

Chapter 506

Item Response Analysis

Introduction

This procedure performs item response analysis. Item response analysis is concerned with the analysis of questions on a test which can be scored as either right or wrong.

Item Response Analysis is not the same as item analysis. Item analysis studies the internal reliability of a particular instrument (test, survey, questionnaire, etc.). The Item Analysis program, discussed elsewhere, conducts this type of analysis.

Discussion

Let A_j represent the j^{th} individual's ability to perform a certain task. This ability may represent intelligence, math aptitude, geography knowledge, etc. Define the *logistic item characteristic curve* (ICC) as follows:

$$P_i(A_j) = \frac{1}{1 + e^{-Z_{ij}}}$$

where

$$Z_{ij} = d_i A_j + a_i$$

Note that $P_i(A_j)$ is the probability that individual j with ability A_j marks item i correctly. Z_{ij} is called the logit. An item's difficulty may be calculated using:

$$b_i = \frac{-d_i}{a_i}$$

This model is similar to the usual logistic regression model. A new problem has arisen in that the ability values, the A_j , are unknown and must be estimated. The program uses the Bock-Aikin (1981) MMLE/EM algorithm as provided in Baker (1992).

Data Structure

The data are entered in two or more columns. Only numeric values are allowed. Also, a column containing the correct answers must be entered. An optional column containing row labels may also be entered.

Note that the answers correspond to items by position number. Thus the answer to the item contained in variable one is in row one, the answer to the item contained in variable two is in row two, and so on.

An example of data appropriate for this procedure is shown in the table below. These data are contained in the Item dataset. These data represent the responses of sixteen individuals to a four-item test.

Item Response Analysis

Item dataset

| Item1 | Item2 | Item3 | Item4 | Answer | Name |
|-------|-------|-------|-------|--------|-----------|
| 1 | 3 | 2 | 1 | 1 | Eric |
| 2 | 2 | 2 | 3 | 3 | Charlotte |
| 1 | 3 | 2 | 2 | 2 | Janet |
| 3 | 3 | 3 | 3 | 1 | Julie |
| 1 | 1 | 2 | 2 | | Katie |
| 3 | 3 | 3 | 1 | | Ryan |
| 2 | 2 | 1 | 2 | | Tyson |
| 1 | 1 | 2 | 1 | | Jordan |
| 1 | 3 | 1 | 2 | | Bob |
| 1 | 1 | 2 | 2 | | Linda |
| 5 | 3 | 2 | 2 | | Mike |
| 1 | 1 | 2 | 1 | | Michell |
| 1 | 3 | 2 | 2 | | Randy |
| 1 | 3 | 3 | 1 | | Jerry |
| 1 | 3 | 2 | 1 | | Chris |
| 1 | 3 | 1 | 1 | | Holly |

Procedure Options

This section describes the options available in this procedure.

Variables Tab

This panel specifies the variables used in the analysis.

Data Variables

Item Variables

Specify the variables to be analyzed. These are the columns containing each individual's answers to the questions on the test. Each variable represents a question. Each row represents an individual.

Note that only numeric variables are allowed here.

Answer Variable

This variable contains a list of the correct answers. The answers in this column correspond to the questions by position. The value in row one is the correct response for variable one, the value in row two is the correct response for variable two, and so on. If your questions start with variable five (variables one - four are identification variables), your correct answers must start in row five!

If you have already scored the test and you want to enter simply right or wrong, use zero for wrong, one for right, and put all ones in this variable.

Other Variables

Frequency Variable

This optional variable contains the frequency (count) to be assigned to this row. Normally, each row receives a count of one. The values in this variable replace this default value.

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Label Variable

This optional variable contains row labels that are used to label various reports.

Options

Iterations

This option specifies the maximum number of iterations. Experience has shown that a value of 50 or more is necessary.

Zero

Specify the value used as zero by the numerical routines. Because of round-off error, values less than this amount (in absolute value) are changed to zero during the calculations.

Reports Tab

The following options control the reports and plots that are displayed.

Select Reports

Counts Report ... Abilities Report

Indicate whether to display the indicated reports.

Report Options

Precision

Specify the precision of numbers in the report. Single precision will display seven-place accuracy, while the double precision will display thirteen-place accuracy.

Variable Names

This option lets you select whether to display variable names, variable labels, or both.

Plots Tab

This panel specifies the item response curve (IRC) plot.

Select Plots

Item Response Plot

Indicate whether to display the item response plot. Click the plot format button to change the plot settings.

Plot Options

Minimum and Maximum

Specify the minimum or maximum of the ability scale.

Smoothing Interval

This value is used in creating the points that appear on the IRC plots. If an individual's ability level falls within plus or minus this amount of the ability value, their response is included in the calculation of the percent correct.

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Ability Data Points

The number of data points displayed along the ability scale. The logistic curve is trying to fit these values.

Plots Per Row

This option controls the size of the plots by specifying the number of plots to display across the page.

Storage Tab

The estimated abilities may be stored on the current database for further analysis. The data are automatically stored while the program is executing.

Note that existing data is replaced. Be careful that you do not specify variables that contain important data.

Select Variables for Data Storage

Ability Variable

This option lets you designate the variable that should receive the estimated ability of each individual.

Example 1 – Item Response Analysis

This section presents an example of how to run an analysis of the data contained in the Item dataset.

You may follow along here by making the appropriate entries or load the completed template **Example 1** by clicking on Open Example Template from the File menu of the Item Response Analysis window.

1 Open the Item dataset.

- From the File menu of the NCSS Data window, select **Open Example Data**.
- Click on the file **Item.NCSS**.
- Click **Open**.

2 Open the Item Response Analysis window.

- Using the Analysis menu or the Procedure Navigator, find and select the **Item Response Analysis** procedure.
- On the menus, select **File**, then **New Template**. This will fill the procedure with the default template.

3 Specify the variables.

- On the Item Response Analysis window, select the **Variables tab**.
- Double-click in the **Item Variables** box. This will bring up the variable selection window.
- Select **Item1** to **Item4** from the list of variables and then click **Ok**. “Item1-Item4” will appear in the Item Variables box.
- Double-click in the **Answer Variable** box. This will bring up the variable selection window.
- Select **Answers** from the list of variables and then click **Ok**. “Answers” will appear in the Answer Variable box.
- Double-click in the **Label Variable** box. This will bring up the variable selection window.
- Select **Name** from the list of variables and then click **Ok**. “Name” will appear in the Label Variable box.

4 Run the procedure.

- From the Run menu, select **Run Procedure**. Alternatively, just click the green Run button.

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Count Distribution Section

| Count Distribution Section | | | | |
|----------------------------|----|----|----|---|
| Variable | 1 | 2 | 3 | 5 |
| Item1 | 11 | 2 | 2 | 1 |
| Item2 | 4 | 2 | 10 | 0 |
| Item3 | 3 | 10 | 3 | 0 |
| Item4 | 7 | 7 | 2 | 0 |
| Total | 25 | 21 | 17 | 1 |

This report shows the number of times each response was chosen for each item.

Percentage Distribution Section

| Percentage Distribution Section | | | | |
|---------------------------------|-------|-------|-------|------|
| Variable | 1 | 2 | 3 | 5 |
| Item1 | 68.75 | 12.50 | 12.50 | 6.25 |
| Item2 | 25.00 | 12.50 | 62.50 | 0.00 |
| Item3 | 18.75 | 62.50 | 18.75 | 0.00 |
| Item4 | 43.75 | 43.75 | 12.50 | 0.00 |
| Total | 39.06 | 32.81 | 26.56 | 1.56 |

This report shows the percentages of each of the possible responses for each item.

Item Detail Section

| Item Detail Section for Item1 | | | | |
|-------------------------------|-------|--------------------|--------------------|-------------------|
| Value | Count | Individual Percent | Cumulative Percent | Percent Bar Chart |
| 1 (Correct) | 11 | 68.75 | 68.75 | |
| 2 | 2 | 12.50 | 81.25 | |
| 3 | 2 | 12.50 | 94.75 | |
| 5 | 1 | 6.25 | 100.00 | |
| Total | 16 | | | |

| Item Detail Section for Item2 | | | | |
|-------------------------------|-------|--------------------|--------------------|-------------------|
| Value | Count | Individual Percent | Cumulative Percent | Percent Bar Chart |
| 1 | 4 | 25.00 | 25.00 | |
| 2 | 2 | 12.50 | 37.50 | |
| 3 (Correct) | 10 | 62.50 | 100.00 | |
| 5 | 0 | 0.00 | 100.00 | |
| Total | 16 | | | |

| Item Detail Section for Item3 | | | | |
|-------------------------------|-------|--------------------|--------------------|-------------------|
| Value | Count | Individual Percent | Cumulative Percent | Percent Bar Chart |
| 1 | 3 | 18.75 | 18.75 | |
| 2 (Correct) | 10 | 62.50 | 81.25 | |
| 3 | 3 | 18.75 | 100.00 | |
| 5 | 0 | 0.00 | 100.00 | |
| Total | 16 | | | |

| Item Detail Section for Item4 | | | | |
|-------------------------------|-------|--------------------|--------------------|-------------------|
| Value | Count | Individual Percent | Cumulative Percent | Percent Bar Chart |
| 1 (Correct) | 7 | 43.75 | 43.75 | |
| 2 | 7 | 43.75 | 87.50 | |
| 3 | 2 | 12.50 | 100.00 | |
| 5 | 0 | 0.00 | 100.00 | |
| Total | 16 | | | |

This report provides an individual break down of the responses to each item.

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Item Response Estimation Section

| Item Response Estimation Section | | | |
|----------------------------------|-----------|----------------------------------|--|
| Variable | Intercept | Discrimination Parameter (Slope) | Ability at which P(Correct)=0.5 (Difficulty) |
| Item1 | 5.977607 | 12.677396 | -0.471517 |
| Item2 | 0.510955 | -0.025970 | 19.675165 |
| Item3 | 0.577043 | 0.775644 | -0.743954 |
| Item4 | -0.296144 | 0.878906 | 0.336946 |

This report gives the results of the IRT estimation for each item. The columns of the report are defined as follows.

Variable

The name of the item (question).

Intercept

The estimated intercept in the logistic ICC model. This is the value of a_i .

Discrimination Parameter (Slope)

The estimated slope in the logistic ICC model. This is the value of d_i . This value is sometimes referred to as the *Discrimination Parameter* of the item.

Ability at which P(Correct)=0.5 (Difficulty)

The estimated value of b_i . It is the ability level at which 50% of those responding are able to get this question right. It is sometimes called the *Difficulty* of the item.

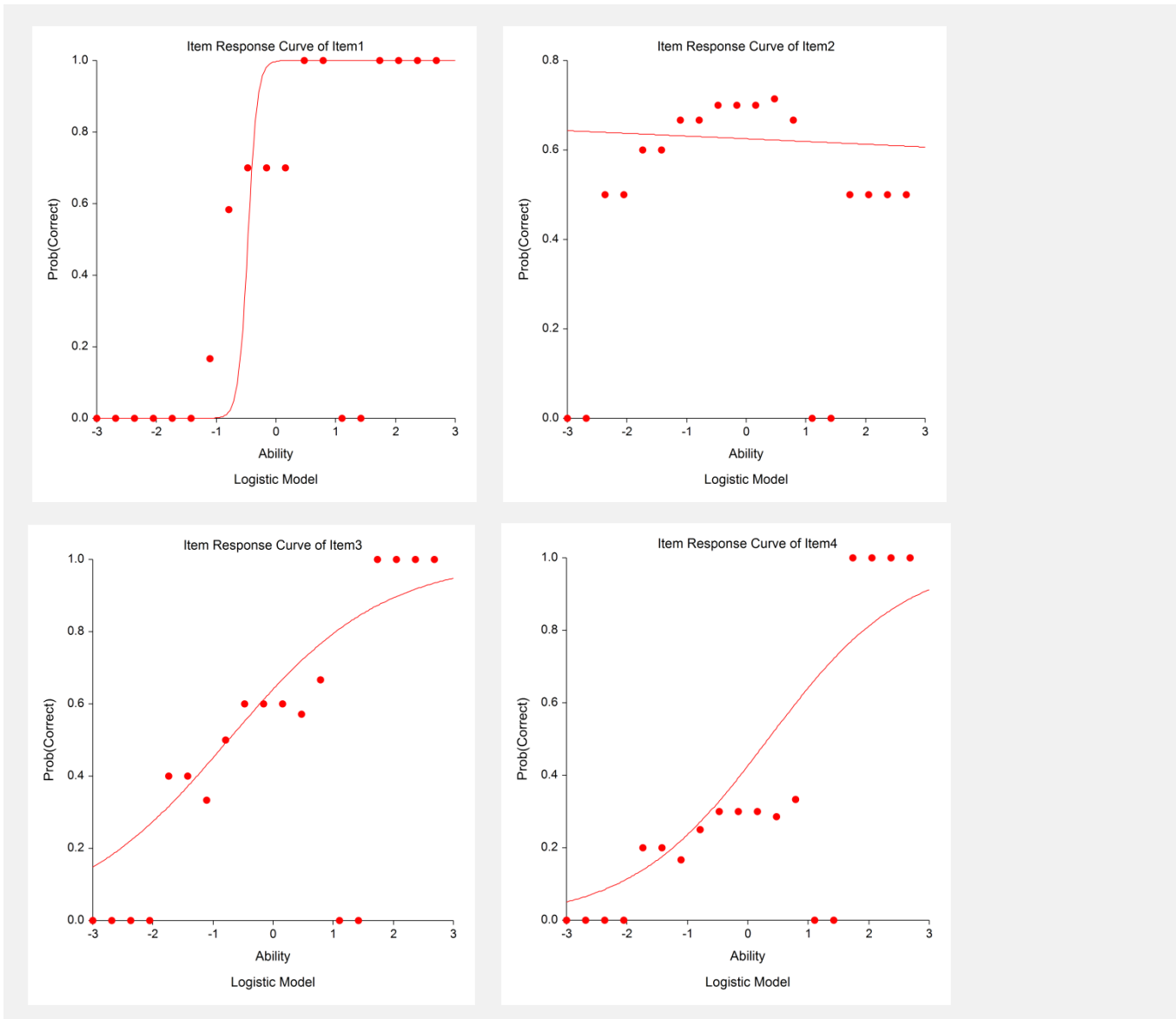
Estimated Abilities Section

| Estimated Abilities Section | | | | |
|-----------------------------|-----------|----------------|-----------------|-----------|
| Row | Name | Number Correct | Percent Correct | Ability |
| 1 | Eric | 4 | 100.00 | 2.500000 |
| 2 | Charlotte | 1 | 25.00 | -0.800205 |
| 3 | Janet | 3 | 75.00 | -0.077078 |
| 4 | Julie | 1 | 25.00 | -1.552304 |
| 5 | Katie | 2 | 50.00 | -0.053399 |
| 6 | Ryan | 2 | 50.00 | -0.777427 |
| 7 | Tyson | 0 | 0.00 | -1.536428 |
| 8 | Jordan | 3 | 75.00 | 2.500000 |
| 9 | Bob | 2 | 50.00 | -0.260121 |
| 10 | Linda | 2 | 50.00 | -0.053399 |
| 11 | Mike | 2 | 50.00 | -0.809005 |
| 12 | Michelle | 3 | 75.00 | 2.500000 |
| 13 | Randy | 3 | 75.00 | -0.077078 |
| 14 | Jerry | 3 | 75.00 | 0.040460 |
| 15 | Chris | 4 | 100.00 | 2.500000 |
| 16 | Holly | 3 | 75.00 | 0.040460 |

This report gives each individual's score and estimated ability. Remember that the test score may not correlate exactly with ability since the ability rating depends not only on how many questions are answered correctly, but also on which questions are answered correctly.

Item Response Analysis

IRC Plots Section



These plots show the logistic item characteristic curve for each question as a solid line. The plotted points show the proportion of individuals with ability in a small neighborhood of the plotted ability that got the question right.

Note that the vertical axis gives the probability that an individual answers the question correctly and the horizontal axis gives their ability.

In most cases, the plots will show the familiar S-curve that is exhibited here. In some cases, however, the plots may look different.