a_i^2 \left\{ 1 + \exp[-(\theta - b_i)] \right\}^{-1} \left\{ 1 - \left( 1 + \exp[-(\theta - b_i)] \right)^{-1} \right\}$$

with the maximum value directly proportional to the square of the item discrimination parameter,  $a$ . A larger value of  $a$  is associated with greater information. The maximum information is obtained at  $b_i$ .

For the three-parameter model, the information function is (Hambleton & Swaminathan, 1985, Table 6-1)

$$\frac{a_i^2 \left\{ 1 - \left( 1 + \exp[-(\theta - b_i)] \right)^{-1} \right\} \left\{ 1 + \exp[-(\theta - b_i)]^{-1} - c_i \right\}^2}{\{1 - c_i\}^2}$$

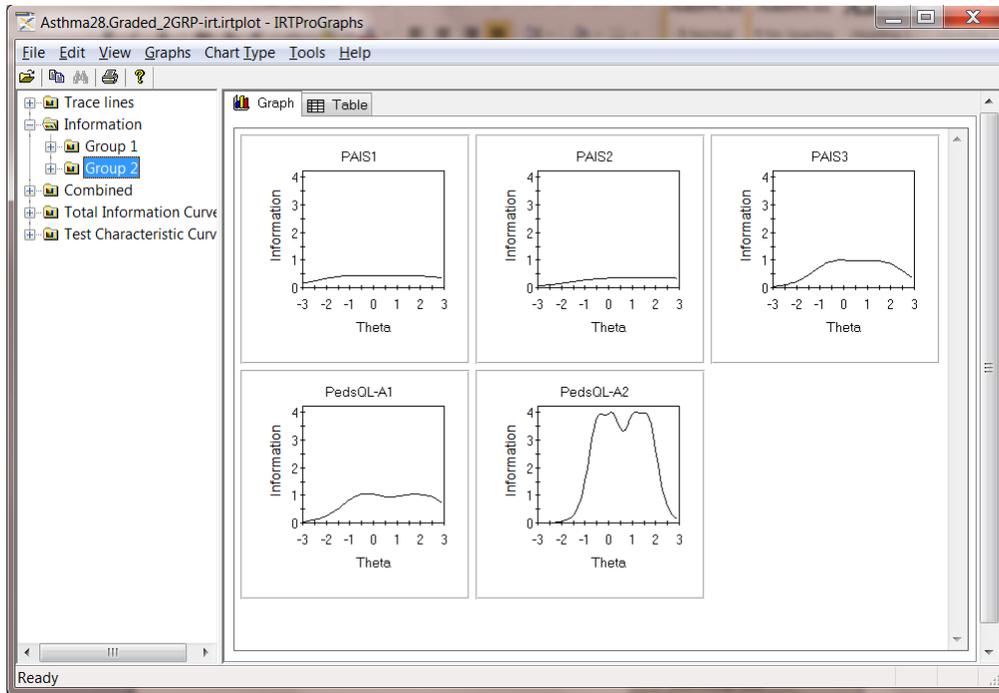
The maximum information is reached at

$$b_i + \frac{1}{a_i} \ln \left[ 1/2 + 1/2 \sqrt{1 + 8c_i} \right]$$

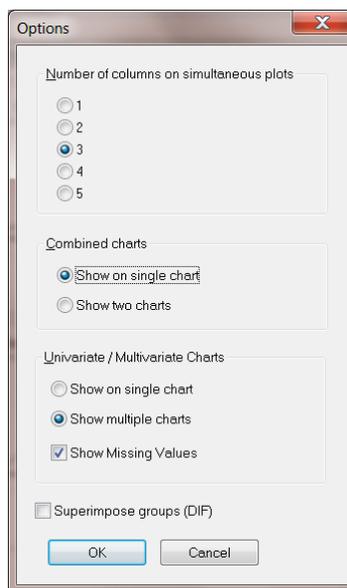
An increase in information is associated with a decrease in  $c_i$ . The maximum information is obtained when  $c_i = 0$ . Baker & Kim (2004) contains information function equations for most of the IRT models available in IRTPRO.

The slope of the trace line plays an important role in the information provided by an item. An increase in the slope means the item provides more information. The use of items with more information leads to smaller standard errors of measurement. By assessing these curves, items that contribute little information, and therefore contribute little to precision, may be identified and discarded.

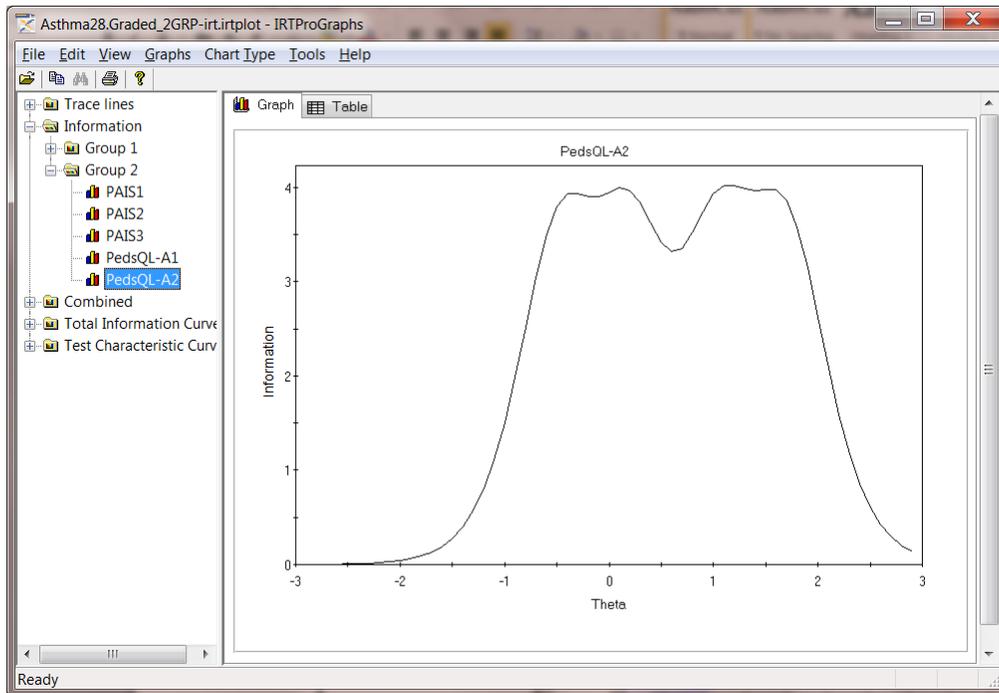
To obtain the item information curves, click on the **Information** link. As before, simultaneous displays of all the item information curves are obtained. By scrolling up or down, all items can be viewed if there are many items in a test.



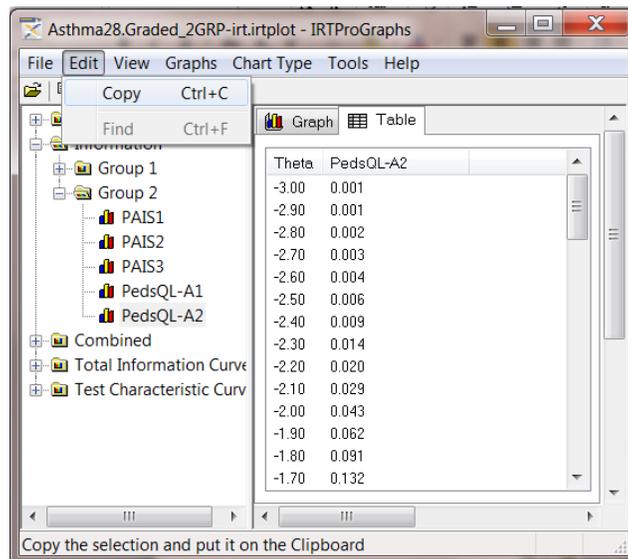
One can also change the number of columns of plots from three (see above) to less or more columns. This is accomplished by clicking **Tools** on the main graphics menu bar to select the **Options** dialog shown below.



Just as in the case of trace lines, one can view one information curve at a time by expanding the **Information** tree and by clicking on the item to be displayed. This is illustrated below for PedsQL-A2 (item 5 of the second group).

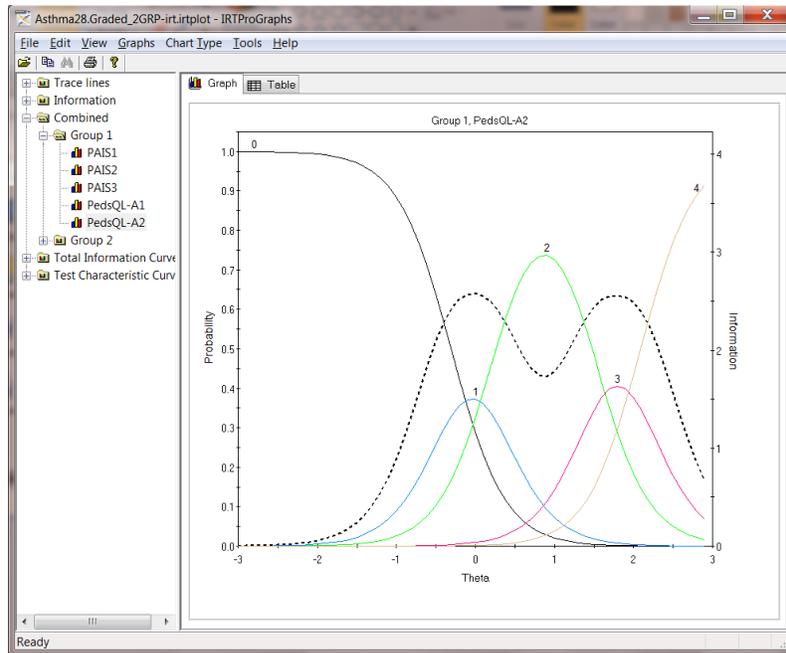


To view the co-ordinates used to plot a graph, the **Table** icon next to the **Graph** icon in the graphics window can be selected. Use **Edit, Copy (Ctrl+C)** to copy the contents of the table to the clipboard if you need to paste these values into another document.

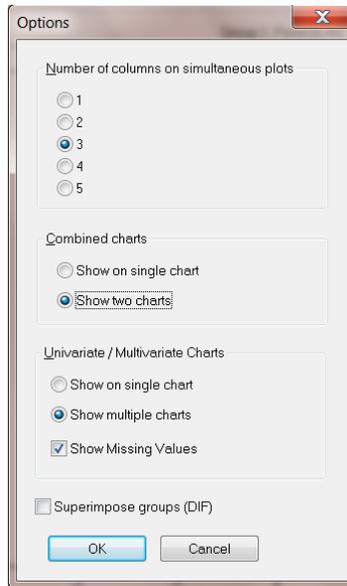


## 1.4 Combined trace lines-information curves

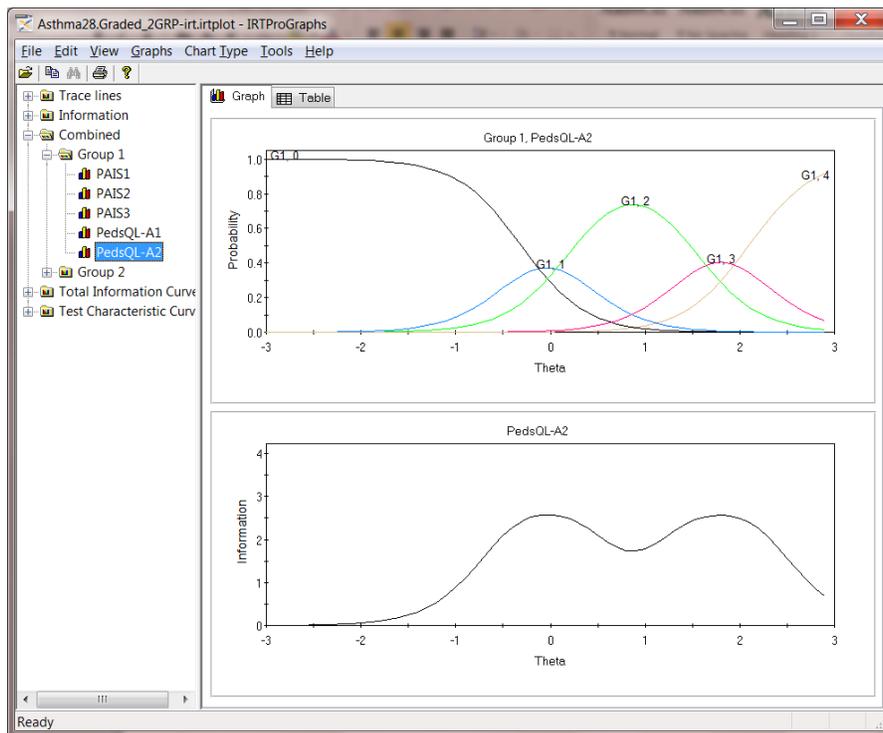
The user additionally has the option to obtain a combined trace lines-information curve presentation. This is illustrated below for Group1, item 5 (PedsQL-A2). Just as in the previous cases, the default selection is the simultaneous display of all the items that are obtained by clicking on **Combined**. Note that the information curve is displayed as a dashed line and that the information scale is shown on the right side of the graph.



For reporting purposes, a researcher may prefer to display the trace lines and information curves as two separate vertically stacked plots. This is achieved by selecting the **Tools, Option** dialog and by making the appropriate choice (**Show two charts**) in the **Combined charts** pane.



The **Show two charts** choice results in a trace lines graph stacked above the information graph for the item selected.



## 1.5 Total Information

The total information (or test information) function summarizes the information function for

a set of items or test. The contribution of each item in the test to the total information is additive.

The slope of the trace line plays an important role in the information provided by an item. An increase in the slope means the item provides more information. The use of items with more information leads to smaller standard errors of measurement. By assessing these curves, items that contribute little information, and therefore contribute little to precision, may be identified and discarded.

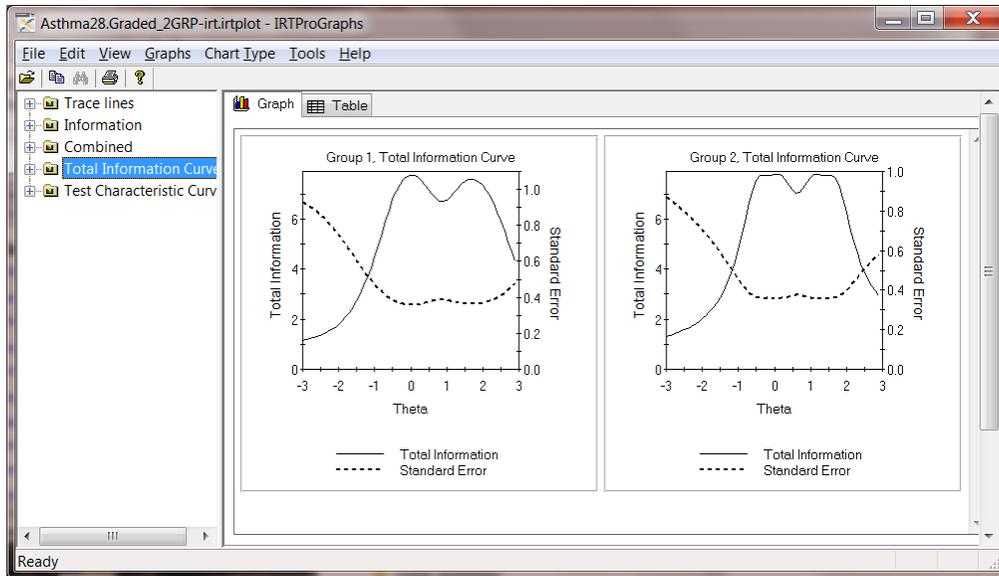
The measurement error variance of the MAP scale score is (on average) inversely related to the amount of information provided by a set of test items at any level of  $\theta$ , so on average, the standard error of MAP estimates at ability level  $\theta$  can be written as

$$SE(\theta) = \frac{1}{\sqrt{I(\theta)}}.$$

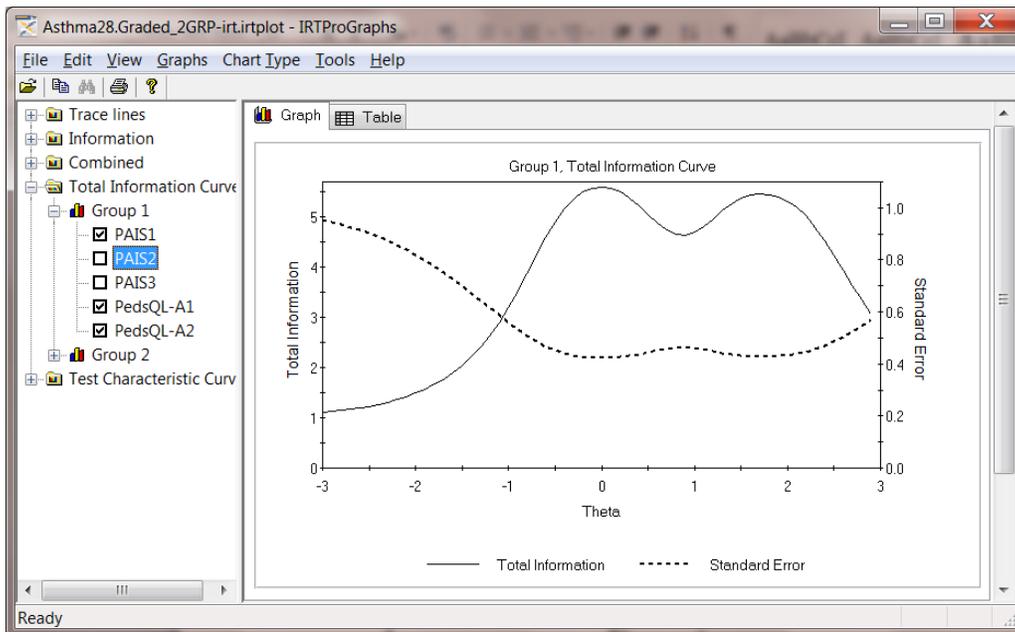
The contribution of both item and test information curves are summarized by Hambleton & Swaminathan (1985) as follows:

"The item and test information functions provide viable alternatives to the classical concepts of reliability and standard error. The information functions are defined independently of any specific group of examinees and represent the standard error of measurement at any chosen ability level. Thus, the precision of measurement can be determined at any level of ability that is of interest. Furthermore, through the information function, the test constructor can precisely assess the contribution of each item to the precision of the total test and hence choose items in a manner that is not contradictory with other aspects of test construction."

The graph shown below is obtained by clicking on the **Total Information Curve** link. The solid line shows the total information curve at various values of  $\theta$ . The corresponding standard errors are presented by the dashed line. The standard error scale is given on the right-hand vertical axis. The curves below are based on all the items that are included in the model.



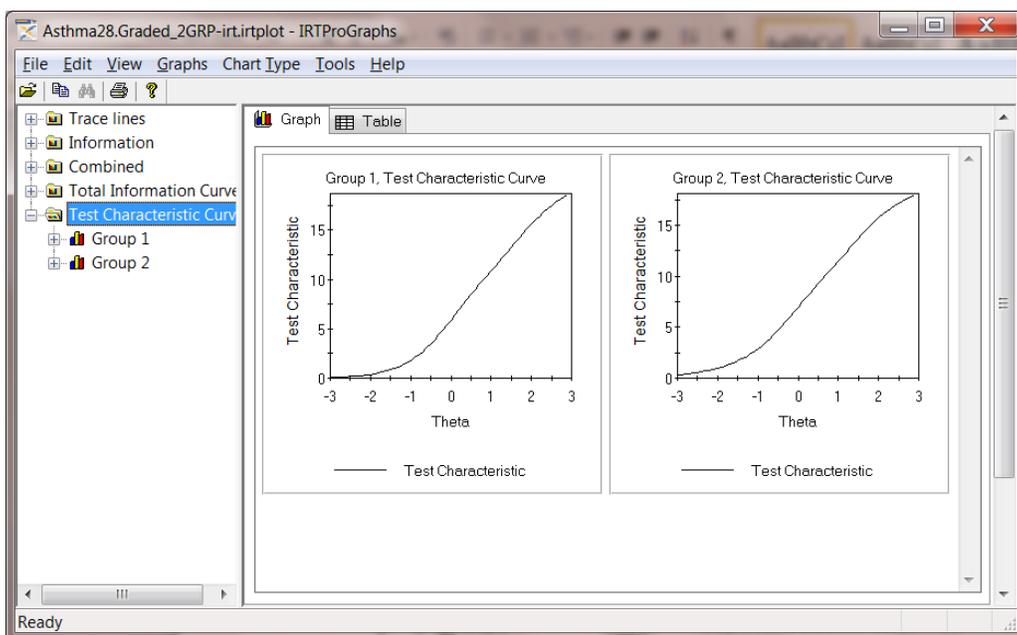
The next graphical presentation shows the total information and standard errors when Items 2 and 3 (PAIS2 and PAIS3) are omitted.



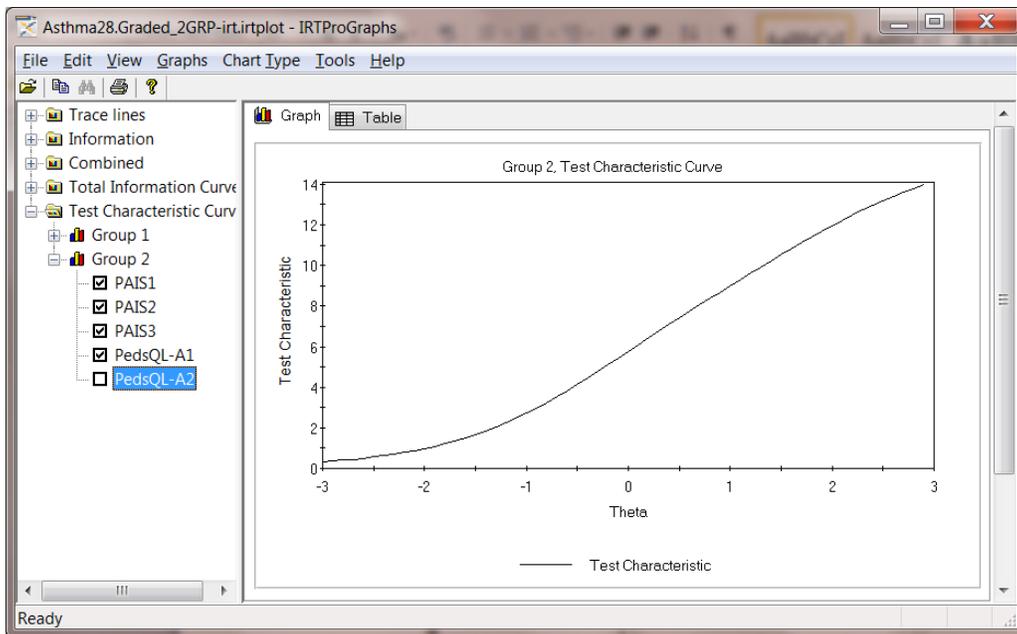
## 1.6 Test Characteristic Curves

The test characteristic curve is the expected value of the summed score for a test, or a set of items, as a function of  $\theta$ .

In the image below, the test characteristic curves for Groups 1 and 2 are displayed.



The next graphical presentation shows the test characteristic curve for group 2 when the item PedsQL-A2 is omitted.



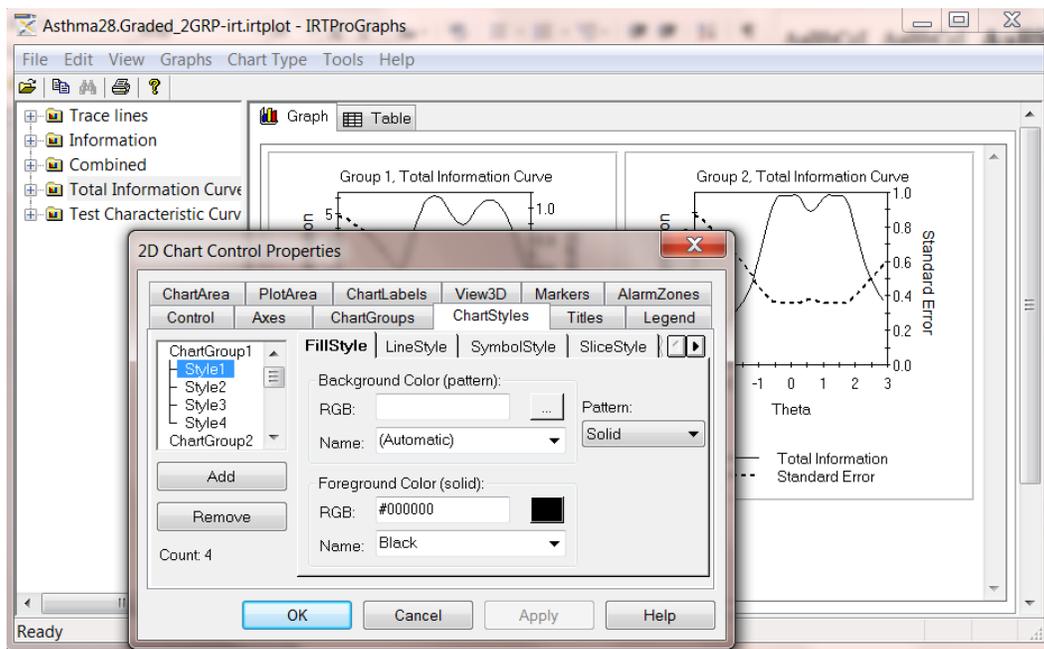
Polytomous items each has expected score curves, which show the expected item score as a function of  $\theta$ , computed by taking literally the numerical values of the item scores  $u = 0, 1, \dots, m-1$  where  $m$  is the number of response categories. Expected score curves are simpler than trace line plots for, say, five response categories, because the latter have five

curves and the expected score is only curve. While it is difficult to compare two items' sets of five trace lines, it is easier to compare two items' expected score curves.

In **IRTProGraphs**, expected score curves for individual items can be graphed by selecting *only one item* with the check boxes in the list at the left side of the graphics window.

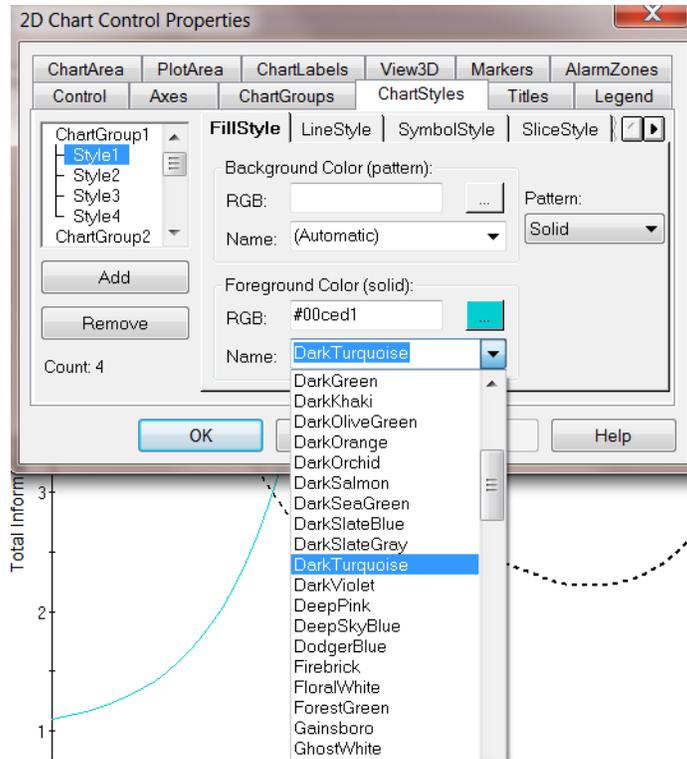
## 1.7 Controlling the appearance of a graph

The visual appearance of a graphical display can be changed before the graph is copied to another document. This is accomplished by right-clicking in the plot area of the display that is to be modified. This action activates the **2D Chart Control Properties** dialog that provides the user with several options (options available depends on the graph type). In the illustration below, we wish to change the colors of the total information and standard error curves of the first group.

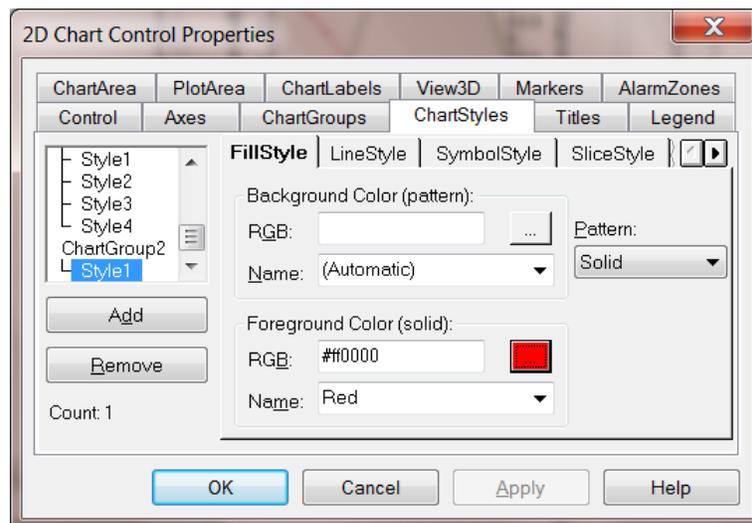


This is accomplished by selecting the **ChartStyles** tab and then by clicking on the **Name:** (of the color) arrow.

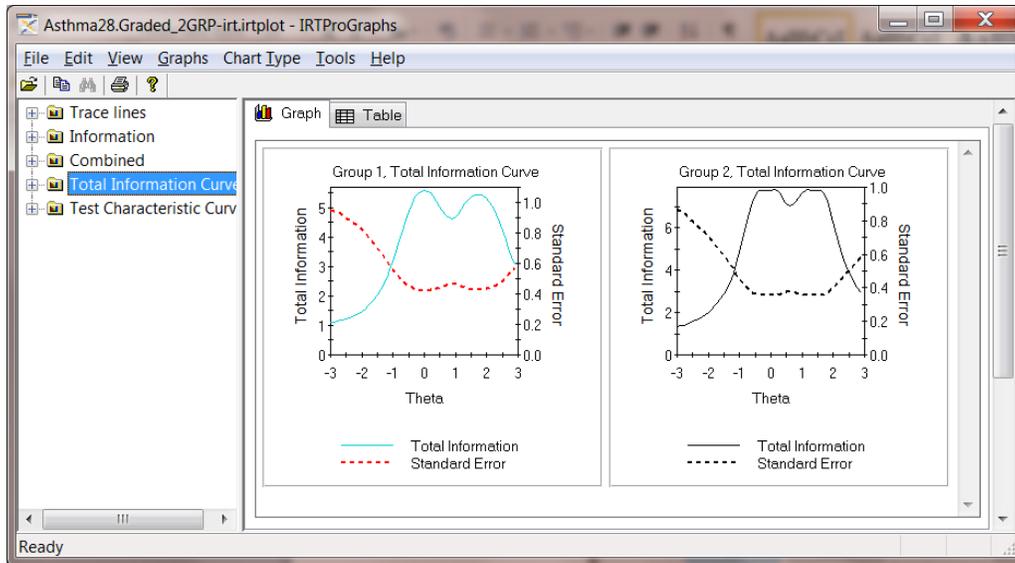
This action results in the display of a drop-down menu with a list of available colors. In the image shown below, the color Dark Turquoise was selected.



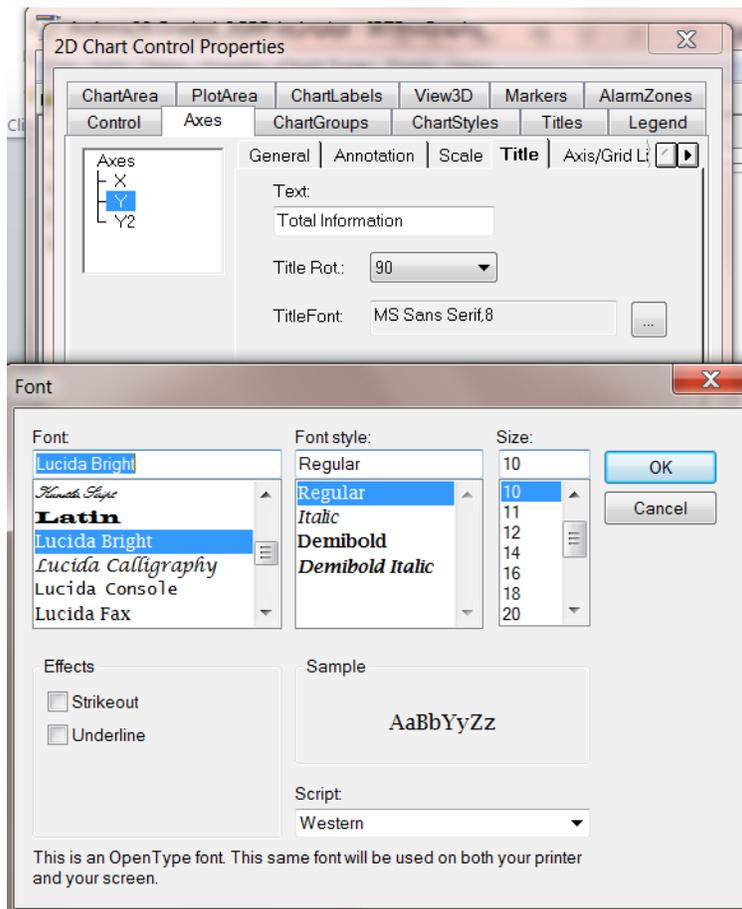
To change the color of the standard error curve from Black to Red, select **ChartGroup2, Style 1** and repeat the procedure described above.



Click **OK** when done to obtain the revised graphical display shown next.



To change the format of the axes labels, select the **Axes** tab and click on the **TitleFont** selector button to display the **Font** dialog. To illustrate, we selected the Lucida Bright font, size 10.



Click **OK** when done to obtain the revised graphical display shown below. Chapter **Error! Reference source not found.** contains additional examples illustrating the functionality of the **2D Chart Control Properties** dialog.

