# THE APPENDIX

To the
WinLTA Users' Guide
Version 3.0

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# Example 1

## A Latent Class Example

# Example 1

This example is a latent class problem, that is, there is no longitudinal measurement. To run a WinLTA analysis, a control file must be created. This file contains a description of the model and instructions for the particular analysis. In order to view the control file for Example 1 on your computer, start WinLTA and then click on File, Open Control File, and choose the folder for Example 1. Then, open the file called ex1.cnt. (To enter your own control file, click on File and choose New Control File.)

This example tests a model of five levels of math skill. Rock and Pollack-Ohls (1987) administered a math test to 1,500 students in their sophomore year of high school and again in their senior year. The sophomore year data is used here. The math test given to the students measured four domains of math skill. From this data, Rock and Pollack-Ohls created four "testlets" corresponding to the four skill domains. Each five-item testlet was a mastery test corresponding to one of four domains of math skill: (1) single operations; (2) powers and roots, decimals, and fractions; (3) algebra; (4) geometry, and algebra with word problems. If four out of the five items in a testlet were answered correctly the student was considered to have passed the testlet and mastered the subject matter. We are interested using latent class analysis to examine how well the testlets differentiate the math skills latent classes (see Collins & Wugalter, 1992).

Suppose we believe that math skill acquisition is cumulative. For example, someone who can do low level algebra can also handle power and roots and single operations on whole numbers. This suggests a model with five latent classes: (1) those with no measurable skill; (2) those who can do only single operations on whole numbers; (3) those who can do powers and roots, decimals, and fractions, and also single operations on whole numbers; (4) those who can do low level algebra, as well as powers and roots and single operations on whole numbers; and (5) those who have mastered low level geometry as well as the other skills mentioned.

Based on this theory of cumulative math skill development, we might expect the following responses:

**Table 1**. **Expected responses to testlets, conditional on latent class membership.**

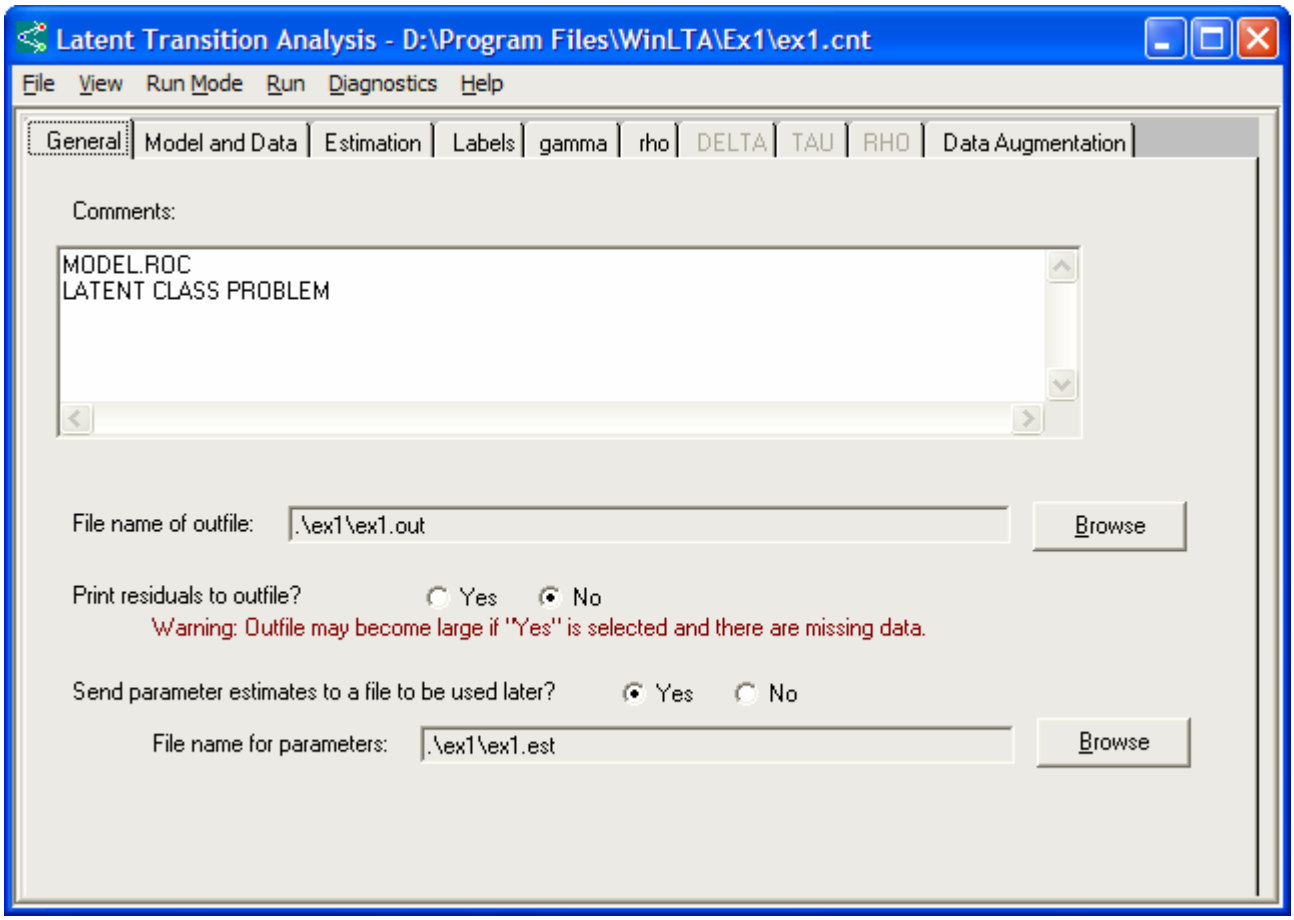
| | **Testlet 1** | **Testlet 2** | **Testlet 3** | **Testlet 4** |
|---|---|---|---|---|
| **No Skill** | Fail | Fail | Fail | Fail |
| **Single Operations** | Pass | Fail | Fail | Fail |
| **Powers** | Pass | Pass | Fail | Fail |
| **Algebra** | Pass | Pass | Pass | Fail |
| **Geometry** | Pass | Pass | Pass | Pass |

The five expected patterns of responses above correspond to our hypothesized latent classes. This means that we expect someone in the no math skill group to fail the four testlets. Furthermore, this latent class structure implies that we do not think there is a latent class made

up of students who have skill in geometry only, that is, do not have skill in single operations, powers, and algebra.

However, in real data, there may be people who fail the first three testlets and pass the final one. Given our latent class structure, this response pattern contains measurement error. If we had some other structure or theory, this response pattern might correspond to a latent class. An advantage of the latent class model is that it estimates measurement error. WinLTA models the entire data set, including response patterns that are inconsistent with the latent structure. Next, we will walk through how one sets up a WinLTA control file for the above latent class model. To begin, start WinLTA and select the General tab, if it is not already (see below).

*General tab window*




The field descriptions for the General tab are:

- **Comments:** Enter a title or comments to appear at the top of the output file.

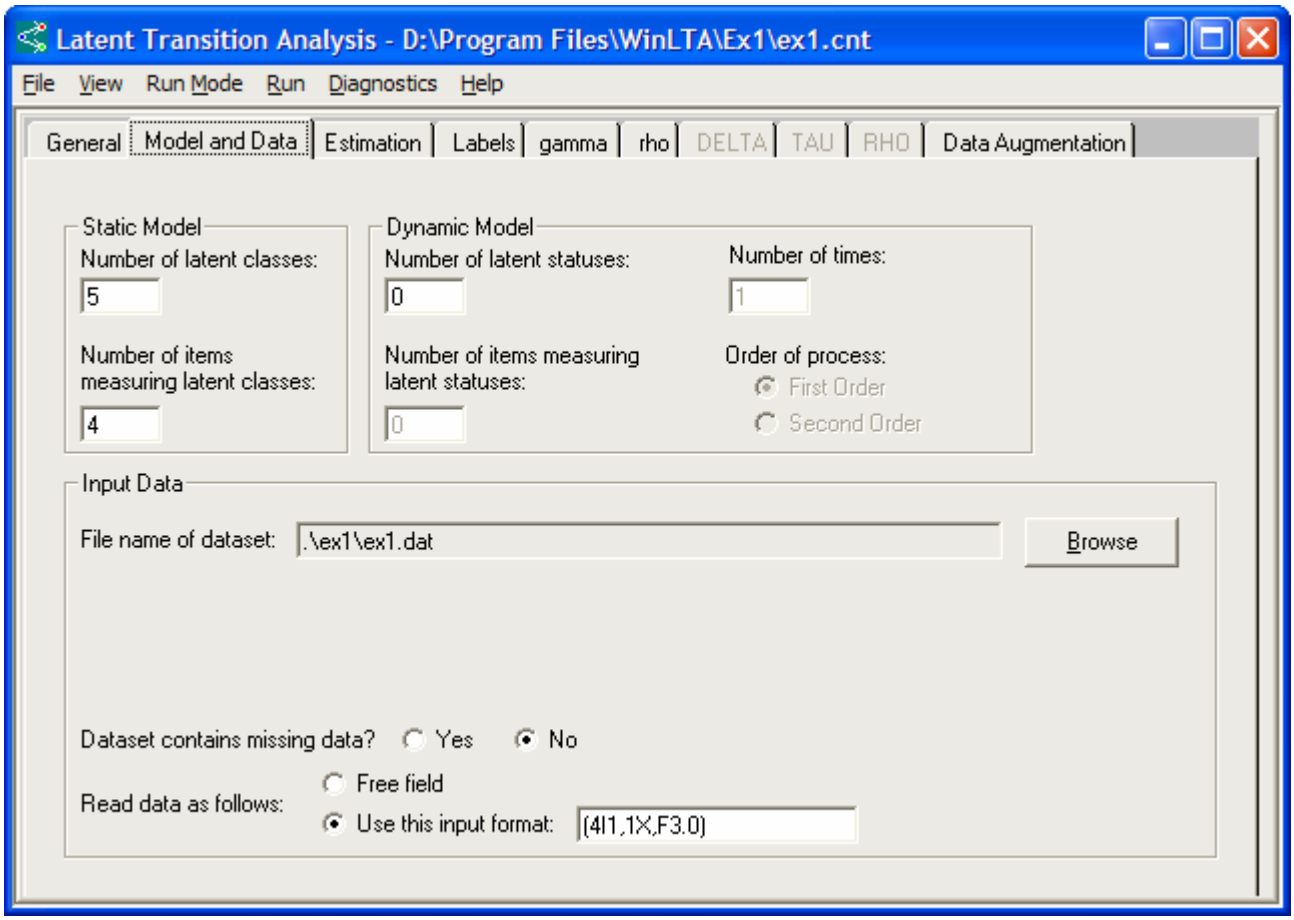
- **File name of outfile:** Specify the file in which the output will be saved by pressing the browse button.

- **Print residuals to outfile?:** Choose whether the residuals will be included in the output file.

- **Send parameter estimates to a file to be used later?:** Choosing "yes" saves the parameter estimates to a separate file specified in the "File name for parameters" field. Saving this file allows you to perform crossvalidation or to continue a run that fails to converge.

The next tab is Model and Data, shown below.

*Model and Data tab window*




The field descriptions for the Model and Data tab are:

- **Static Model:** This section contains information about the static latent variable.
  - **Number of latent classes:** In this example, there are 5 latent classes.
  - **Number of items measuring latent classes:** In this example, there are 4 items.

- **Dynamic Model:** This section contains information about the dynamic latent variable.
  - **Number of latent statuses:** Because this example is a latent class problem, this number is 0. For latent class problems, all fields related to the dynamic part of the model are inaccessible.
  - **Number of items measuring latent statuses:** 0
  - **Number of times:** 1
  - **Order of process:** First order.

- **Input Data:**
  - **File name of dataset:** Specify the file containing the data by pressing the browse button, which will bring up a dialog box in which you can search for a file (not shown). This dialog box automatically lists .dat as the extension, but you can change this to view all files (*.*), if necessary. The data file must be in response pattern format. See the main body of this manual for more information.
  - **Dataset contains missing data?:** If the dataset contains missing data, select yes; otherwise, select no. Remember that missing data must always be coded as 0 in the dataset.
  - **Read data as follows:** This option allows you to specify free or fixed formatting in your data file. If each field in the data file (i.e., variables and the frequency) is separated by one or more spaces, then it is not necessary to specify an input format. In this case, choose the free field option. If each variable is not separated by a space, you will need to specify an input format. Use a Fortran input format for this purpose.

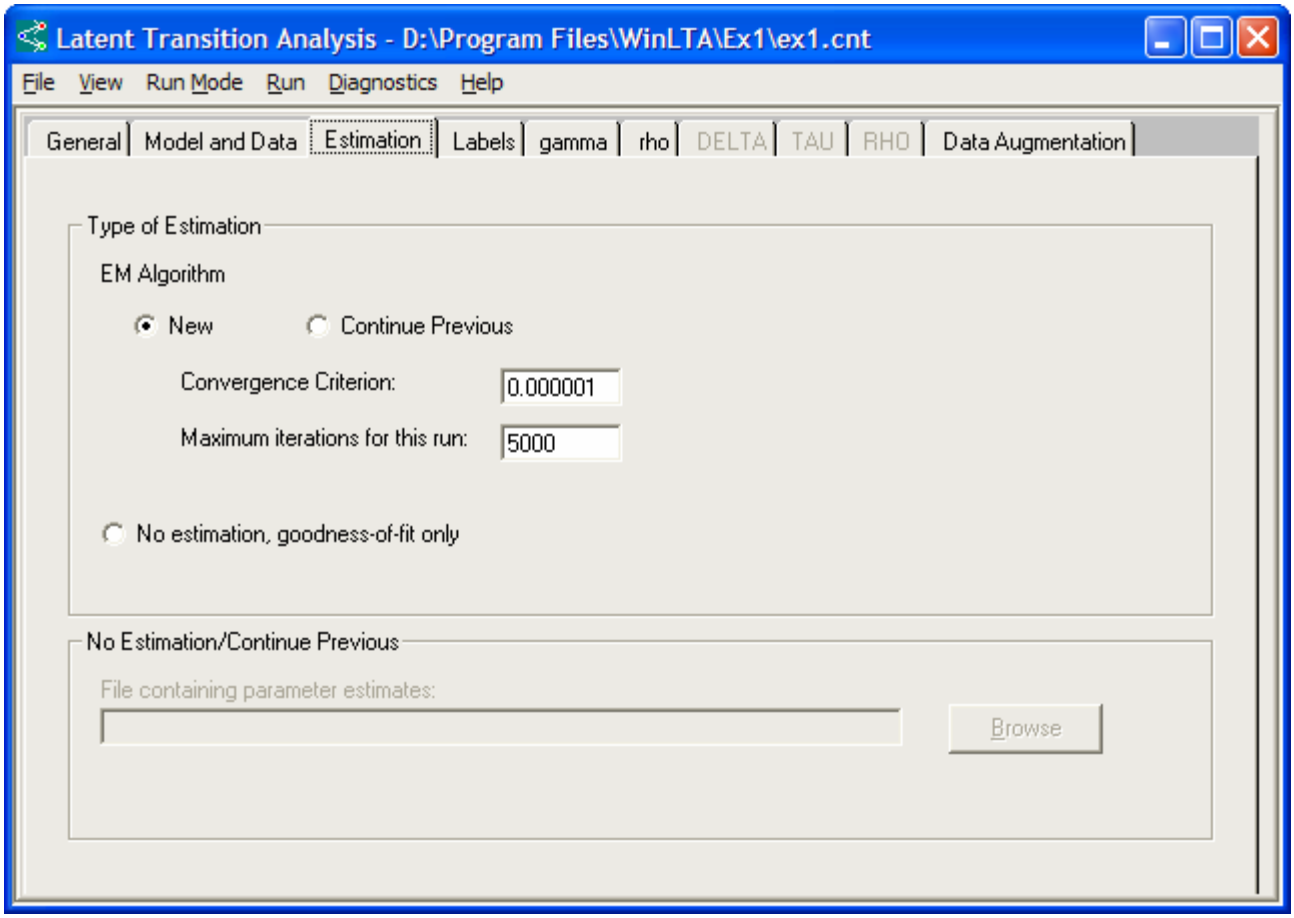
    In this example, the dataset is in the following format:

    ```
    1111 408
    1112   2
    1121  12
    1122   1
    …
    ```

    Because there are not spaces between every variable, we must specify an input format. The Fortran input format used here is (4I1,1X,F3.0). 4I1 indicates that there are four columns with one integer in each column. 1X indicates one column that is blank, or that acts as a space. F3.0 provides information about the column that contains the number of subjects having each response pattern. This is a real number that is 3 digits long and has 0 digits after the decimal place. If you have 1000 or more subjects in a particular response pattern, the format would need to be F4.0. **Note:** the part of the format statement corresponding to the variables must be integer type and the frequency count must be a real type. More information about input formats as well as another example can be found in the Help file in WinLTA.

The Estimation tab is next.

*Estimation tab window*




The field descriptions for the Estimation tab are:

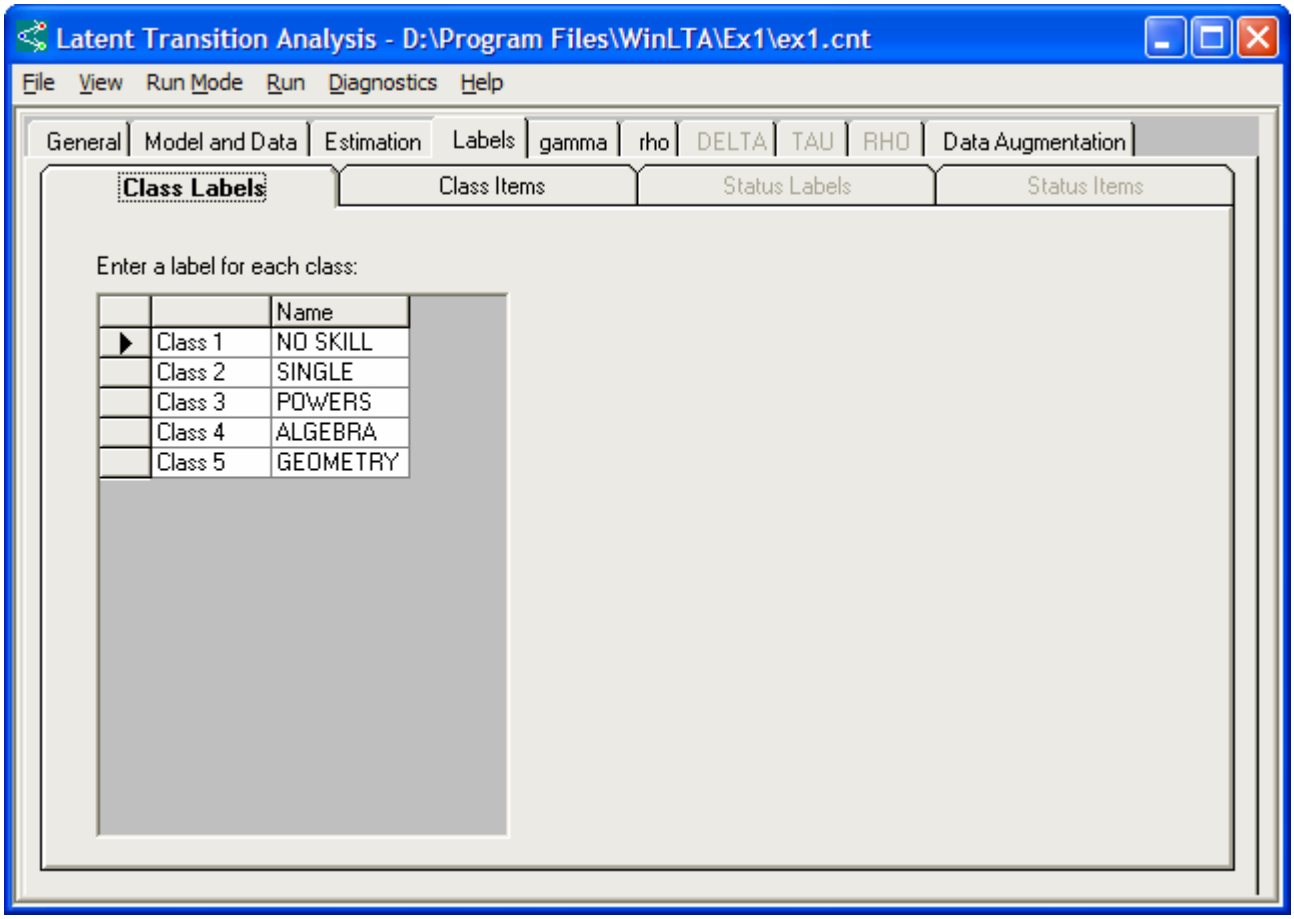
- **Type of estimation:**
  - **EM Algorithm:**
    - **New/Continue Previous:** For new runs, select New. Select Continue Previous only when you want to continue a run that previously failed to converge. (See the section How to Continue a Run That Did Not Converge in the manual.)
    - **Convergence Criterion:** When the Mean Absolute Deviation (MAD) is less than or equal to the convergence criterion, the program has converged and stops estimation. It is set to the default value of $10^{-6}$.
    - **Maximum iterations for this run:** If 5000 iterations of the EM algorithm are performed, the program will stop. The default value for this field is 5000.
    - **No estimation, goodness-of-fit only:** Selecting this option causes the program to calculate the likelihood ratio statistic only; no estimation is performed. (See the section How to Crossvalidate in the manual.)

  - **File containing parameter estimates:** If you choose to continue a previous run or if you select no estimation, the name of a file containing parameter estimates must be

provided. The Browse button will allow you to search for the file if you do not know the name.

There are two tabs nested within the Labels tab. The first of these is the Class Labels tab, shown below.

*Labels—Class Labels tab window*

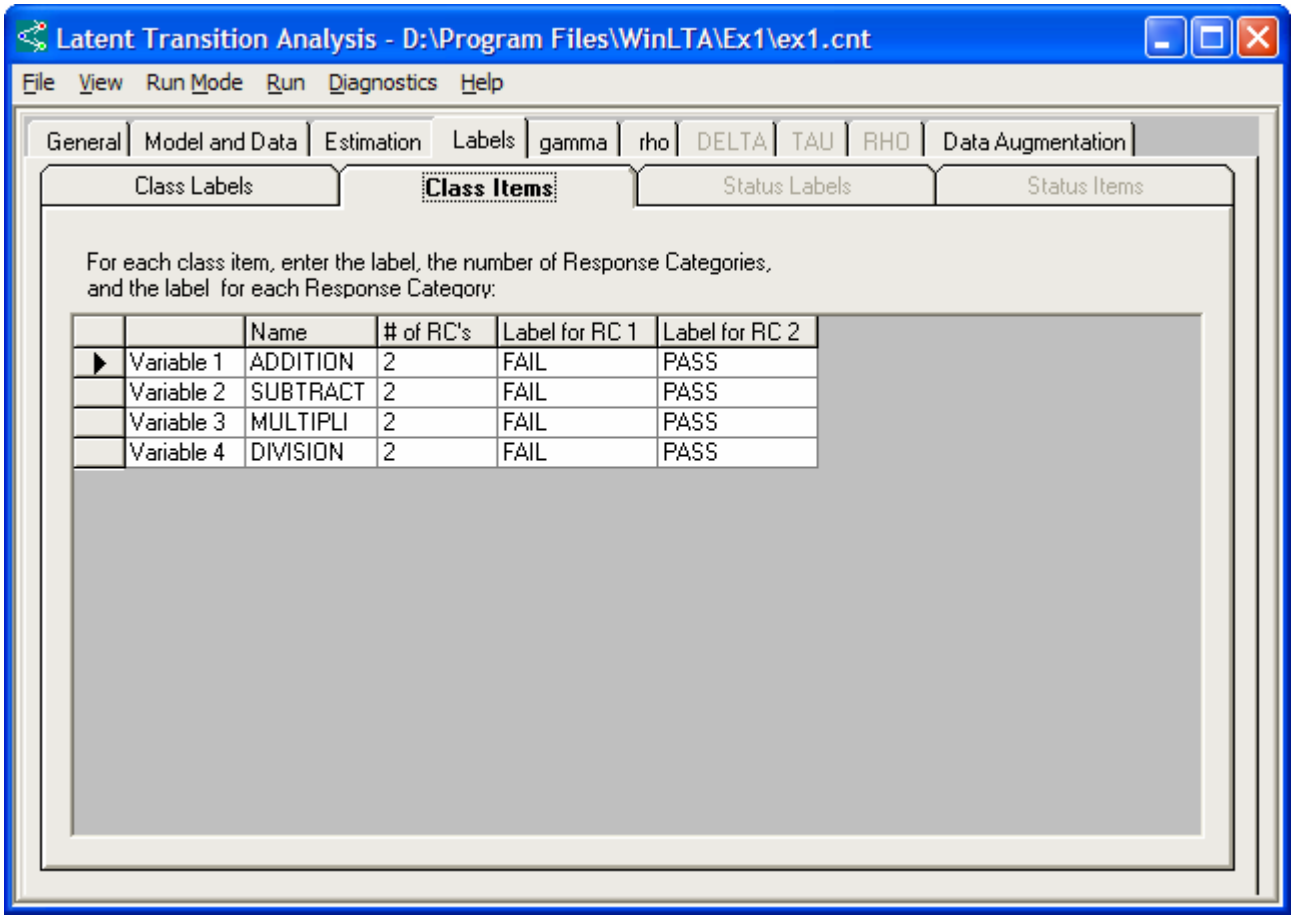



The field descriptions for the Labels—Class Labels tab are:

- **Class labels:** Here you may enter labels for the latent classes. There is a limit of 8 characters per label.

The other tab found within the Labels tab is the Class Items tab.

*Labels—Class Items tab window*

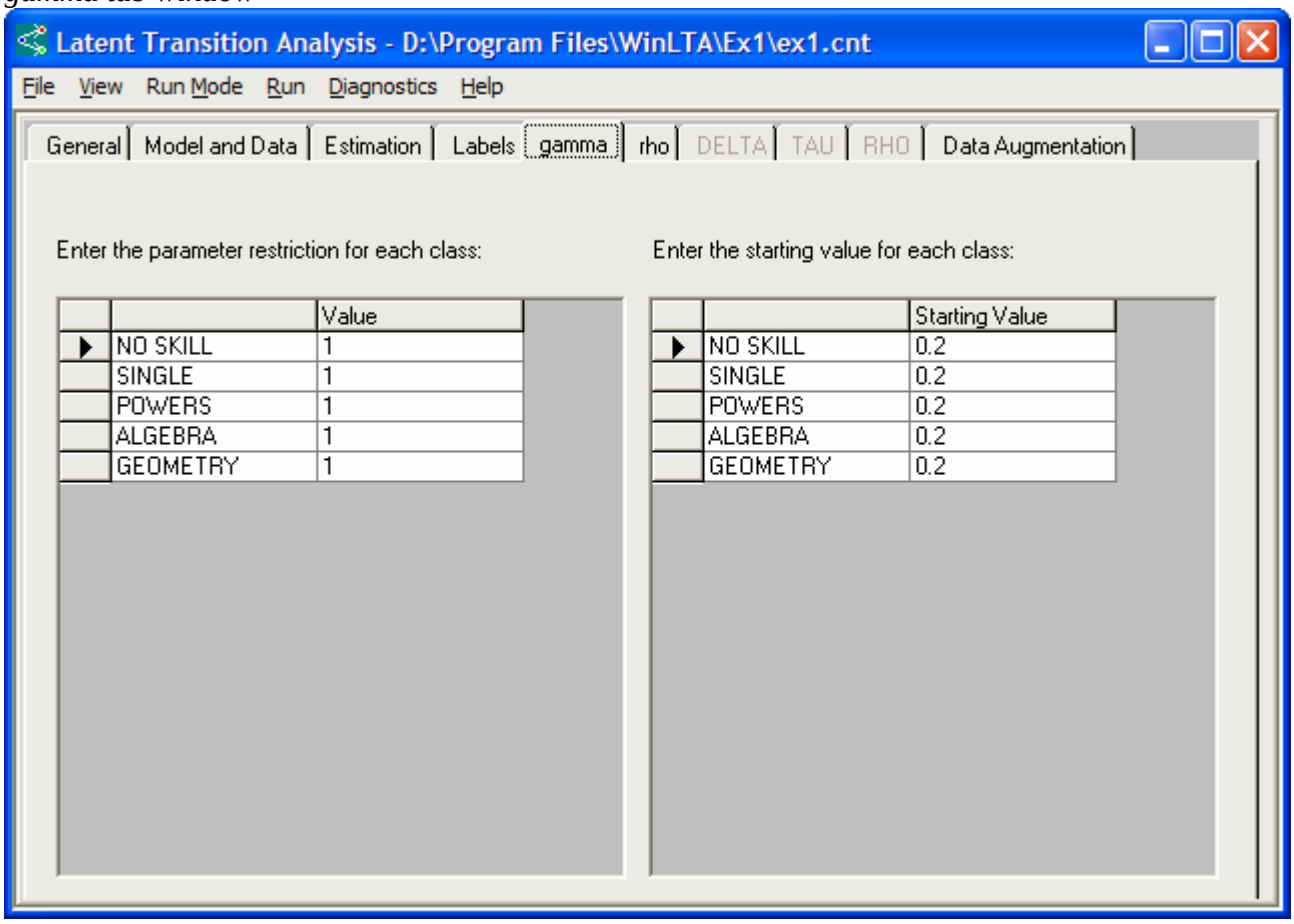



The field descriptions for the Labels—Class Items tab are:

- **Class items:** In the Model and Data tab, the number of items measuring the latent classes was entered. There are 4 items. Accordingly, these items are listed as the 4 **variables** in the Class Items tab. For each of these items, the following is entered: 1) a **label**, 2) the **number of response categories**, and 3) a **label for each of the response categories**. For example, the first variable is named "Addition" and it has 2 response categories. Response category #1 is named "FAIL" and response category #2 is named "PASS".

The gamma tab is next.

*gamma tab window*




The gamma parameters are the unconditional probabilities of membership in each latent class. Estimating the gamma parameters yields the expected proportion of students in each latent class.

The field descriptions for the gamma tab are:

- **Enter the parameter restrictions for each class:** A parameter can be constrained, estimated freely, or not estimated at all. A "1" denotes that the parameter is to be estimated freely. A "0" denotes that the parameter is not to be estimated (i.e., it will be fixed at the starting value). Integers greater than 1 denote parameters that are constrained to be equal. In this example, all gammas are estimated freely.

- **Enter the starting value for each class:** In this column, the starting values for each of the latent classes are provided. If any equality constraints have been placed on the parameters (i.e., if you entered a 2 or greater in the constraints column), then the starting values should also be equal. For example, if two parameters are constrained to be equal, their starting values should also be equal. Note: the sum of the gamma starting values must be one.

Finally, we need to fill in the rho tab. Recall that the little rhos are the probability of responding yes (or no) to an item conditional on latent class membership. For example, we expect that people in the No Skill latent class will have a low probability of passing any of the testlets. Therefore, these people must have a high probability of failing the testlets (there are only two outcomes, passing or failing). Similarly, individuals in the Algebra latent class are expected to have a high probability of passing the first three testlets and a low probability of passing the fourth. Given the expectations we have about the response patterns of individuals in each latent class, we can now construct the little rho constraint matrices. The following table shows the expected probability of failing the testlets, given latent class membership. (A similar matrix can be constructed for the probability of passing the testlets.)

**Table 2**. **Expected probability of failing a testlet , conditional on latent class membership.**

| | **Testlet 1** | **Testlet 2** | **Testlet 3** | **Testlet 4** |
|---|---|---|---|---|
| **No Skill** | High | High | High | High |
| **Single Operations** | Low | High | High | High |
| **Powers** | Low | Low | High | High |
| **Algebra** | Low | Low | Low | High |
| **Geometry** | Low | Low | Low | Low |

To create the above table, we have taken Table 1 and substituted a "High" for "Fail" and a "Low" for "Pass." The people in the No Skill latent class have a high probability of failing each testlet, so there are four High's in the above table.

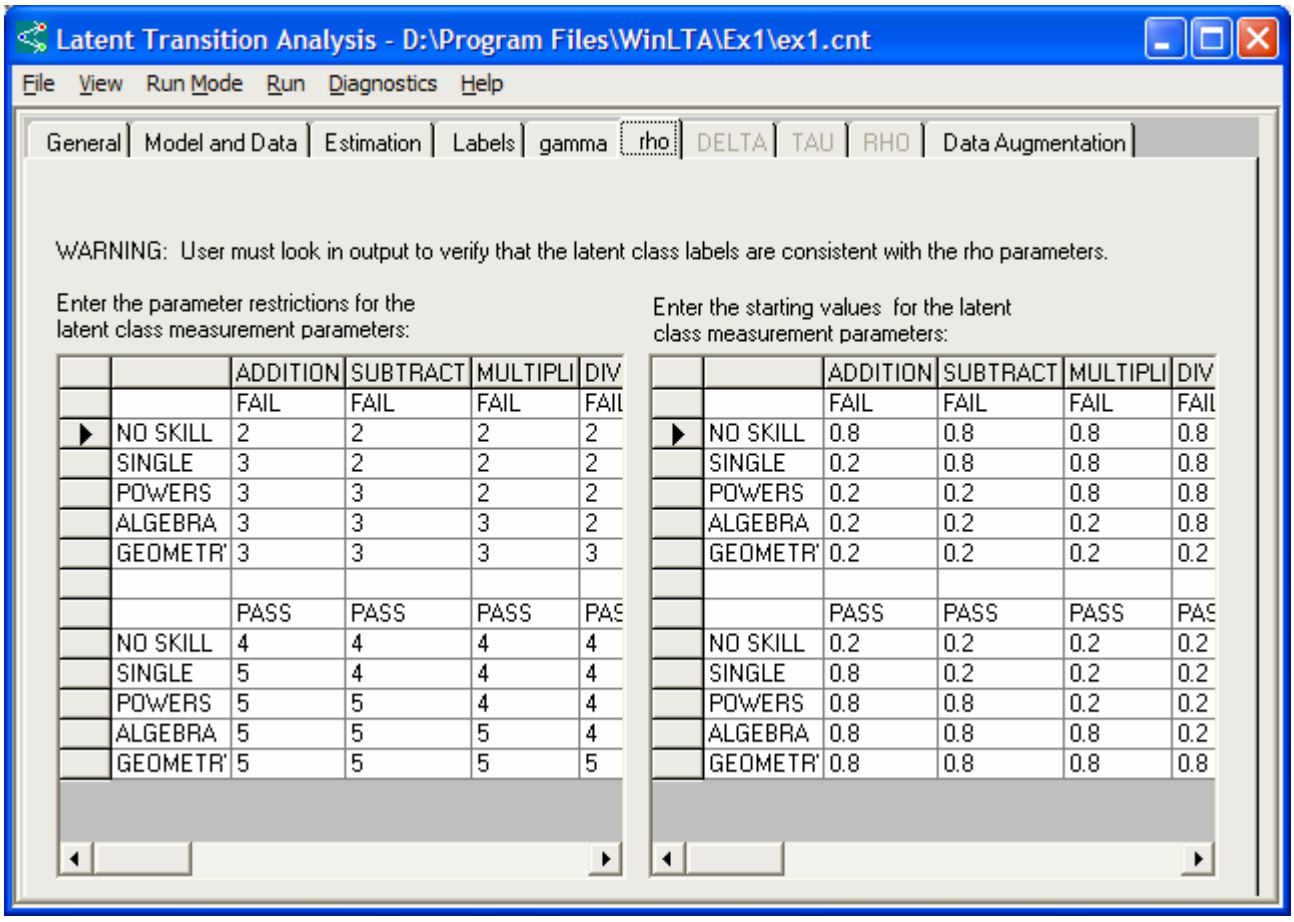
Notice that the people in the Geometry latent class have a Low, non-zero probability of failing each testlet. This represents measurement error in this model. If there were no measurement error, the Low's would be zeroes and the High's would be ones. This means that if there were no error, the no skill people would fail every testlet with probability one, and the geometry people would pass every testlet.

Once we have this conceptual table of the high and low response probabilities, we can fill in the parameter restrictions matrix. There is a rho parameter for each response category, item, latent class combination. The next page shows the parameter restrictions for the response category "FAIL" on the rho tab in WinLTA. Notice that a number of cells contain the number "2." These 2's denote equality constraints and they identify a group of rho parameters that will be estimated to be equal to each other. The number "2" itself is arbitrary and could be any integer greater than one. The equality constraints in this example set all of the rho parameters for a high probability of failing to be equal. Similarly, all the low probabilities of passing are equal. (The probability of passing is equal to one minus the probability of failing. Therefore, the probability of passing is not really estimated.) This means, for example, that a person in the No Skill latent class has the same probability of failing testlet 4 as a person in the Algebra latent class. Only one error rate for failing and one for passing are estimated in this model.

If we wanted to estimate any rho parameters freely, we would have been entered 1's in the appropriate cells. One function of parameter restrictions is to reduce the amount of estimation. By using equality constraints, only 2 rho parameters are estimated when 20 could be

(five latent classes and four dichotomous items). Look at the constraints for the second response category, "PASS." Note that because the rho parameters for the first response category have been constrained, WinLTA expects those for the second response cateogry to be constrained accordingly.

*rho tab window*




| | ADDITION | SUBTRACT | MULTIPLI | DIV |
|---|---|---|---|---|
| | FAIL | FAIL | FAIL | FAIL |
| NO SKILL | 2 | 2 | 2 | 2 |
| SINGLE | 3 | 2 | 2 | 2 |
| POWERS | 3 | 3 | 2 | 2 |
| ALGEBRA | 3 | 3 | 3 | 2 |
| GEOMETR' | 3 | 3 | 3 | 3 |
| | | | | |
| | PASS | PASS | PASS | PASS |
| NO SKILL | 4 | 4 | 4 | 4 |
| SINGLE | 5 | 4 | 4 | 4 |
| POWERS | 5 | 5 | 4 | 4 |
| ALGEBRA | 5 | 5 | 5 | 4 |
| GEOMETR' | 5 | 5 | 5 | 5 |

| | ADDITION | SUBTRACT | MULTIPLI | DIV |
|---|---|---|---|---|
| | FAIL | FAIL | FAIL | FAIL |
| NO SKILL | 0.8 | 0.8 | 0.8 | 0.8 |
| SINGLE | 0.2 | 0.8 | 0.8 | 0.8 |
| POWERS | 0.2 | 0.2 | 0.8 | 0.8 |
| ALGEBRA | 0.2 | 0.2 | 0.2 | 0.8 |
| GEOMETR' | 0.2 | 0.2 | 0.2 | 0.2 |
| | | | | |
| | PASS | PASS | PASS | PASS |
| NO SKILL | 0.2 | 0.2 | 0.2 | 0.2 |
| SINGLE | 0.8 | 0.2 | 0.2 | 0.2 |
| POWERS | 0.8 | 0.8 | 0.2 | 0.2 |
| ALGEBRA | 0.8 | 0.8 | 0.8 | 0.2 |
| GEOMETR' | 0.8 | 0.8 | 0.8 | 0.8 |

The field descriptions for the rho tab are:

- **Enter the parameter restrictions for latent class measurement parameters:** In the left-hand side of the rho tab window, enter the parameter restrictions for all response categories.

- **Enter the starting values for latent class measurement parameters:** First look at the starting values for the response category "FAIL." A cell in this matrix must sum to one with its complement in the matrix for "PASS" or the program will halt. Starting values for the measurement parameters are chosen according to the conceptual ideas behind the model being tested. In this example, students in the first latent class are expected to have a high probability of failing all testlets, so 0.8's have been entered for every testlet. Similarly, in the matrix for "PASS", those in the first latent class are not expected to pass any of the testlets, so 0.2's have been entered for each testlet.

- Note the horizontal scroll bars at the bottom of the window.

- Note that the model being estimated is a static latent class model, and there is not a dynamic latent variable. Parameters associated with the dynamic part of the model (delta, tau, and big rho parameters) are not being estimated, and thus the tabs are grayed out.

# Saving Your Work and Running WinLTA

- **Saving the control file:** To save the control file, in WinLTA, click on File, and then Save. If this is the first time you have saved this file, a Save As dialog box will appear. In this box you can choose the location of the file and you will be required to enter a filename. By default, the file will be saved with the file extension .cnt. You are encouraged to save your work often during the process of creating a control file.

- **To run WinLTA:** Once the control file is complete, click on Run, and then Run EM. The EM part of WinLTA will begin running automatically. If you have not saved the current version of the control file, you will see a dialog box that asks you if you would like to save before proceeding. Choosing Yes will save the file and run EM automatically. Choosing No will run EM without saving the file. Choosing Cancel will allow you to return to the control file without running EM.

    - Once EM begins running, a separate dialog box entitled "LTA EM Run" will appear on your screen and WinLTA will automatically be minimized. This dialog box tells you the status of the EM run as well as the date and time the run began and finished. The box also has two buttons: Abort and Get Info. Pressing the Abort button during the run will cancel the run. Pressing Get Info gives you the iteration number and the MAD at the time shown, although the information is automatically updated every 5 seconds. Once the run is finished (either because the run has converged, you pressed Abort, or the maximum number of iterations has been reached), the Abort button changes to Close. When you press the Close button, WinLTA will automatically be restored as the active window. You can still access WinLTA on your taskbar without pressing the Close button, but Close must be pressed before another EM run can be started.

- **Viewing the WinLTA outfile:** Once the EM run is completed, you can view the output file by clicking on View, and Current LTA Outfile (if you would like to view an older saved outfile, click on Choose LTA Outfile). This will bring up the output file that corresponds with the most recent EM run.

# The WinLTA Output File

The following is an example of an output file from the WinLTA program. The reference numbers that have been added to the output correspond to the endnotes.

```
1 PROGRAM STARTED:       Wed Dec 19 11:51:42 2001

* MODEL.ROC
* LATENT CLASS PROBLEM

 ************************************************

2 INFORMATION ABOUT THIS JOB:

 RUN TYPE: PARAMETER ESTIMATION BY EM

 CONTROL DATA READ FROM FILE:
C:\Program Files\WinLTA\Ex1\ex1.cnt

 DATA ANALYZED IN THIS RUN READ FROM FILE:
.\ex1\ex1.dat

 OUTPUT SAVED IN FILE:
.\ex1\ex1.out

 PARAMETER ESTIMATES SAVED IN FILE:
.\ex1\ex1.est

 STATIC LATENT VARIABLE                    YES
 NUMBER OF LATENT CLASSES                    5
 NUMBER OF MANIFEST ITEMS                    4

 DYNAMIC LATENT VARIABLE                    NO

 NUMBER OF SUBJECTS                       1500
 NUMBER OF UNIQUE RESPONSE PATTERNS         14
 MAXIMUM NUBMER OF ITERATIONS             5000
 CONVERGENCE CRITERION          .00000100000000
 MISSING DATA IN RESPONSE PATTERNS          NO
 PRINT RESIDUALS                            NO

 ************************************************


3 THE FOLLOWING PARAMETER RESTRICTIONS HAVE BEEN SPECIFIED
 WHERE 0=FIXED TO START VALUE
       1=FREE
       2 OR GREATER MEANS CONSTRAINED EQUAL TO ANY OTHER
         PARAMETER WITH THE SAME DESIGNATION

 ************************************************

4 LITTLE RHO PARAMETERS
 LITTLE RHOS ARE PROBABILITIES OF RESPONSES
 TO ITEMS MEASURING THE STATIC LATENT VARIABLE
 CONDITIONAL ON LATENT CLASS MEMBERSHIP

          RESPONSE CATEGORY  1

         | A F | S F | M F | D F |
         | D A | U A | U A | I A |
         | D I | B I | L I | V I |
         | I L | T L | T L | I L |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
NO SKILL   2     2     2     2
SINGLE     3     2     2     2
POWERS     3     3     2     2
ALGEBRA    3     3     3     2
GEOMETRY   3     3     3     3

          RESPONSE CATEGORY  2

         | A P | S P | M P | D P |
         | D A | U A | U A | I A |
         | D S | B S | L S | V S |
         | I S | T S | T S | I S |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
NO SKILL   4     4     4     4
SINGLE     5     4     4     4
POWERS     5     5     4     4
ALGEBRA    5     5     5     4
GEOMETRY   5     5     5     5

 ************************************************

5 GAMMA PARAMETER RESTRICTIONS
 GAMMAS ARE UNCONDITIONAL PROBABILITIES OF MEMBERSHIP
 IN EACH LATENT CLASS OF THE STATIC LATENT VARIABLE

 NO SKILL    1
 SINGLE      1
 POWERS      1
 ALGEBRA     1
 GEOMETRY    1

 ************************************************

        6 START VALUES

 ************************************************

 LITTLE RHO PARAMETERS
 LITTLE RHOS ARE PROBABILITIES OF RESPONSES
 TO ITEMS MEASURING THE STATIC LATENT VARIABLE
 CONDITIONAL ON LATENT CLASS MEMBERSHIP

        7 RESPONSE CATEGORY  1

         | A F | S F | M F | D F |
         | D A | U A | U A | I A |
         | D I | B I | L I | V I |
         | I L | T L | T L | I L |
```

| | T I O N | R A C T | I P L I | S I O N |
|---|---|---|---|---|
| NO SKILL | 0.800 | 0.800 | 0.800 | 0.800 |
| SINGLE | 0.200 | 0.800 | 0.800 | 0.800 |
| POWERS | 0.200 | 0.200 | 0.800 | 0.800 |
| ALGEBRA | 0.200 | 0.200 | 0.200 | 0.800 |
| GEOMETRY | 0.200 | 0.200 | 0.200 | 0.200 |

[8] RESPONSE CATEGORY 2

| | A P D A D S I S | S P U A B S T S | M P U A L S T S | D P I A V S I S |
|---|---|---|---|---|
| | T I O N | R A C T | I P L I | S I O N |
| NO SKILL | 0.200 | 0.200 | 0.200 | 0.200 |
| SINGLE | 0.800 | 0.200 | 0.200 | 0.200 |
| POWERS | 0.800 | 0.800 | 0.200 | 0.200 |
| ALGEBRA | 0.800 | 0.800 | 0.800 | 0.200 |
| GEOMETRY | 0.800 | 0.800 | 0.800 | 0.800 |

**********

[9] GAMMA PARAMETERS

GAMMAS ARE UNCONDITIONAL PROBABILITIES OF MEMBERSHIP IN EACH LATENT CLASS
OF THE STATIC LATENT VARIABLE

| | |
|---|---|
| NO SKILL | 0.200 |
| SINGLE | 0.200 |
| POWERS | 0.200 |
| ALGEBRA | 0.200 |
| GEOMETRY | 0.200 |

**********

[10] ITERATION HISTORY

**********

STARTING G-SQUARED= 1119.767

| ITERATION | MAD | ITERATION | MAD | ITERATION | MAD |
|---|---|---|---|---|---|
| 1 | .0627422150 | 2 | .0226335079 | 3 | .0108474473 |
| 4 | .0042409117 | 5 | .0021253695 | 6 | .0011272062 |
| 7 | .0006782676 | 8 | .0005618575 | 9 | .0004997093 |
| 10 | .0004383839 | 11 | .0003828333 | 12 | .0003338481 |
| 13 | .0002910423 | 14 | .0002537496 | 15 | .0002212889 |
| 16 | .0001930366 | 17 | .0001684416 | 18 | .0001470233 |
| 19 | .0001283639 | 20 | .0001121015 | 21 | .0000979227 |
| 22 | .0000855557 | 23 | .0000747653 | 24 | .0000653472 |
| 25 | .0000571246 | 26 | .0000499437 | 27 | .0000436709 |
| 28 | .0000381902 | 29 | .0000334006 | 30 | .0000292143 |
| 31 | .0000255546 | 32 | .0000223549 | 33 | .0000195570 |
| 34 | .0000171102 | 35 | .0000149702 | 36 | .0000130984 |
| 37 | .0000114610 | 38 | .0000100287 | 39 | .0000087755 |
| 40 | .0000076792 | 41 | .0000067200 | 42 | .0000058807 |
| 43 | .0000051463 | 44 | .0000045036 | 45 | .0000039413 |
| 46 | .0000034492 | 47 | .0000030186 | 48 | .0000026418 |
| 49 | .0000023120 | 50 | .0000020234 | 51 | .0000017709 |
| 52 | .0000015499 | 53 | .0000013564 | 54 | .0000011871 |
| 55 | .0000010390 | 56 | .0000009093 | | |

**********

MODEL FIT

[11] G-Squared Test of Model Fit: 42.010
Degrees of Freedom: 9

**********

**WARNING**: BE SURE TO INTERPRET THE LATENT CLASSES CAREFULLY
BASED ON THE ESTIMATED RHO PARAMETERS REPORTED BELOW.
YOU MAY WISH TO CHANGE THE LABELS YOU PREVIOUSLY ASSIGNED
TO THE LATENT CLASSES IN ORDER TO MAKE THEM
CONSISTENT WITH YOUR INTERPRETATION.

**********

LITTLE RHO PARAMETERS
LITTLE RHOS ARE PROBABILITIES OF RESPONSES
TO ITEMS MEASURING THE STATIC LATENT VARIABLE
CONDITIONAL ON LATENT CLASS MEMBERSHIP

[12] RESPONSE CATEGORY 1

| | A F D A D I I L | S F U A B I T L | M F U A L I T L | D F I A V I I L |
|---|---|---|---|---|
| | T I O N | R A C T | I P L I | S I O N |
| NO SKILL | 0.986 | 0.986 | 0.986 | 0.986 |
| SINGLE | 0.122 | 0.986 | 0.986 | 0.986 |
| POWERS | 0.122 | 0.122 | 0.986 | 0.986 |
| ALGEBRA | 0.122 | 0.122 | 0.122 | 0.986 |
| GEOMETRY | 0.122 | 0.122 | 0.122 | 0.122 |

[13] RESPONSE CATEGORY 2

```
          | A P | S P | M P | D P |
          | D A | U A | U A | I A |
          | D S | B S | L S | V S |
          | I S | T S | T S | I S |
          | T   | R   | I   | S   |
          | I   | A   | P   | I   |
          | O   | C   | L   | O   |
          | N   | T   | I   | N   |
 NO SKILL 0.014 0.014 0.014 0.014
 SINGLE   0.878 0.014 0.014 0.014
 POWERS   0.878 0.878 0.014 0.014
 ALGEBRA  0.878 0.878 0.878 0.014
 GEOMETRY 0.878 0.878 0.878 0.878


 ************************************************

14GAMMA PARAMETERS
 GAMMAS ARE UNCONDITIONAL PROBABILITIES OF MEMBERSHIP IN
EACH LATENT CLASS
 OF THE STATIC LATENT VARIABLE

 NO SKILL  0.248
 SINGLE    0.299
 POWERS    0.204
 ALGEBRA   0.193
 GEOMETRY  0.057

 PROGRAM FINISHED: Wed Dec 19 11:51:42 2001
 ELAPSED TIME:    0 HOURS,    0 MINUTES,    0 SECONDS.
```

# Explanation of the WinLTA Output File for Example 1

The first sections of the output contain a listing of the parameter restrictions, starting values, and other information entered in the program control file. The next section is the iteration history, which is followed by the parameter estimates. In this example, residuals were not requested, so the parameter estimates are the final section of the output.

**Program Control File Information**

**1** The title lines and comments entered in the General tab will be printed first.

**2** Basic information from the Model and Data tab and the Estimation tab is echoed back in the first section of the output file. The filenames for the control file, the data, and the output are shown first. The next lines include the number of latent classes, number of latent statuses, number of items (for statuses and classes), number of participants, number of observed response patterns, maximum number of iterations allowed, convergence criterion, and whether there are missing data in the response patterns. Finally, there is a line stating whether or not residuals will be printed.

**Parameter Restrictions**

**3** This section contains a listing of the user-specified parameter restrictions.

**4** The little rho parameter restrictions are sectioned by response categories. In the example provided, two response categories are represented (fail = 1, pass = 2).

**5** In this section, the user-specified parameter restrictions for the gamma parameters are printed.

**Starting Values**

**6** This section contains a listing of the user-specified starting values.

**7** In this section, the user-specified starting values for the little rho parameters in response category 1 are printed.

**8** These are user-specified starting values for the little rho parameters in response category 2.

**9** In this section, the user-specified starting values for the gamma parameters are printed.

**Iteration History**

**10** After each iteration, the iteration number and the Mean Absolute Deviation (MAD) are printed. The maximum iterations for the run as specified in the Estimation tab determine the maximum number of iterations allowed. MAD is the mean absolute difference between the

parameter estimates resulting from the current iteration and the parameter estimates from the previous iteration.

**11** The final $G^2$ reflects the fit of the model, with degrees of freedom equal to the number of possible response patterns minus the number of parameters estimated minus one. The value of the goodness-of-fit statistic is compared to a chi-squared distribution. In this case, the observed test statistic, $G^2 = 42.010$, is much greater than the $\alpha = .05$ critical value of the chi-squared distribution, $\chi^2(9) = 16.925$. Therefore, we conclude that the model does not fit the data very well. One approach to obtaining a better fitting model would be to free some of the restrictions on the rho parameters or try a completely different set of parameter restrictions. If the models are nested, a $G^2$ difference test can be used (see Rindskopf (1983) for details).

**Parameter Estimates**

The estimates for the parameters are printed in the next sections of output.

Little Rho Parameters

**12** The little rho parameters are the probabilities of a particular item response conditional on latent class membership. The probabilities are grouped by response category. This section is for the first response category (1 = fail). For example, the probability of failing testlet 1 given membership in the single operations latent class is 0.122. This is consistent with our expectations (see Table 1).

**13** The estimates for the little rho parameters for the second response category are given in this section. In this example, a response of "2" designates a pass. For example, the probability of passing testlet 3 given membership in the single operations latent class is 0.014, and the probability of passing testlet 1 given membership in this latent class is 0.878.

In factor analysis, the patterns of factor loadings characterize the factors. In latent class analysis, the conditional probabilities characterize the latent classes. For the first latent class, the probability of failing any of the four testlets is very high, $\rho_{1|1} = \rho_{2|1} = \rho_{3|1} = \rho_{4|1} = 0.986$. Therefore, this latent class is characterized as the "no skills" latent class. Although this pattern appears in the starting values (see section 8 of the output), the use of these starting values did not force the solution in this direction. It is not unusual for the final estimates to be quite different from the starting values.

Gamma Parameters

**14** The estimates for the gamma parameters are the unconditional probabilities of latent class membership. For example, the unconditional probability of being in the no skill latent class 1 is 0.248, and the probability of being in the algebra latent class 4 is 0.193. That means that according to this model, 24.8% of the participants did not have any math skills in their sophomore year in high school, and 19.3% had achieved sufficient skill to perform algebra problems.

# Response Patterns and Statistics

If requested by the option in the General tab, response patterns and residuals are printed. These were not requested in this example. For an example in which residuals are printed, see Example 2.

# Example 2

## A Latent Transition Example

# Example 2

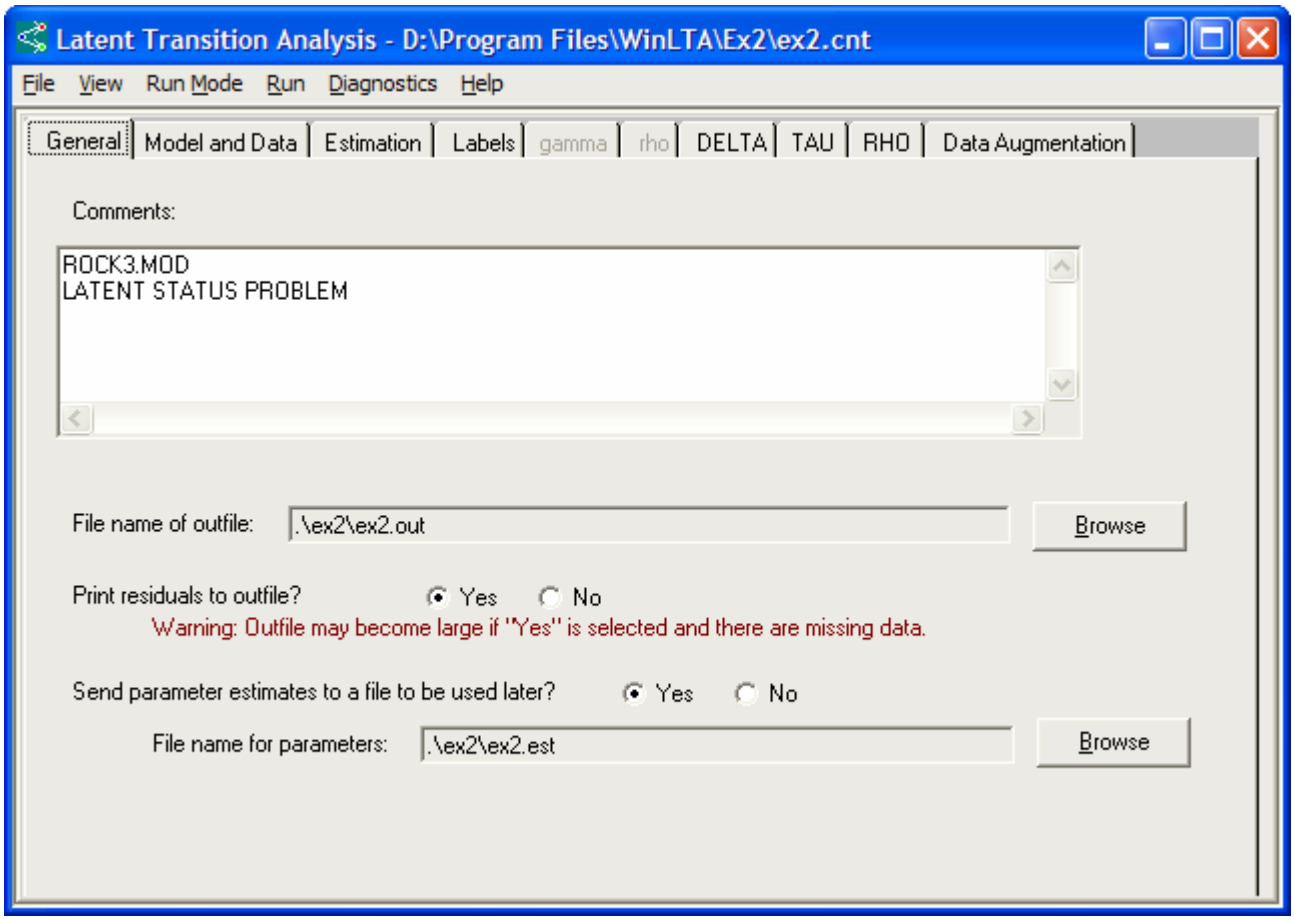
The following example is a latent transition problem. Four testlets that assessed the math skills of 1,500 high school students were administered at two occasions, sophomore year and senior year (see the Latent Class example, Example 1, for more information about the data). Each student is hypothesized to be a member of one of the following latent statuses at each measurement occasion.

| | |
|---|---|
| Latent Status 1: | No skill |
| Latent Status 2: | Single operations on whole numbers |
| Latent Status 3: | Powers and roots |
| Latent Status 4: | Algebra |
| Latent Status 5: | Geometry |

The researchers want to determine how the students are distributed among these latent statuses at the first year and how they change between the two measurement occasions.

To open this example control file, start WinLTA and click on File, Open Control File, and choose the folder for Example 2. Then open the file called ex2.cnt.

*General tab window*




The field descriptions for the General tab are:

- **Comments:** Enter a title or comments here. These are the first lines of the output file.

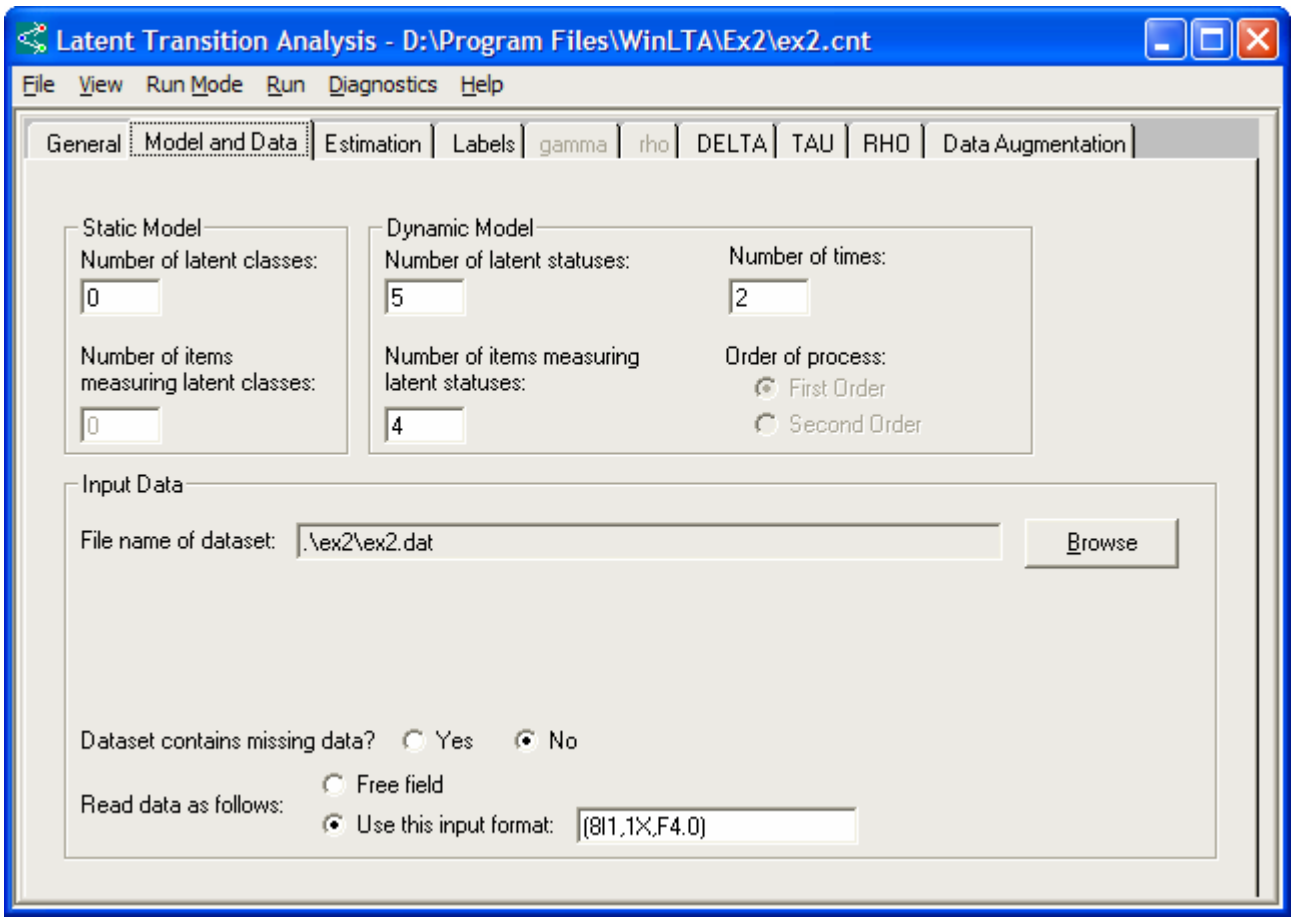
- **File name of outfile:** Specify the file in which the output will be saved by pressing the browse button.

- **Print residuals to outfile?:** This option allows the user to request a listing of the observed response pattern residuals. It is appended to the output file.

- **Send parameter estimates to a file to be used later?:** Selecting yes here specifies that the program write the parameters estimates to another file. Specify the name of the file by pressing the browse button in the field below (File name for parameters).

The Model and Data tab is next.

*Model and Data tab window*




The field descriptions for the Model and Data tab are:

- **Static Model:** This section contains information about the static (non-changing) latent variable. When the model being fit involves no latent classes, all fields related to the static part of the model are inaccessible.
- **Number of latent classes:** In this example, there are no latent classes.
- **Number of items measuring latent classes:** In this example, there are no items measuring latent class.

- **Dynamic Model:** This section contains information about the dynamic latent variable.
- **Number of latent statuses:** 5
- **Number of items measuring latent statuses:** 4
- **Number of times:** 2
- **Order of process:** First order

- **Input Data:**
- **File name of dataset:** Specify the file name by pressing the browse button.
- **Dataset contains missing data?:** These data do not contain missing data.
- **Read data as follows:** This option allows you to specify free-field or fixed-input format. If each field is separated by one or more spaces, it is not necessary to specify an input format. In this case, choose the free-field option. If there are not spaces between each variable, a

Fortran input format must be specified.

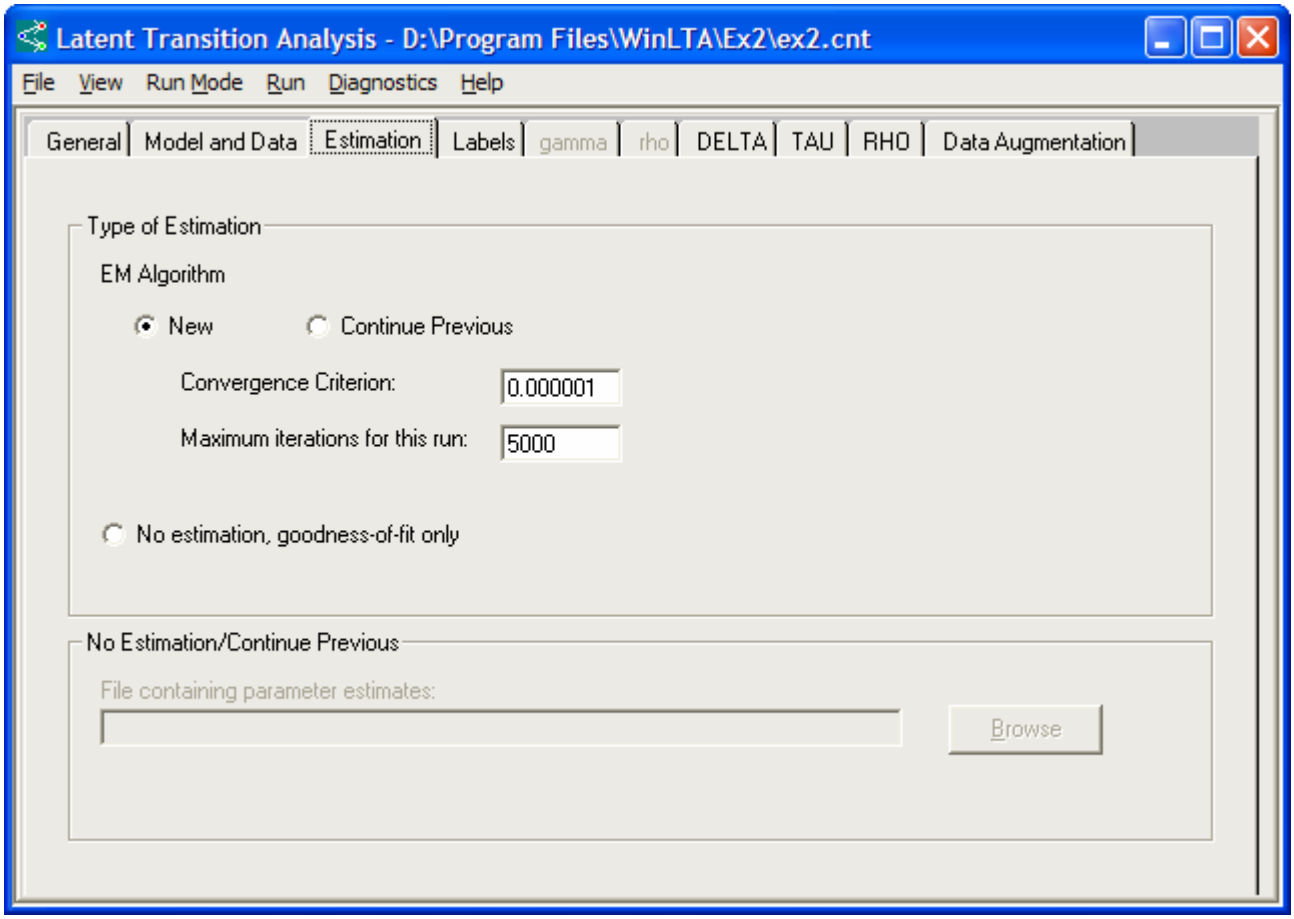
Here are the top four lines of the data set used in this example:

```
11111111  217
11111112    1
11111121    2
11111211   14
…
```

The first eight columns are the responses to the four variables at the two measurement occasions and the last column is the number of people who made the particular response pattern. The Fortran input format for this data is (8I1,1X,F4.0). 8I1 indicates that there are eight integer values of one column width. 1X indicates that the next column is ignored. F4.0 indicates that the next value is a real number and it is four columns wide. The '.0' part of 'F4.0' means that there is no decimal portion to the number, i.e., the number is an integer four columns wide. More information about input formats as well as another example can be found in the WinLTA Help file.

Next, choose the Estimation tab, shown below.

*Estimation tab window*




The field descriptions for the Estimation tab are:

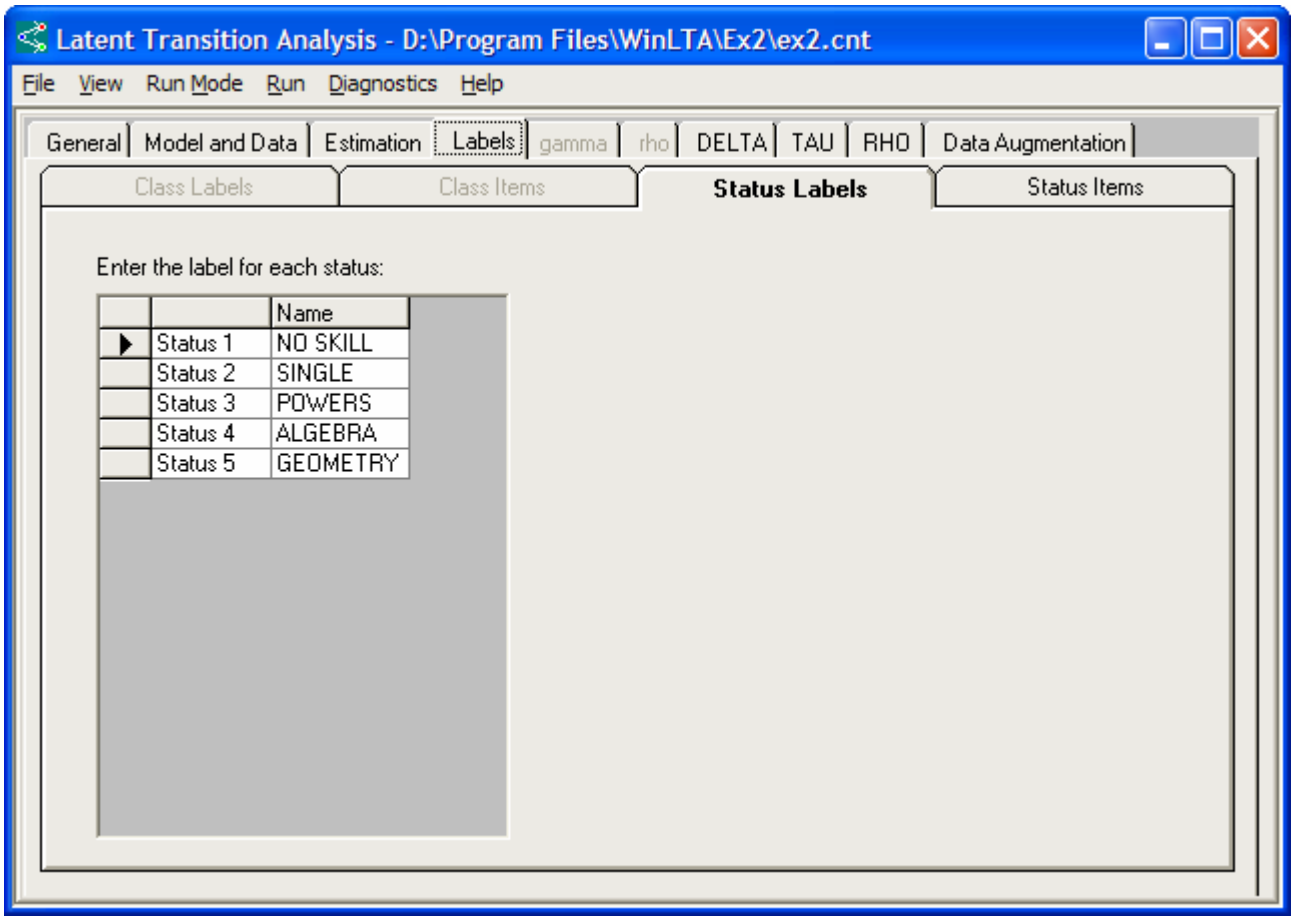
- **Type of estimation:**
- **EM Algorithm:**
  - **New/Continue Previous:** For new runs, select New. Select Continue Previous only when you want to continue a run that failed to converge. (See the section, How to Continue a Run That Did Not Converge in the WinLTA manual.)
  - **Convergence Criterion:** This is the value at which the program is determined to have converged, i.e., the Mean Absolute Deviation (MAD). It may be changed from the default value. In this example, it is set to $10^{-6}$.
  - **Maximum iterations for this run:** If the program reaches 5000 iterations and has not converged, it will stop. You may change this number.
  - **No estimation, goodness-of-fit only:** When this option is selected, the program only assesses the fit of a set of parameter estimates to a data set; no estimation is performed. (See the section How to Crossvalidate in the manual.)

- **File containing parameter estimates:** If you choose to continue a previous run or if you select "No estimation, goodness of fit only", you must enter the name of the file containing the parameter estimates.

The Labels tab is next and there are four tabs therein—two for any latent classes and two for any

latent statuses. The two tabs used for a latent transition model are the Status Labels and Status Items tabs. The Status Labels tab is shown below.

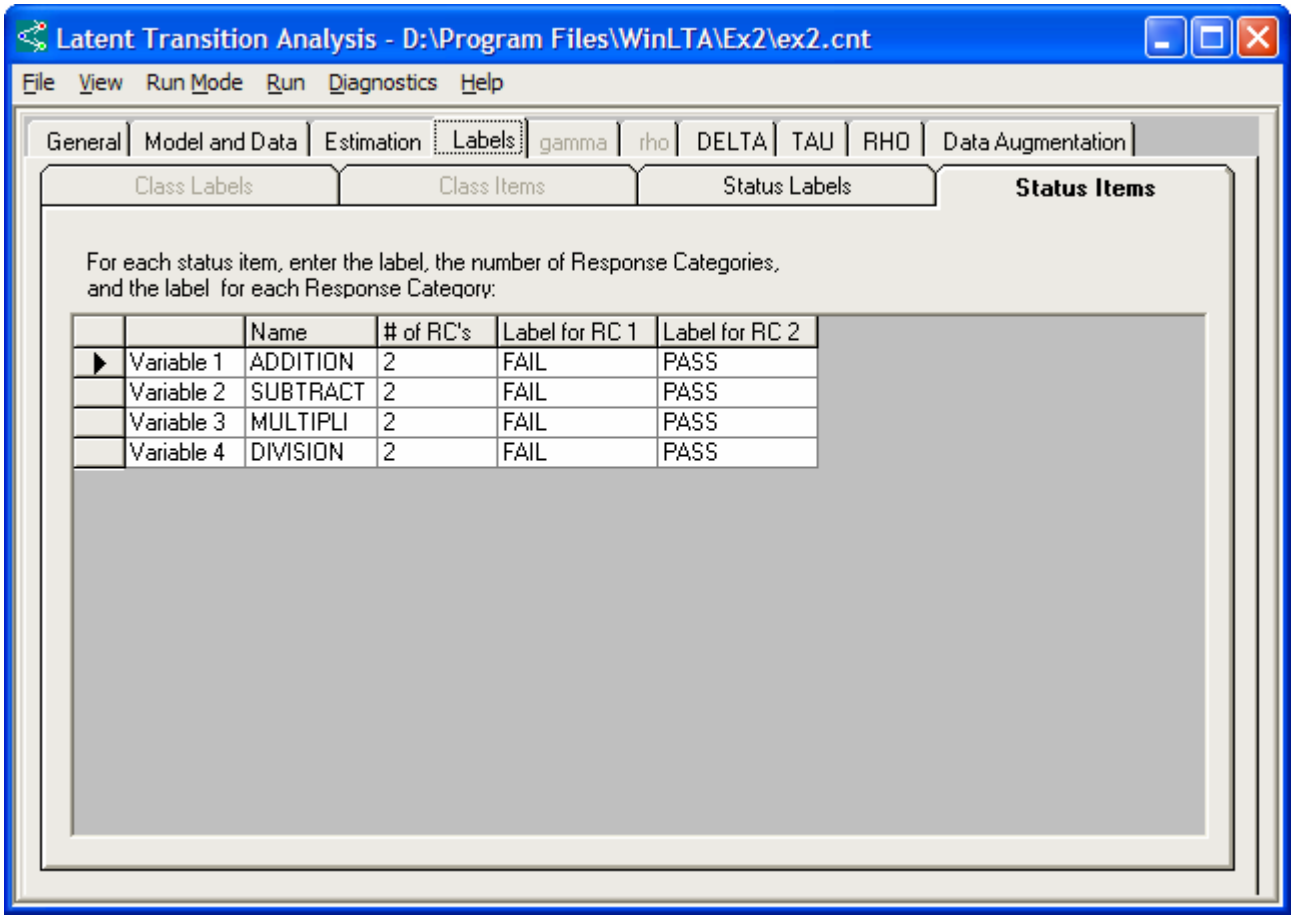
*Labels—Status Labels tab window*




The **Status Labels tab** contains fields for you to enter a label for each of the latent statuses. There is a limit of 8 characters per label.

The next tab under the Labels tab is the Status Items tab.

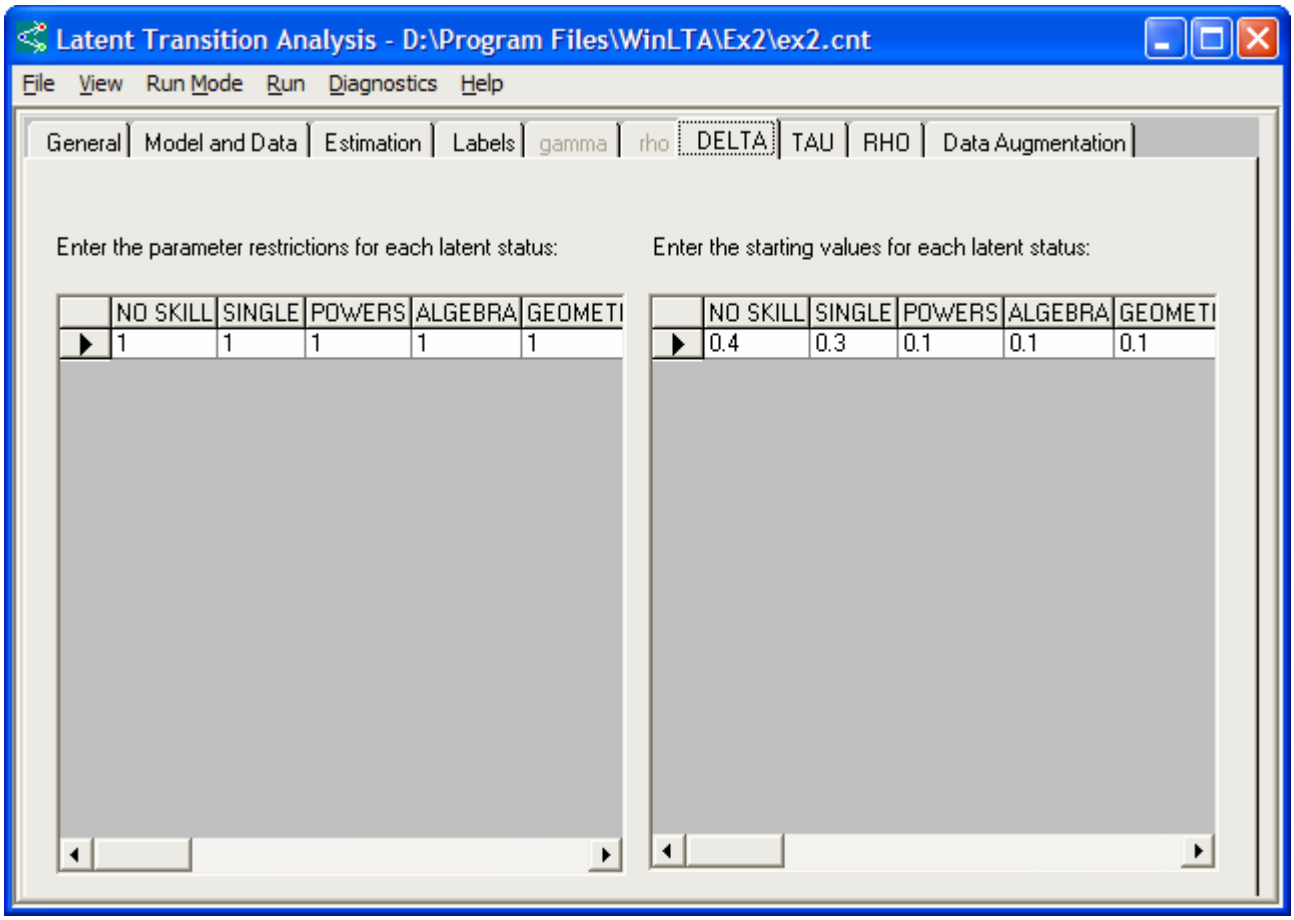
*Labels—Status Items tab window*




**The Status items tab:** In the Model and Data tab, the number of items measuring the latent statuses was entered---four in this example. Accordingly, 4 variables are shown in the Status Items tab. For each variable, enter an item name, the number of response categories, and a label for each of the response categories. In this example, the first variable is named "ADDITION" and it has 2 response categories. Response category #1 is "FAIL" and response category #2 is "PASS."

Having identified the number of latent statuses and having named the statuses and the items used to indicate the statuses, you are now ready to provide information required to estimate the various model parameters. The first set of parameters we will discuss are the delta parameters. (Remember, the gamma and rho parameters are not needed in this model. This is why the gamma and rho tabs are grayed out in the screen shot.)

*DELTA tab window*




The field descriptions for the DELTA tab are:

- **Enter the parameter restrictions for each latent status:** The delta parameters represent the unconditional probability of being in a latent status at a given measurement occasion. They can be estimated freely, constrained to be equal to another value, or fixed to a user specified value. A "1" indicates that the parameter is to be estimated freely. A "0" indicates that the parameter is to be fixed to the starting value, that is, not estimated. Integers greater than or equal to "2" indicate a set of integers that are to be estimated at the same value. In this example, all deltas are estimated freely.

- **Enter the starting values for each latent status:** The starting values for the delta parameters must sum to one.

- The horizontal scroll bar at the bottom of each column will allow you to view all of the statuses.

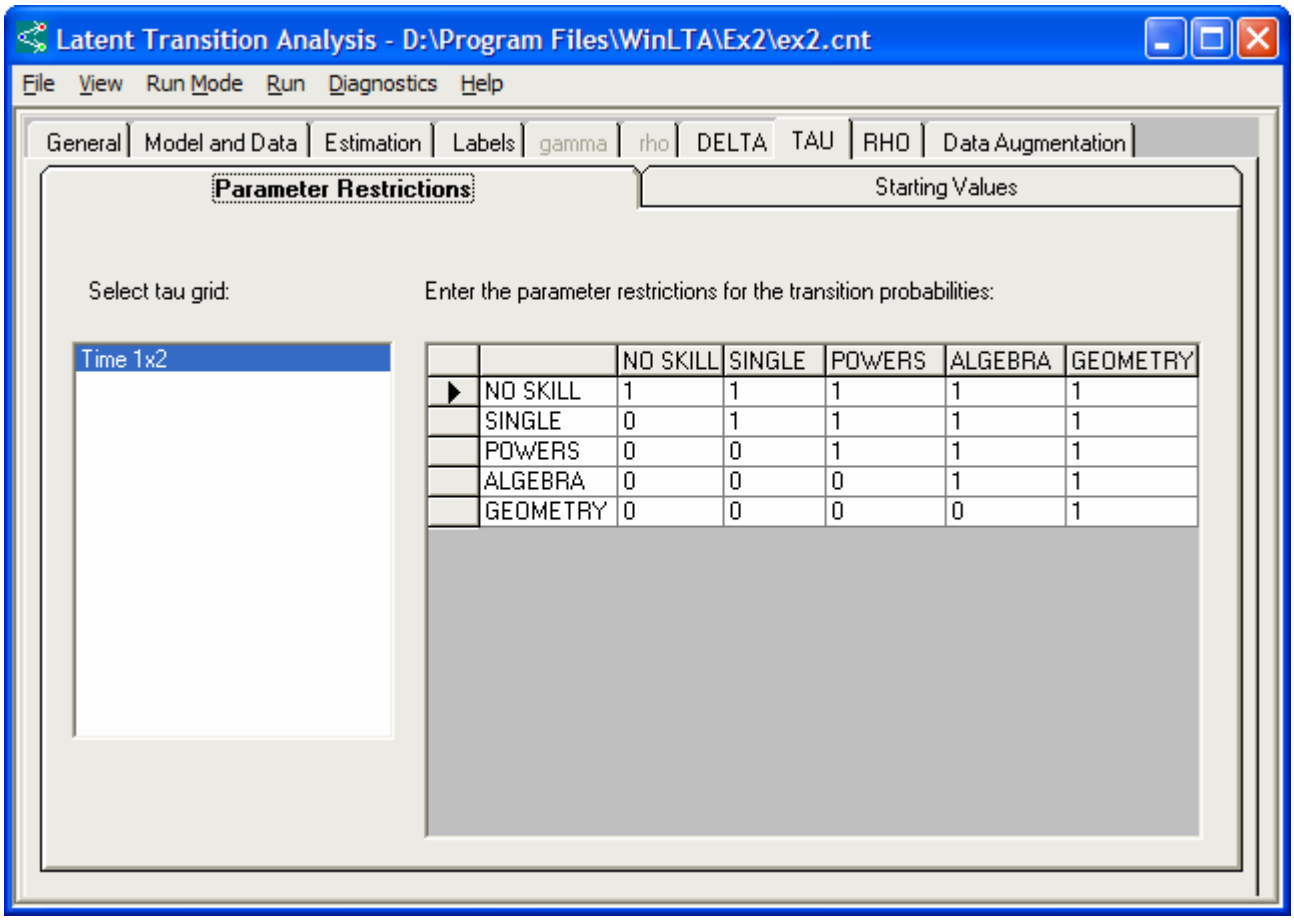
Having provided information about the unconditional probability of being in each of the latent statuses at Time T, you can now consider the (conditional) probability of being in the same or a

different latent status at Time T + 1, given the latent status membership at Time T. Information about the transition probabilities, specifically whether these transitions are to be fixed, constrained, or freely estimated, is provided in the TAU—Parameter Restrictions tab.

Before we can enter values into this tab, we need to think about the theory of math knowledge behind this model. We must consider whether our model will only allow for learning (so that students' math knowledge can only increase) or also for forgetting (so that students can also move backward through the latent statuses). For the purpose of illustration, we will test a model of forward progression only, that is, we assume that math knowledge is not lost.

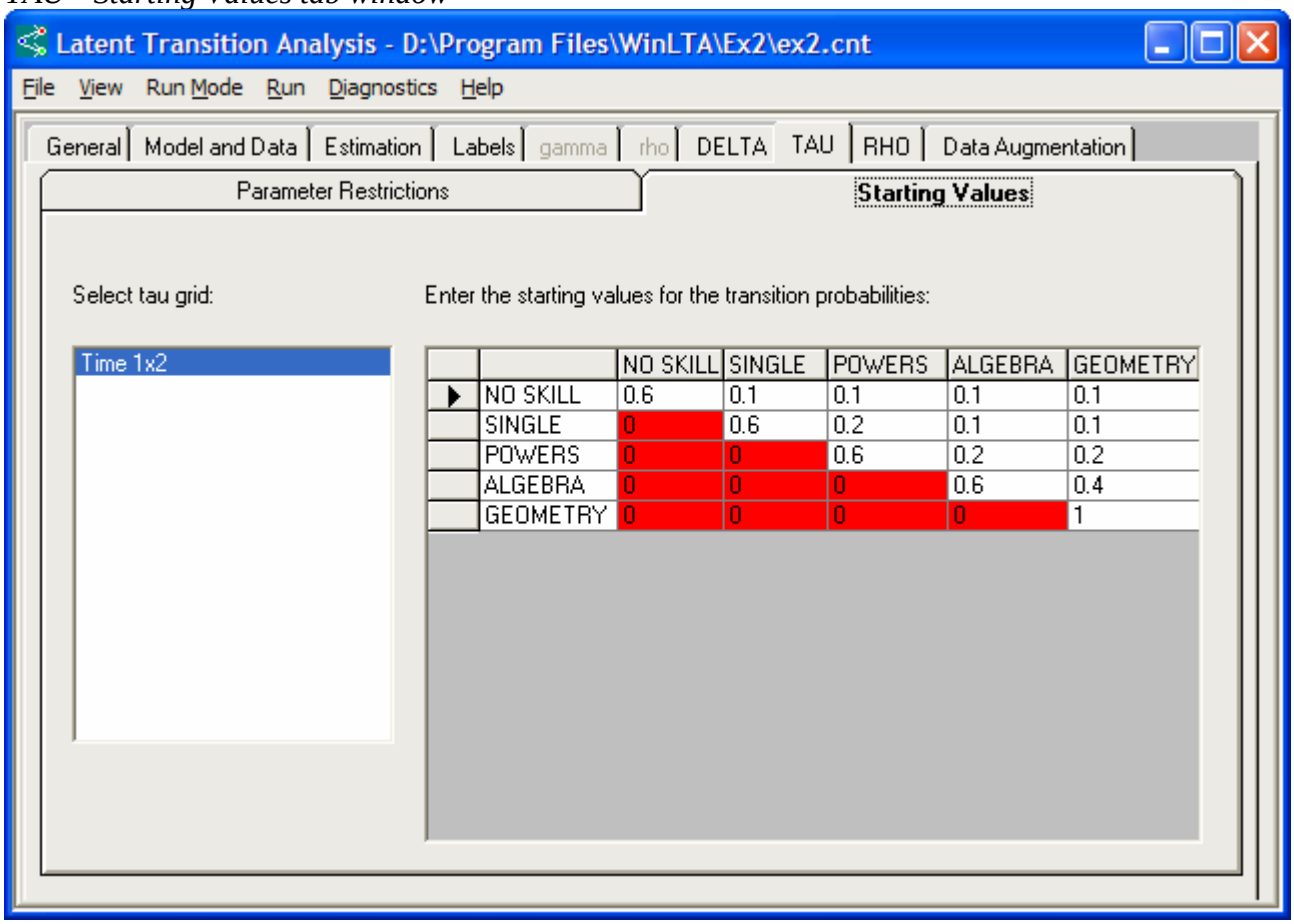
Two tabs are nested within the TAU tab. Below is a picture of the Parameter Restrictions tab. (See the section Identification and Parameter Restrictions in the manual). The cells in the upper triangle of the matrix will all be estimated freely (this is denoted by the number 1). The cells in the lower triangle are all fixed to their starting value (denoted by 0). If all the start values corresponding to the fixed values below are zero, then this pattern indicates that only forward progression is allowed in the model.

*TAU—Parameter Restrictions tab window*




The next tab within the TAU tab is the TAU—Starting Values tab. Note that the lower triangle of this matrix appears in red. These starting values are all "0" because we are testing a model that permits only forward movement.

*TAU—Starting Values tab window*

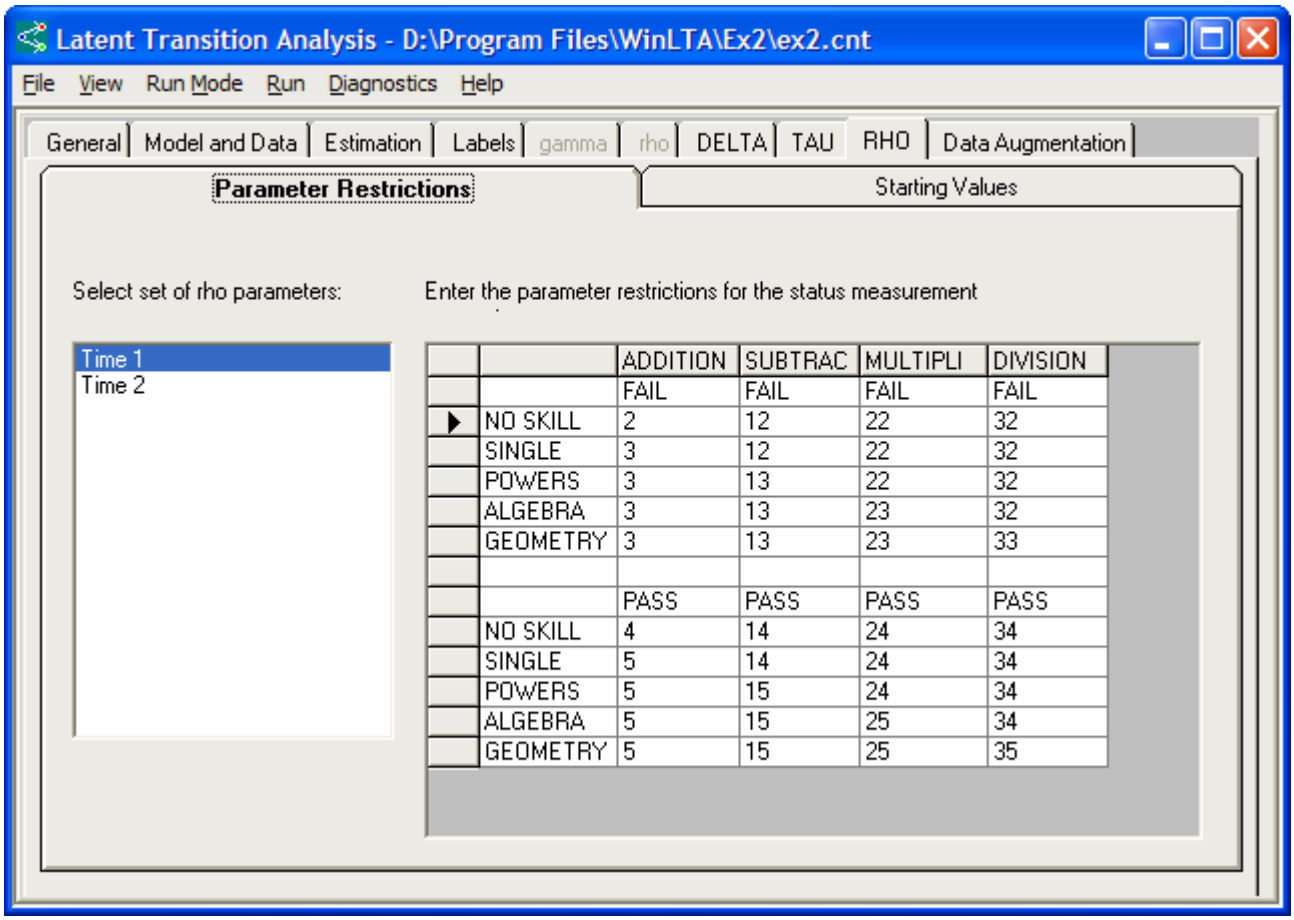



Listed below are the field descriptions for the TAU—Starting Values tab:

- Enter the starting values for the tau parameters on this tab. The start values can be any set of decimal values that sum to one across each row. However, if there are any fixed parameters on the restrictions tab, the value put in the matrix above is the fixed value. Also, estimation will proceed more quickly if you are able to specify start values that are close to what the final result will be.

The final tab is the RHO tab. Two tabs are nested here again: Parameter Restrictions, which is shown below, and the Starting Values tab.

*RHO—Parameter Restrictions tab window*




| | ADDITION | SUBTRAC | MULTIPLI | DIVISION |
|---|---|---|---|---|
| | FAIL | FAIL | FAIL | FAIL |
| NO SKILL | 2 | 12 | 22 | 32 |
| SINGLE | 3 | 12 | 22 | 32 |
| POWERS | 3 | 13 | 22 | 32 |
| ALGEBRA | 3 | 13 | 23 | 32 |
| GEOMETRY | 3 | 13 | 23 | 33 |
| | | | | |
| | PASS | PASS | PASS | PASS |
| NO SKILL | 4 | 14 | 24 | 34 |
| SINGLE | 5 | 14 | 24 | 34 |
| POWERS | 5 | 15 | 24 | 34 |
| ALGEBRA | 5 | 15 | 25 | 34 |
| GEOMETRY | 5 | 15 | 25 | 35 |

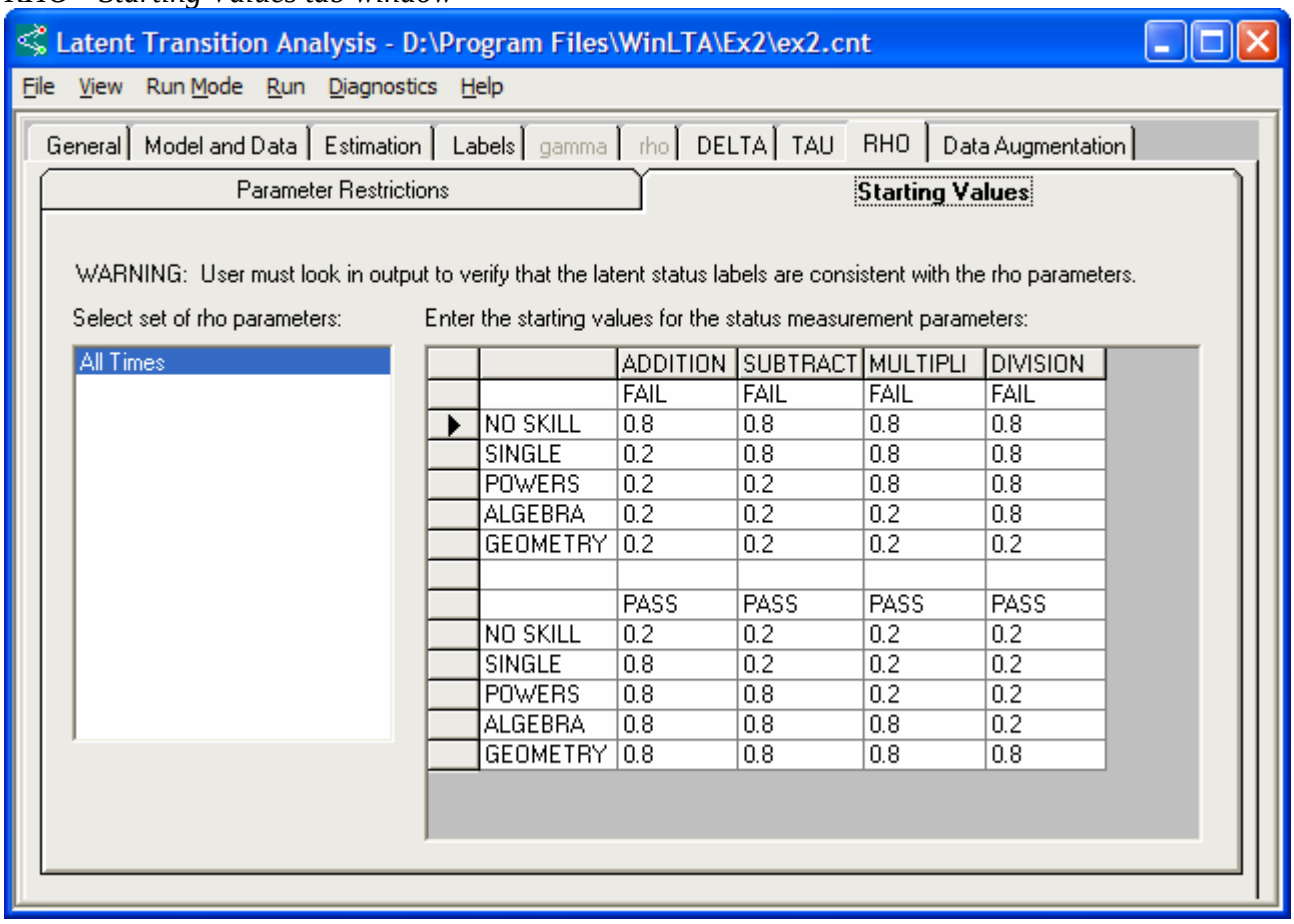
It is important to recall that there is a rho parameter for each combination of latent status, testlet, response category, and time. In this example, the rho parameters are constrained to be equal across time, so the matrix above is duplicated at Time 2.

Below are the field descriptions for the RHO—Parameter Restrictions tab:

- The upper matrix contains the restrictions for the first response category (1 = fail) for Time 1.
- The lower matrix contains the restrictions for the second response category (2 = pass) for Time 1. If the rho parameters for the first response category have been constrained, then those for the second response category must also be constrained.
- To enter the parameter restrictions for the second occasion of measurement, select Time 2 on the left of the window. Enter these constraints just as you did for Time 1. Because the measurement parameters are constrained to be equal across times in this example, the two sets of constraints (Time 1 and Time 2) are identical (not shown).

- The final tab is the RHO—Starting Values tab. Because these parameters are conditional, the rho parameters for each latent status, item, time combination must sum to one across the response categories.

*RHO—Starting Values tab window*




The field descriptions for the RHO—Starting Values tab are below:

- The upper matrix contains the starting values for the measurement parameters in the first response category.
- The lower matrix contains the starting values for the rho parameters in the second response category. The program assumes that the measurement parameters will have the same starting values for all measurement occasions, so there is no need to enter starting values for more than one occasion.

# Saving Your Work and Running WinLTA

- **Saving the control file:** In WinLTA, click on File, and then Save. If this is the first time you have saved this file, a Save As dialog box will appear. In this box you can choose the location of the file and you will be required to enter a filename. By default, the file will be saved with the file extension .cnt.

- **To run WinLTA:** Once the information is completely entered into the control file, click on Run, and then Run EM. EM will begin running automatically. If you have not saved the current version of the control file, you will see a dialog box that asks you if you would like to save before proceeding. Choosing Yes will save the file and run EM automatically. Choosing No will run EM without saving the file. Choosing Cancel will allow you to return to the control file without running EM.

    - Once EM begins running, a separate dialog box entitled "LTA EM Run" will appear on your screen and WinLTA will automatically be minimized. This dialog box tells you the status of the EM run as well as the date and time the run began and finished. The box also has two buttons: Abort and Get Info. Pressing the Abort button will cancel the run. Pressing Get Info gives you the iteration number and the MAD at the time shown, although the information is automatically updated every 5 seconds. Once the run is finished (because the run has converged, you pressed Abort, or the maximum number of iterations has been reached), the Abort button changes to Close. When you press the Close button, WinLTA will automatically be restored as the active window. You can still access WinLTA on your taskbar without pressing the Close button, but Close must be pressed before another EM run can be started.

- **Viewing the WinLTA outfile:** Once the EM run is completed, you can view the output file by clicking on View, and Current LTA Outfile (if you would like to view an older saved outfile, click on Choose LTA Outfile). This will bring up the output file that corresponds with the last EM run.

# The WinLTA Output File

The following is an example of an output file from the WinLTA program. The endnote reference numbers that have been added to the output correspond to the endnotes that follow.

```
1PROGRAM STARTED:       Wed Dec 19 11:52:19 2001

* ROCK3.MOD
* LATENT STATUS PROBLEM

 ************************************************

2INFORMATION ABOUT THIS JOB:

 RUN TYPE: PARAMETER ESTIMATION BY EM

 CONTROL DATA READ FROM FILE:
C:\Program Files\WinLTA\Ex2\ex2.cnt

 DATA ANALYZED IN THIS RUN READ FROM FILE:
.\ex2\ex2.dat

 OUTPUT SAVED IN FILE:
.\ex2\ex2.out

 PARAMETER ESTIMATES SAVED IN FILE:
.\ex2\ex2.est


 STATIC LATENT VARIABLE                     NO

 DYNAMIC LATENT VARIABLE                   YES
 NUMBER OF LATENT STATUSES                   5
 NUMBER OF OCCASIONS OF MEASUREMENT          2
 NUMBER OF MANIFEST ITEMS PER OCCASION       4
 TYPE OF PROCESS                   FIRST-ORDER

 NUMBER OF SUBJECTS                       1500
 NUMBER OF UNIQUE RESPONSE PATTERNS        178
 MAXIMUM NUBMER OF ITERATIONS             5000
 CONVERGENCE CRITERION         .00000100000000
 MISSING DATA IN RESPONSE PATTERNS          NO
 PRINT RESIDUALS                           YES

 ************************************************


3THE FOLLOWING PARAMETER RESTRICTIONS HAVE BEEN SPECIFIED
 WHERE 0=FIXED TO START VALUE
       1=FREE
       2 OR GREATER MEANS CONSTRAINED EQUAL TO ANY OTHER
         PARAMETER WITH THE SAME DESIGNATION

 ************************************************

4BIG RHO PARAMETER RESTRICTIONS
 BIG RHOS ARE PROBABILITIES OF RESPONSE
TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
CONDITIONAL ON LATENT STATUS AND TIME

          BIG RHO PARAMETER RESTRICTIONS FOR TIME  1

          RESPONSE CATEGORY  1

         | A F | S F | M F | D F |
         | D A | U A | U A | I A |
         | D I | B I | L I | V I |
         | I L | T L | T L | I L |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
NO SKILL   2     12    22    32
SINGLE     3     12    22    32
POWERS     3     13    22    32
ALGEBRA    3     13    23    32
GEOMETRY   3     13    23    33

          RESPONSE CATEGORY  2

         | A P | S P | M P | D P |
         | D A | U A | U A | I A |
         | D S | B S | L S | V S |
         | I S | T S | T S | I S |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
NO SKILL   4     14    24    34
SINGLE     5     14    24    34
POWERS     5     15    24    34
ALGEBRA    5     15    25    34
GEOMETRY   5     15    25    35

          BIG RHO PARAMETER RESTRICTIONS FOR TIME  2

          RESPONSE CATEGORY  1

         | A F | S F | M F | D F |
         | D A | U A | U A | I A |
         | D I | B I | L I | V I |
         | I L | T L | T L | I L |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
NO SKILL   2     12    22    32
SINGLE     3     12    22    32
POWERS     3     13    22    32
ALGEBRA    3     13    23    32
GEOMETRY   3     13    23    33
```

```
          RESPONSE CATEGORY  2

         | A P | S P | M P | D P |
         | D A | U A | U A | I A |
         | D S | B S | L S | V S |
         | I S | T S | T S | I S |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
 NO SKILL   4     14    24    34
 SINGLE     5     14    24    34
 POWERS     5     15    24    34
 ALGEBRA    5     15    25    34
 GEOMETRY   5     15    25    35

 ************************************************

5DELTA PARAMETER RESTRICTIONS
 DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP

          TIME 1
 NO SKILL    1
 SINGLE      1
 POWERS      1
 ALGEBRA     1
 GEOMETRY    1

 ************************************************

6TAU PARAMETER RESTRICTIONS
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME
T+1 (COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)



  TRANSITION PROBABILITIES

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  N |  S |  P |  A |  G |
         |  O |  I |  O |  L |  E |
         |    |  N |  W |  G |  O |
         |  S |  G |  E |  E |  M |
         |  K |  L |  R |  B |  E |
         |  I |  E |  S |  R |  T |
         |  L |    |    |  A |  R |
         |  L |    |    |    |  Y |
 NO SKILL   1    1    1    1    1
 SINGLE     0    1    1    1    1
 POWERS     0    0    1    1    1
 ALGEBRA    0    0    0    1    1
 GEOMETRY   0    0    0    0    1

 ************************************************

         7START VALUES

 ************************************************

8BIG RHO PARAMETERS
 BIG RHOS ARE PROBABILITIES OF RESPONSES
 TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
 CONDITIONAL ON LATENT STATUS AND TIME

          RHO PARAMETERS FOR TIME  1

          RESPONSE CATEGORY  1

         | A F | S F | M F | D F |
         | D A | U A | U A | I A |
         | D I | B I | L I | V I |
         | I L | T L | T L | I L |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
 NO SKILL 0.800 0.800 0.800 0.800
 SINGLE   0.200 0.800 0.800 0.800
 POWERS   0.200 0.200 0.800 0.800
 ALGEBRA  0.200 0.200 0.200 0.800
 GEOMETRY 0.200 0.200 0.200 0.200

          RESPONSE CATEGORY  2

         | A P | S P | M P | D P |
         | D A | U A | U A | I A |
         | D S | B S | L S | V S |
         | I S | T S | T S | I S |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
 NO SKILL 0.200 0.200 0.200 0.200
 SINGLE   0.800 0.200 0.200 0.200
 POWERS   0.800 0.800 0.200 0.200
 ALGEBRA  0.800 0.800 0.800 0.200
 GEOMETRY 0.800 0.800 0.800 0.800

          RHO PARAMETERS FOR TIME  2

          RESPONSE CATEGORY  1
```

```
          | A F | S F | M F | D F |
          | D A | U A | U A | I A |
          | D I | B I | L I | V I |
          | I L | T L | T L | I L |
          | T   | R   | I   | S   |
          | I   | A   | P   | I   |
          | O   | C   | L   | O   |
          | N   | T   | I   | N   |
 NO SKILL 0.800 0.800 0.800 0.800
 SINGLE   0.200 0.800 0.800 0.800
 POWERS   0.200 0.200 0.800 0.800
 ALGEBRA  0.200 0.200 0.200 0.800
 GEOMETRY 0.200 0.200 0.200 0.200

          RESPONSE CATEGORY  2

          | A P | S P | M P | D P |
          | D A | U A | U A | I A |
          | D S | B S | L S | V S |
          | I S | T S | T S | I S |
          | T   | R   | I   | S   |
          | I   | A   | P   | I   |
          | O   | C   | L   | O   |
          | N   | T   | I   | N   |
 NO SKILL 0.200 0.200 0.200 0.200
 SINGLE   0.800 0.200 0.200 0.200
 POWERS   0.800 0.800 0.200 0.200
 ALGEBRA  0.800 0.800 0.800 0.200
 GEOMETRY 0.800 0.800 0.800 0.800

 ************************************************

9
 DELTA PARAMETERS
 DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP

           TIME 1
 NO SKILL  0.400
 SINGLE    0.300
 POWERS    0.100
 ALGEBRA   0.100
 GEOMETRY  0.100

 ************************************************

10
  TAU PARAMETERS
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME
T+1 (COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)

  TRANSITION PROBABILITIES

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

          |  N  |  S  |  P  |  A  |  G  |
          |  O  |  I  |  O  |  L  |  E  |
          |     |  N  |  W  |  G  |  O  |
          |  S  |  G  |  E  |  E  |  M  |
          |  K  |  L  |  R  |  B  |  E  |
          |  I  |  E  |  S  |  R  |  T  |
          |  L  |     |     |  A  |  R  |
          |  L  |     |     |     |  Y  |
 NO SKILL 0.600 0.100 0.100 0.100 0.100
 SINGLE   0.000 0.600 0.200 0.100 0.100
 POWERS   0.000 0.000 0.600 0.200 0.200
 ALGEBRA  0.000 0.000 0.000 0.600 0.400
 GEOMETRY 0.000 0.000 0.000 0.000 1.000

 ************************************************

11
  ITERATION HISTORY

 ************************************************

 STARTING G-SQUARED=  2238.252

ITER-   MAD         ITER-   MAD         ITER-   MAD
ATION               ATION               ATION

   1  .0659844848      2  .0184273120      3  .0095720592
   4  .0061006221      5  .0042580028      6  .0031152403
   7  .0023810290      8  .0018612847      9  .0014791731
  10  .0011979130     11  .0009875146     12  .0008255279
  13  .0006964822     14  .0005925681     15  .0005117561
  16  .0004437032     17  .0003860032     18  .0003368097
  19  .0002946760     20  .0002584488     21  .0002271955
  22  .0002001531     23  .0001766916     24  .0001562868
  25  .0001385001     26  .0001229623     27  .0001095085
  28  .0000981400     29  .0000881414     30  .0000792974
  31  .0000714606     32  .0000645038     33  .0000583175
  34  .0000529181     35  .0000481690     36  .0000438997
  37  .0000400713     38  .0000366132     39  .0000334866
  40  .0000306569     41  .0000280933     42  .0000257686
  43  .0000238586     44  .0000221282     45  .0000205389
  46  .0000190776     47  .0000177328     48  .0000164940
  49  .0000153517     50  .0000142974     51  .0000133235
  52  .0000124231     53  .0000115898     54  .0000108181
  55  .0000101028     56  .0000094393     57  .0000088234
  58  .0000082554     59  .0000077280     60  .0000072369
  61  .0000067793     62  .0000063527     63  .0000059610
  64  .0000055963     65  .0000052552     66  .0000049361
  67  .0000046373     68  .0000043574     69  .0000040952
  70  .0000038495     71  .0000036190     72  .0000034029
  73  .0000032001     74  .0000030098     75  .0000028315
  76  .0000026644     77  .0000025074     78  .0000023598
  79  .0000022212     80  .0000020923     81  .0000019714
```

```
   82  .0000018575     83  .0000017502     84  .0000016491
   85  .0000015538     86  .0000014640     87  .0000013795
   88  .0000012998     89  .0000012247     90  .0000011539
   91  .0000010873     92  .0000010248     93  .0000009659


 ************************************************

 MODEL FIT

12G-Squared Test of Model Fit:              286.199
  Degrees of Freedom:                           233


 ************************************************

  **WARNING**: BE SURE TO INTERPRET THE LATENT STATUSES
CAREFULLY
               BASED ON THE ESTIMATED RHO PARAMETERS
REPORTED BELOW.
               YOU MAY WISH TO CHANGE THE LABELS YOU
PREVIOUSLY ASSIGNED
               TO THE LATENT STATUSES IN ORDER TO MAKE THEM
               CONSISTENT WITH YOUR INTERPRETATION.

 ************************************************

 BIG RHO PARAMETERS
 BIG RHOS ARE PROBABILITIES OF RESPONSES
 TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
 CONDITIONAL ON LATENT STATUS AND TIME

       13RHO PARAMETERS FOR TIME  1

          RESPONSE CATEGORY  1

         | A F | S F | M F | D F |
         | D A | U A | U A | I A |
         | D I | B I | L I | V I |
         | I L | T L | T L | I L |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
 NO SKILL 0.665 0.898 0.957 0.992
 SINGLE   0.062 0.898 0.957 0.992
 POWERS   0.062 0.100 0.957 0.992
 ALGEBRA  0.062 0.100 0.141 0.992
 GEOMETRY 0.062 0.100 0.141 0.381

       14RESPONSE CATEGORY  2

         | A P | S P | M P | D P |
         | D A | U A | U A | I A |
         | D S | B S | L S | V S |
         | I S | T S | T S | I S |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
 NO SKILL 0.335 0.102 0.043 0.008
 SINGLE   0.938 0.102 0.043 0.008
 POWERS   0.938 0.900 0.043 0.008
 ALGEBRA  0.938 0.900 0.859 0.008
 GEOMETRY 0.938 0.900 0.859 0.619

       15RHO PARAMETERS FOR TIME  2

          RESPONSE CATEGORY  1

         | A F | S F | M F | D F |
         | D A | U A | U A | I A |
         | D I | B I | L I | V I |
         | I L | T L | T L | I L |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
 NO SKILL 0.665 0.898 0.957 0.992
 SINGLE   0.062 0.898 0.957 0.992
 POWERS   0.062 0.100 0.957 0.992
 ALGEBRA  0.062 0.100 0.141 0.992
 GEOMETRY 0.062 0.100 0.141 0.381

          RESPONSE CATEGORY  2

         | A P | S P | M P | D P |
         | D A | U A | U A | I A |
         | D S | B S | L S | V S |
         | I S | T S | T S | I S |
         | T   | R   | I   | S   |
         | I   | A   | P   | I   |
         | O   | C   | L   | O   |
         | N   | T   | I   | N   |
 NO SKILL 0.335 0.102 0.043 0.008
 SINGLE   0.938 0.102 0.043 0.008
 POWERS   0.938 0.900 0.043 0.008
 ALGEBRA  0.938 0.900 0.859 0.008
 GEOMETRY 0.938 0.900 0.859 0.619

 ************************************************

16DELTA PARAMETERS
 DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP
```

```
          TIME 1 TIME 2
 NO SKILL  0.442  0.378
 SINGLE    0.180  0.164
 POWERS    0.146  0.108
 ALGEBRA   0.150  0.215
 GEOMETRY  0.083  0.136

 ***********************************************

17 TAU PARAMETERS
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME
T+1 (COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)

  TRANSITION PROBABILITIES

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  N  |  S  |  P  |  A  |  G  |
         |  O  |  I  |  O  |  L  |  E  |
         |     |  N  |  W  |  G  |  O  |
         |  S  |  G  |  E  |  E  |  M  |
         |  K  |  L  |  R  |  B  |  E  |
         |  I  |  E  |  S  |  R  |  T  |
         |  L  |     |     |  A  |  R  |
         |  L  |     |     |     |  Y  |
 NO SKILL 0.855 0.103 0.024 0.019 0.000
 SINGLE   0.000 0.658 0.163 0.134 0.044
 POWERS   0.000 0.000 0.466 0.486 0.048
 ALGEBRA  0.000 0.000 0.000 0.745 0.255
 GEOMETRY 0.000 0.000 0.000 0.000 1.000

 ***********************************************

         18 EXPECTED CELL FREQUENCIES AND RESIDUALS

   19      20 OBS    21 EXP       22 RESID    23 PEARSON

 11111111   217   184.5136    32.4864     2.3916 *
 21111111   100   100.5599    -0.5599    -0.0558
 12111111    11    21.1099   -10.1099    -2.2004 *
 22111111    10    12.0549    -2.0549    -0.5919
 11211111     1     8.2234    -7.2234    -2.5189 *
 21211111     5     4.4955     0.5045     0.2379
 12211111     1     0.9492     0.0508     0.0522
 22211111     5     0.6652     4.3348     5.3147 *
 11112111   133   131.2222     1.7778     0.1552
 21112111   164   180.3321   -16.3321    -1.2162
 12112111    17    15.5567     1.4433     0.3659
 22112111    40    29.2417    10.7583     1.9895
 11212111     1     5.8619    -4.8619    -2.0081 *
 21212111     8     8.2519    -0.2519    -0.0877
 12212111     1     0.8213     0.1787     0.1972
 22212111     7     3.2433     3.7567     2.0860 *
 11122111     1     1.0838    -0.0838    -0.0805
 22122111     2     0.2871     1.7129     3.1965 *
 11111211    14    21.7641    -7.7641    -1.6643
 21111211    17    14.4076     2.5924     0.6830
 12111211     2     2.8241    -0.8241    -0.4904
 22111211     9     6.7759     2.2241     0.8544
 11211211     1     0.9783     0.0217     0.0219
 12211211     1     0.2018     0.7982     1.7768
 22211211     1     1.4531    -0.4531    -0.3759
 11121211     1     0.1799     0.8201     1.9335
 22221211     1     0.1776     0.8224     1.9516
 11112211    24    25.4706    -1.4706    -0.2914
 21112211    63    64.8963    -1.8963    -0.2354
 12112211    12     8.0394     3.9606     1.3969
 22112211    73    85.1663   -12.1663    -1.3183
 11212211     1     1.2631    -0.2631    -0.2341
 21212211     6     4.8322     1.1678     0.5313
 12212211     4     1.5094     2.4906     2.0272 *
 22212211    32    21.2417    10.7583     2.3343 *
 21122211     3     0.5815     2.4185     3.1714 *
 22122211     3     1.1141     1.8859     1.7868
 11222211     1     0.0288     0.9712     5.7183 *
 22222211     3     2.6848     0.3152     0.1924
 11111121     2     8.2747    -6.2747    -2.1813 *
 21111121     4     4.7366    -0.7366    -0.3385
 22111121     1     1.1505    -0.1505    -0.1404
 11211121     1     0.3745     0.6255     1.0222
 11112121     8     6.6391     1.3609     0.5282
 21112121    22    11.9061    10.0939     2.9253 *
 12112121     4     1.3678     2.6322     2.2506 *
 22112121    14    10.5985     3.4015     1.0448
 11212121     1     0.3828     0.6172     0.9975
 22212121    12    12.3226    -0.3226    -0.0919
 21122121     2     0.1293     1.8707     5.2014 *
 11111221     1     1.4395    -0.4395    -0.3663
 21111221     3     2.9382     0.0618     0.0360
 12111221     4     0.5261     3.4739     4.7895 *
 22111221     2     5.8172    -3.8172    -1.5827
 21211221     1     0.9129     0.0871     0.0912
 12211221     1     0.4874     0.5126     0.7343
 22211221     3     7.2904    -4.2904    -1.5890
 22221221     1     1.0715    -0.0715    -0.0691
 11112221     6     8.2518    -2.2518    -0.7839
 21112221    33    37.6913    -4.6913    -0.7641
 12112221     8     6.4240     1.5760     0.6218
 22112221    84    87.3803    -3.3803    -0.3616
 11212221     6     1.1496     4.8504     4.5237 *
 21212221    20    13.5299     6.4701     1.7590
 12212221    11     7.3174     3.6826     1.3614
 22212221    90   110.4529   -20.4529    -1.9461
 21122221     1     0.5903     0.4097     0.5333
```

```
 22122221     3     3.2309    -0.2309    -0.1285
 21222221     3     1.8162     1.1838     0.8784
 22222221    17    16.2390     0.7610     0.1889
 11111112     1     1.5239    -0.5239    -0.4244
 21112112     3     1.5858     1.4142     1.1230
 11111212     1     0.1835     0.8165     1.9061
 11112212     1     0.2678     0.7322     1.4151
 22112212     2     2.3051    -0.3051    -0.2009
 22212212     1     5.7308    -4.7308    -1.9762
 22122212     1     0.6869     0.3131     0.3777
 22222212     1     4.1267    -3.1267    -1.5392
 21111222     1     0.3751     0.6249     1.0202
 22111222     1     0.6936     0.3064     0.3679
 22211222     1     2.2991    -1.2991    -0.8568
 21112222     7     5.6287     1.3713     0.5780
 12112222     1     0.6986     0.3014     0.3606
 22112222    12    10.5053     1.4947     0.4612
 21212222     3     4.0736    -1.0736    -0.5319
 22212222    52    34.8430    17.1570     2.9066 *
 21122222     1     0.5001     0.4999     0.7068
 22122222     1     4.1661    -3.1661    -1.5512
 22222222    44    25.2038    18.7962     3.7440 *
************************************************


 PROGRAM FINISHED: Wed Dec 19 11:52:20 2001
 ELAPSED TIME:    0 HOURS,    0 MINUTES,    1 SECONDS.
```

# Explanation of the WinLTA Output File for Example 2

The following sections refer to the output from running the example 2 control file. The first section of the output contains a listing of the parameter restrictions, starting values, and other information entered in the program control file. The next section is the iteration history, which is followed by the parameter estimates. In this example, residuals were requested, so the final section of the output includes the response patterns, observed and expected frequencies, and Pearson residuals.

**Program Control File Information**

**1** The title lines and comments entered in the General tab will be printed first.

**2** Basic information from the Model and Data tab and the Estimation tab is echoed back in the first section of the output file. The filenames for the control file, the data, the output, and the parameter estimates are shown first. The next lines include the number of latent classes, number of latent statuses, number of items (for statuses and classes), number of participants, number of observed response patterns, maximum number of iterations allowed, convergence criterion, and whether there is missing data in the response patterns. Finally, there is line indicating whether or not residuals were requested.

**Parameter Restrictions**

**3** This section contains a listing of the user-specified parameter restrictions.

**4** The big rho parameter restrictions are printed in this section.

**5** In this section, the user-specified parameter restrictions for the delta parameters are printed.

**6** In this section, the user-specified parameter restrictions for the tau parameters are printed.

**Starting Values**

**7** This section contains a listing of the user-specified starting values.

**8** In this section, the user-specified starting values for the big rho parameters in response category 1 and response category 2 are printed.

**9** In this section, the user-specified starting values for the delta parameters are printed.

**10** In this section, the user-specified starting values for the tau parameters are printed.

**Iteration History**

**11** After each iteration, the iteration number and the Mean Absolute Deviation (MAD) are printed. MAD is the mean absolute deviation; i.e. the average of the absolute value of the difference between parameter estimates from the current and prior iteration.

**12** The final likelihood ratio statistic ($G^2$) reflects the fit of the model, with degrees of freedom equal to the number of response patterns minus the number of parameters estimated minus one. In this case, the observed test statistic, $G^2 = 286.199$, which is greater than the $\alpha = .05$ critical value of the chi-squared distribution, $\chi^2(233) = 269.608$. Therefore, we concluded that the model does not fit the data (also see the discussion of fit in the manual). It is probably too restrictive, meaning that some of the constraints are probably inappropriate. Therefore freeing some of the constraints may improve model fit, although one must also pay attention to model identification.

**Parameter Estimates**

The estimates for the parameters are printed in the next sections of output.

Big Rho Parameters

**13** The big rho parameters are the probabilities of a particular item response conditional on latent status. The probabilities are grouped by response category and time. This section is for the first response category at Time 1. In this example, a "1" designates a failure. For example, the probability of failing testlet 1 given membership in latent status 2 is 0.062. People in this latent status are likely to pass testlet 1 and unlikely to pass any other testlets. Therefore, we judge that those in latent status 2 are at the single operations level of math skill, in other words, the label we have chosen for this latent status is a reasonable one.

**14** The estimates for the big rho parameters for the second response category are given in this section. In this example, a "2" designates that the testlet was passed. For example, the probability of passing testlet 3 given membership in the single operations latent status is 0.043, and the probability of passing testlet 2 given membership in the single operations latent status is 0.102. The probability of passing testlet 2 given membership in the powers and roots latent status is 0.900.

**15** The next section contains the big rho parameters for Time 2. Because the rhos were constrained to be equal across times, this section is identical to **13** and **14**.

In factor analysis, the patterns of factor loadings characterize the factors. In latent transition analysis, the conditional probabilities characterize the latent statuses. The big rhos have been constrained to be equal across time, so that discussion of the patterns of these conditional probabilities applies to both Times 1 and 2. For the first latent status, the probabilities of failing the four items is fairly high. Therefore, this latent status is characterized as the "no skills" latent

status. Latent statuses 2 through 5 are characterized similarly by the patterns of the big rho parameter estimates.

Delta Parameters

**16** The estimates for the delta parameters are the unconditional probabilities of latent status membership. For example, the estimated unconditional probability of being in the no skills latent status at Time 1 is 0.442, and the probability of being in the geometry latent status at Time 2 is 0.136. According to this model, 44.2% of the participants did not have any of the measured math skills in their sophomore year in high school, and 13.6% of the seniors had all of the tested skills.

Tau Parameters

**17** The tau parameters represent the probability of being in a particular latent status at Time 2 conditional on Time 1 latent status membership. The diagonal of the transition probability matrix indicates the probability that the participants remain in a particular latent status across time, that is, these individuals do not change. For example, the first diagonal element, $\tau_{1|1}$ = 0.855, indicates that students who were in the "no skill" latent status during their sophomore year had a high probability of being in the no skill latent status during their senior year. There is only an approximately 15% chance that a student in the no skill latent status at Time 1 will have gained some math skill by Time 2. Of the students in the "single" latent status, about 66% remain there ($\tau_{2|2}$ = 0.658). The probability of students transitioning from the "powers" latent status to the "algebra" latent status ($\tau_{4|3}$ = 0.486) is fairly high. This is an example of "forward" movement since it is an off-diagonal element of the upper-triangle of this matrix. These elements usually indicate the probability of "growth" or, as in the case of the current example, "learning." Similarly, off-diagonal elements in the lower-triangle of this matrix usually indicate "decline," "forgetting," or "unlearning." The model does not allow decline, but such a model could be fit. [Note: Dayton & Macready (1976) refer to "unlearning" as "forgetting" in a similar mastery test situation involving chemistry items.]

**Response Patterns and Residuals**

**18** If requested in the General tab of the control file, response patterns, residuals, and other statistics are printed.

**19** These are the response patterns that the program read in as raw data. Only those observed in the sample are printed. In the example output, the first four numbers of the response pattern are for Time 1 responses. The first response pattern 11111111 means that participant failed the 4 items at Time 1 and failed the 4 items at Time 2.

**20** These are the observed frequencies for each response pattern.

**21** Given the parameter estimates associated with the model being tested, these are the expected frequencies.

**22** The observed minus the expected frequencies equals the residuals.

**23** The Pearson residuals are also printed as part of the output. The Pearson residual is (OBS-EXP)/√EXP. Any Pearson residuals greater than 2 or less than –2 are marked with an asterisk.

# Example 3

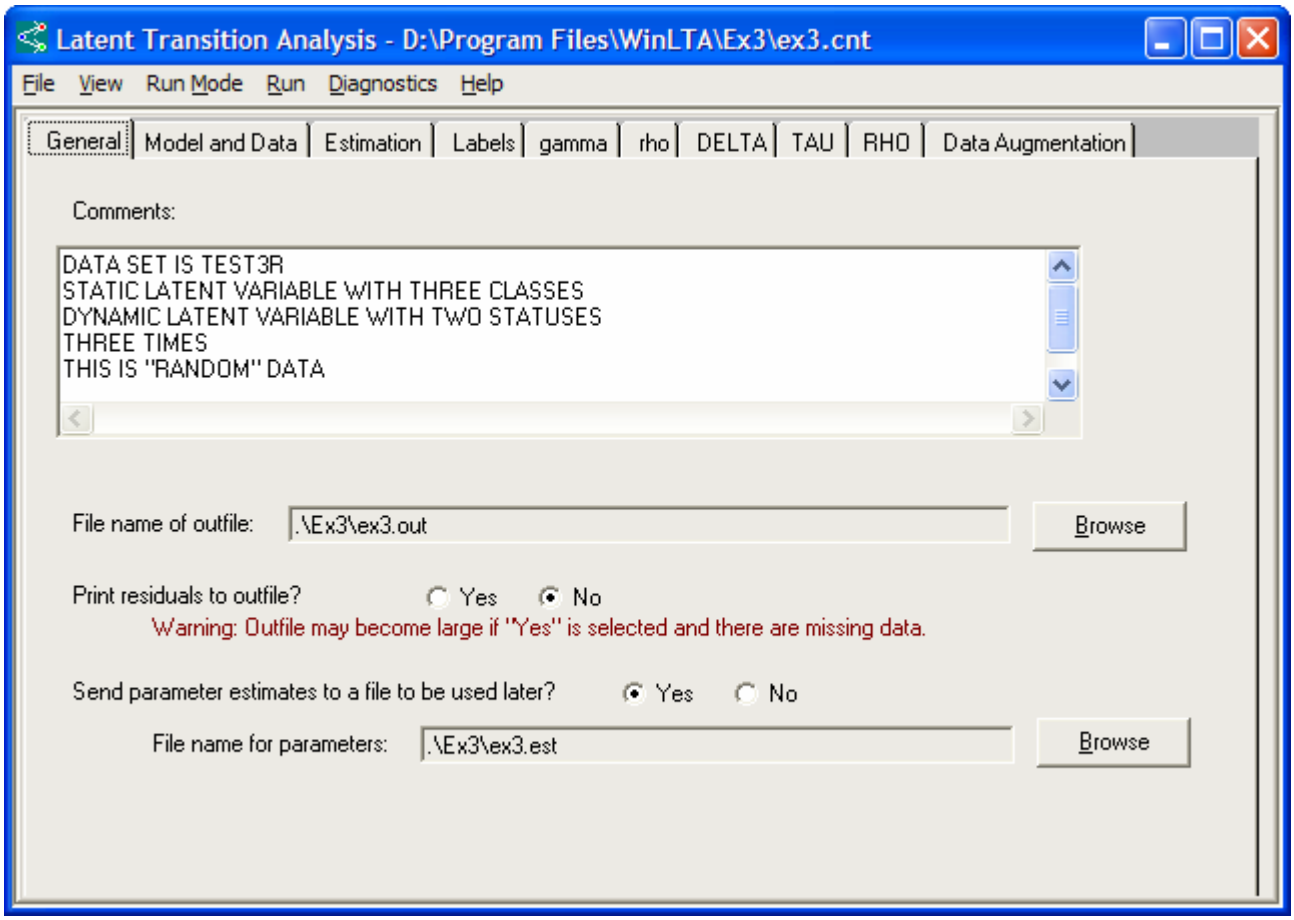
## Three Time, Three Latent Class, Two Latent Status Example

# Example 3

This section presents an example of a latent transition problem with three measurement occasions, involving a static latent class variable and a dynamic latent status variable. Although these are artificial data, let us assume that the participants are 2000 underprivileged school children. Their teachers have been asked to answer three additional questions about each child's performance in math, reading, and science three times during the school year: the beginning, middle and end of the school year. These three questions will be used to determine whether the child's performance is above grade level or at or below grade level. Because performance may change over time, this is the dynamic latent variable. In addition, at the beginning of the year, the teachers were asked to answer three questions about each child. The answers will be used to identify three groups of children: those who have no learning disability, those who have a mild learning disability, and those who have a severe learning disability. Learning disability is a three category static latent variable. This model allows us to compare transitions in school performance across the three learning disability groups.

In order to fit the above model with WinLTA, the user must create a WinLTA control file. To begin entering information into WinLTA, first click on File, and choose New Control File. Select the General tab. If you would like to follow along with these examples instead of entering your own information, click on File, Open Control File, and choose the folder for Example 3. Then open the file called ex3.cnt.

*General tab window*

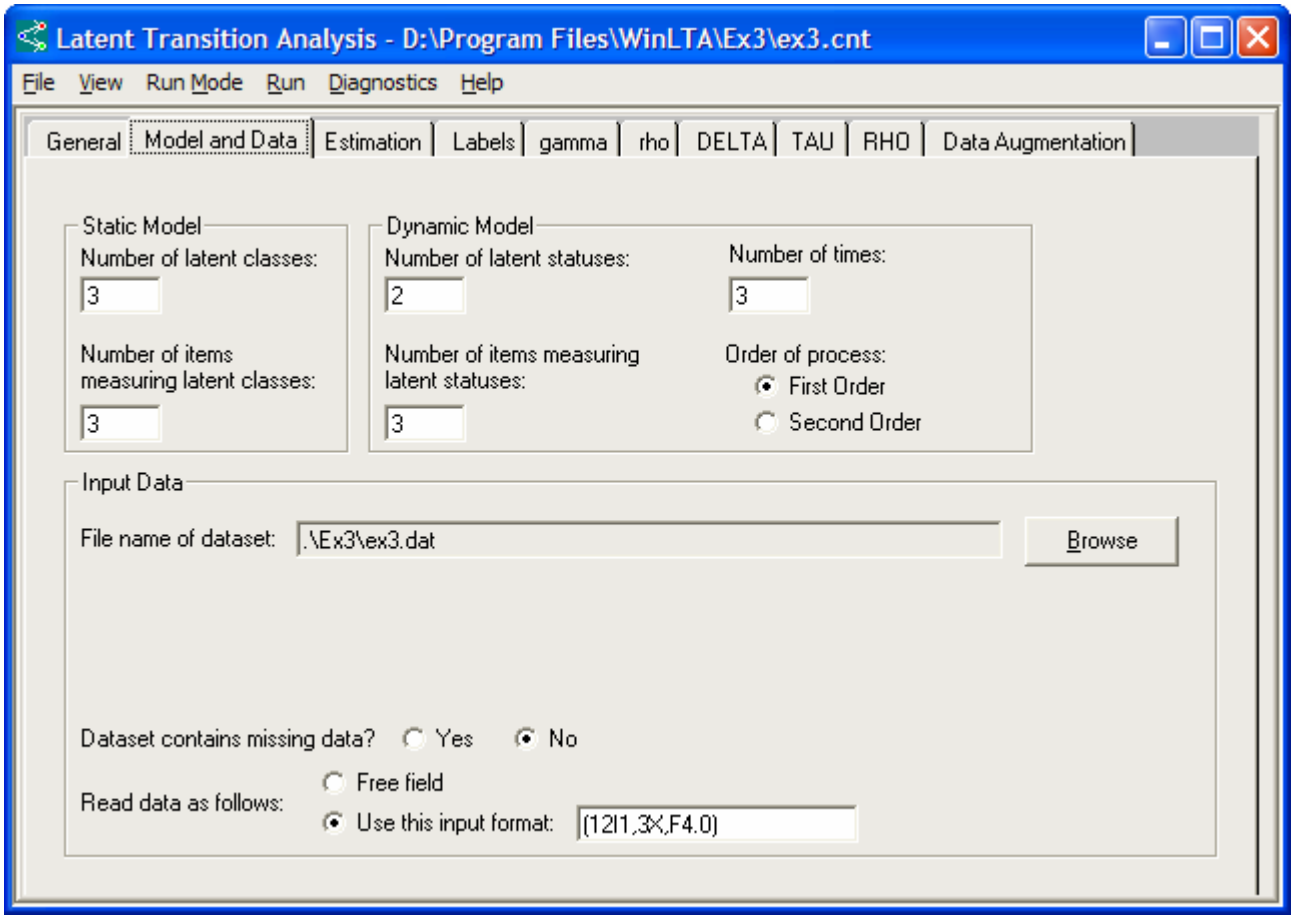



The field descriptions for the General tab are:

- **Comments:** Enter titles and comments in this space. These are the first lines in the output.
- **File name of outfile:** Specify the file in which the output will be saved by pressing the Browse button.
- **Print residuals to outfile?:** Allows the user to choose to have residuals printed at the end of the output file.
- **Send parameter estimates to a file to be used later?:** Choosing Yes here will save the final parameter estimates in a separate file. Select the file by pressing the Browse button.

The Model and Data tab is shown next.

*Model and Data tab window*




The field descriptions for the Model and Data tab are:

- **Static Model:** This section contains information about the static latent variable.
  - **Number of latent classes:** There are 3 latent classes: (1) no learning disability, (2) mild learning disability, and (3) severe learning disability.
- **Number of items measuring latent classes:** Three items measure the latent class variable.

- **Dynamic Model:** This section contains information about the dynamic latent variable.
  - **Number of latent statuses:** There are 2 latent statuses in this example: (1) above grade level and (2) at or below grade level.
  - **Number of items measuring latent statuses:** 3
- **Number of times:** 3
- **Order of process:** First order (Caution: clicking the "second order" button will clear any tau parameter starting values that were entered for the first order model. Be careful!)

- **Input Data:**
  - **File name of dataset:** Select the file by pressing the Browse button.
- **Dataset contains missing data?:** There are no missing data in this example.

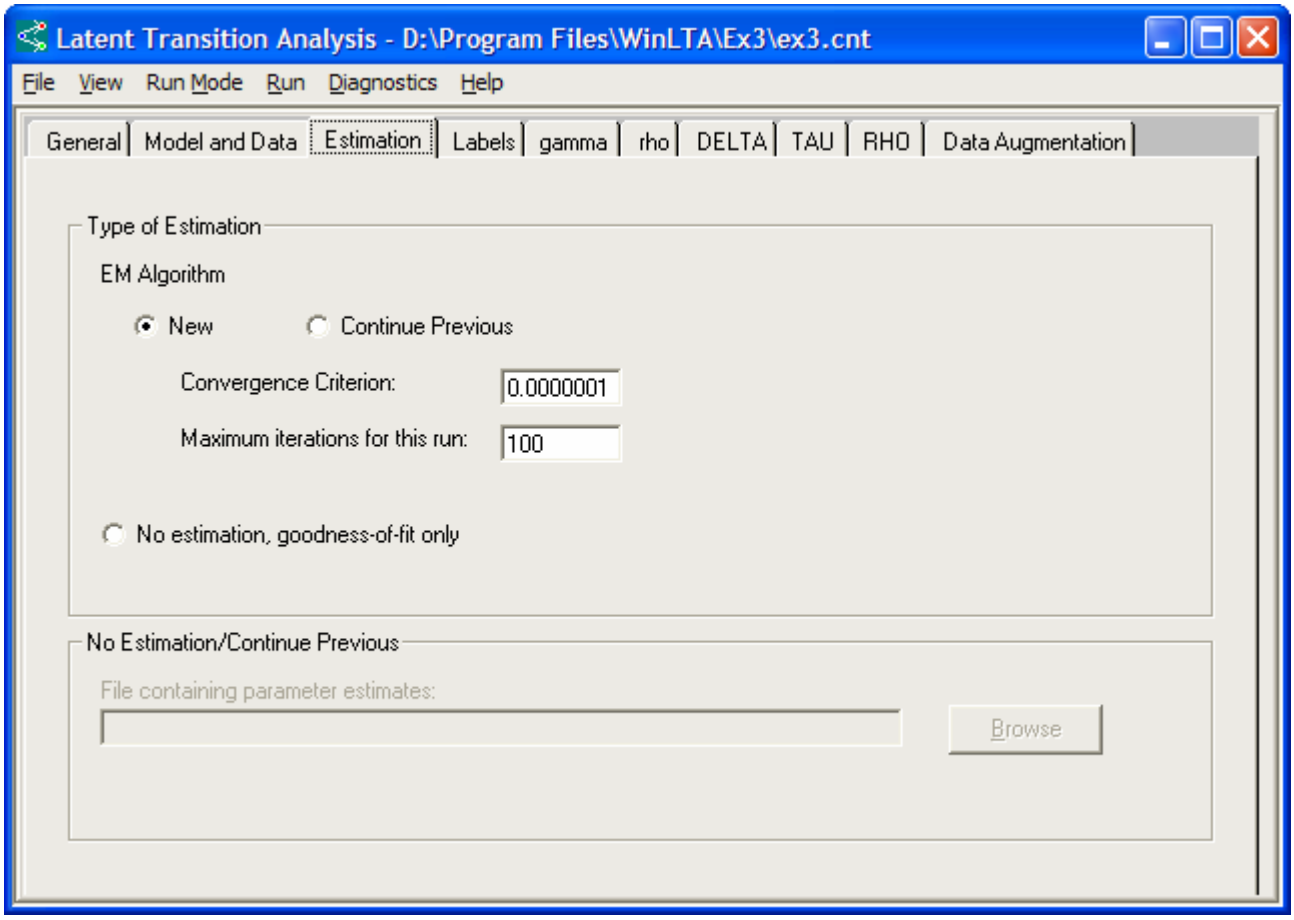
- **Read data as follows:** Specify whether the data are in free or fixed format. If the data are in fixed format (i.e., no whitespace between each item and the frequency count), then a Fortran format statement must be provided in the "Use this input format" field. The Fortran input format for this data is (12I1,3X,F4.0). The first four lines of the data file follow.

```
111111111111   16
111111111112    6
111111111121    1
111111111122    2
…
```

  More information about input formats see Examples 1 or 2, the WinLTA helpfile or a book on Fortran.

The Estimation tab is discussed next.

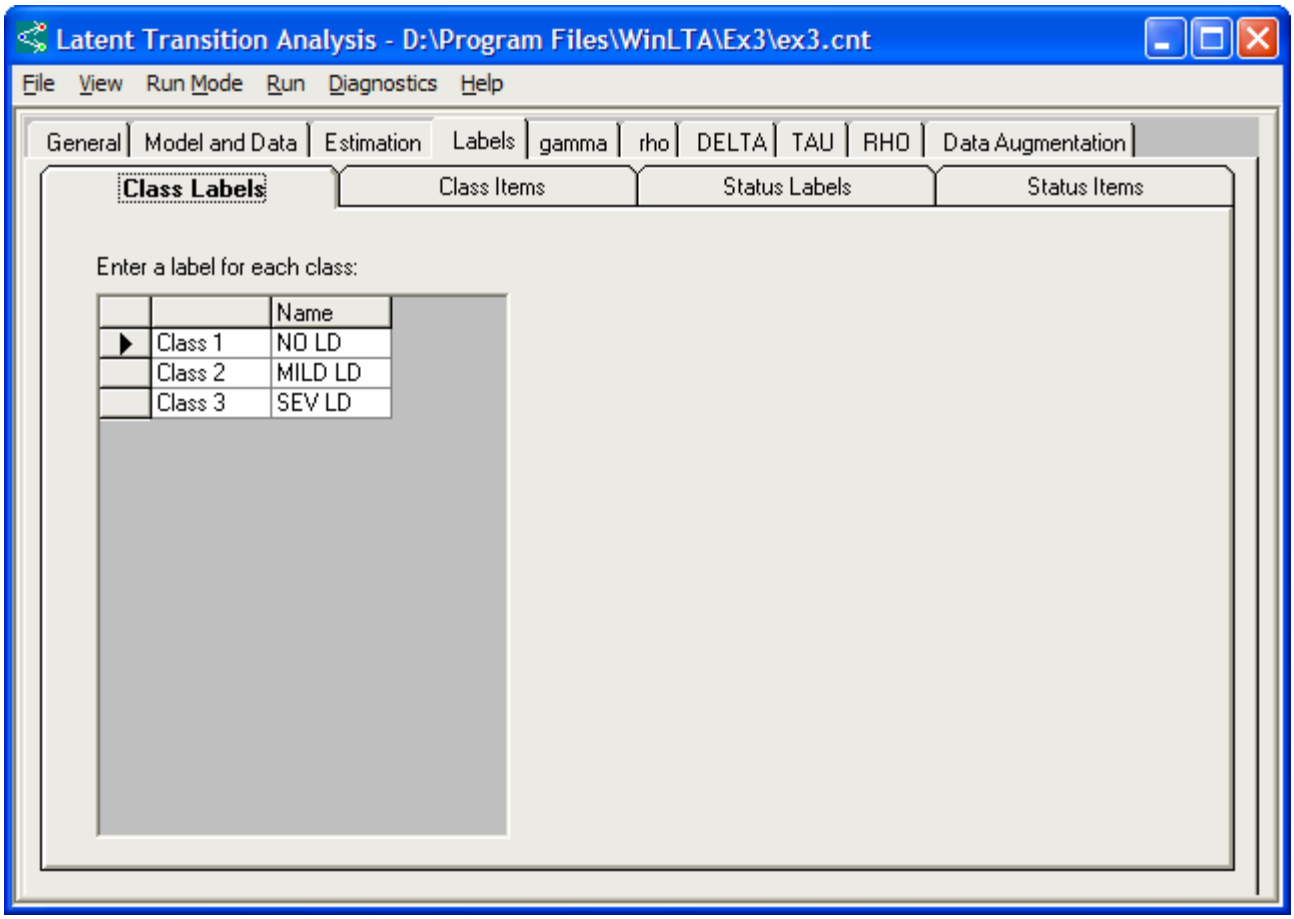
*Estimation tab window*




- **Type of estimation:**
- **EM Algorithm:**
  - **New/Continue Previous:** For new runs, select New. Select Continue Previous only when you want to continue a run that previously failed to converge.
  - **Convergence Criterion:** When the Mean Absolute Deviation (MAD) reaches or falls below this number, the program has converged and will stop the estimation. In this example, it is set to $10^{-7}$.
  - **Maximum iterations for this run:** In this example, if 100 iterations are performed, the program will stop whether or not convergence has been reached.
- **No estimation, goodness-of-fit only:** Selecting this option fits the estimates from another WinLTA run to the current data. A goodness-of-fit statistic is calculated.
- **File containing parameter estimates:** Choosing No estimation, goodness-of-fit only above requires a file of parameter estimates from a previous run. Select the filename by pressing the Browse button.

Because this model contains both latent classes and latent statuses (i.e., a static and a dynamic latent variable), all four sub-tabs of the Labels tab are used. The first of these is the Class Labels tab, shown below.

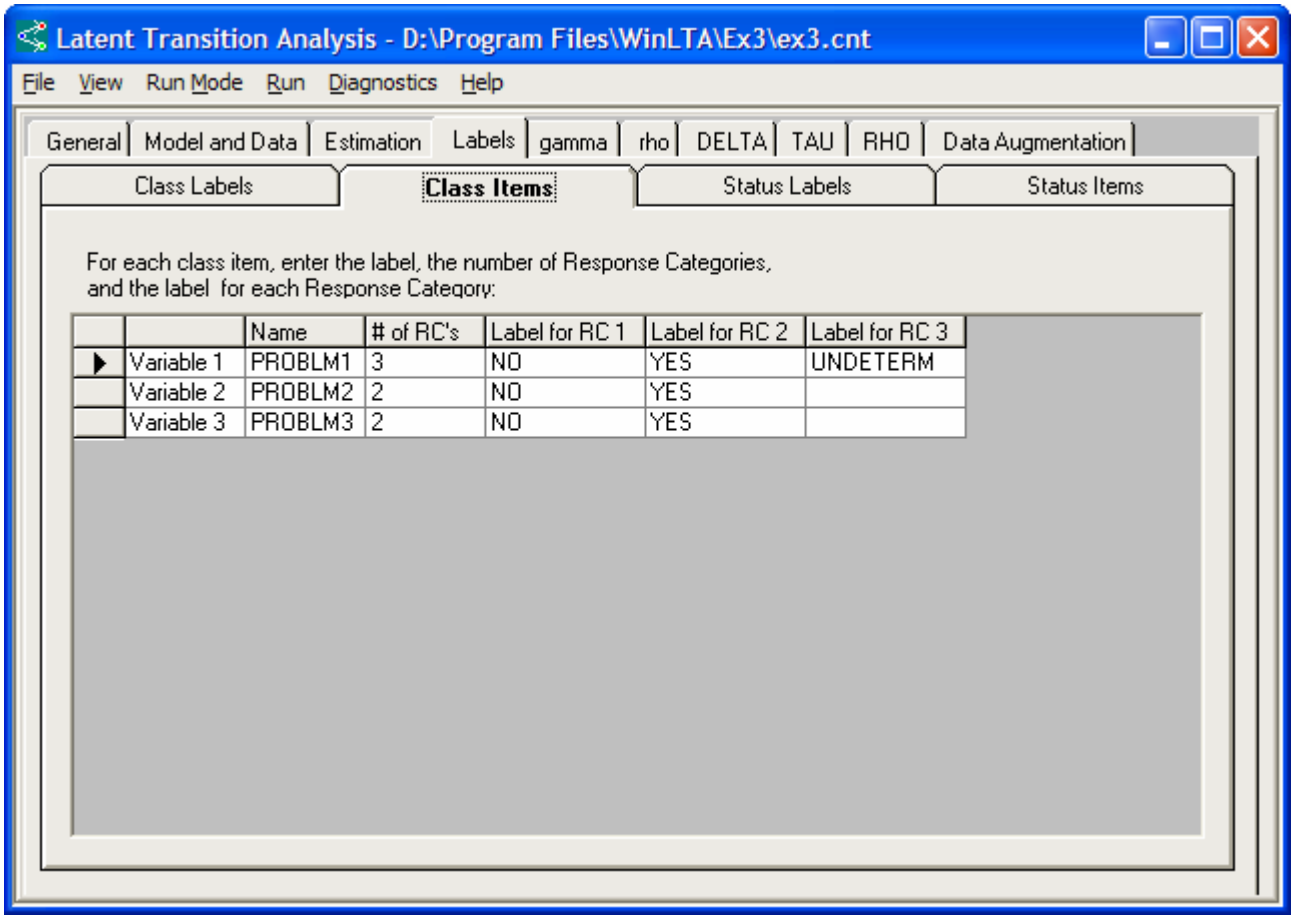
*Labels—Class Labels tab window*




The **Class labels tab** contains fields for latent class names. The label fields are limited to eight characters.

The second sub-tab is the Class Items tab.

*Labels—Class Items tab window*

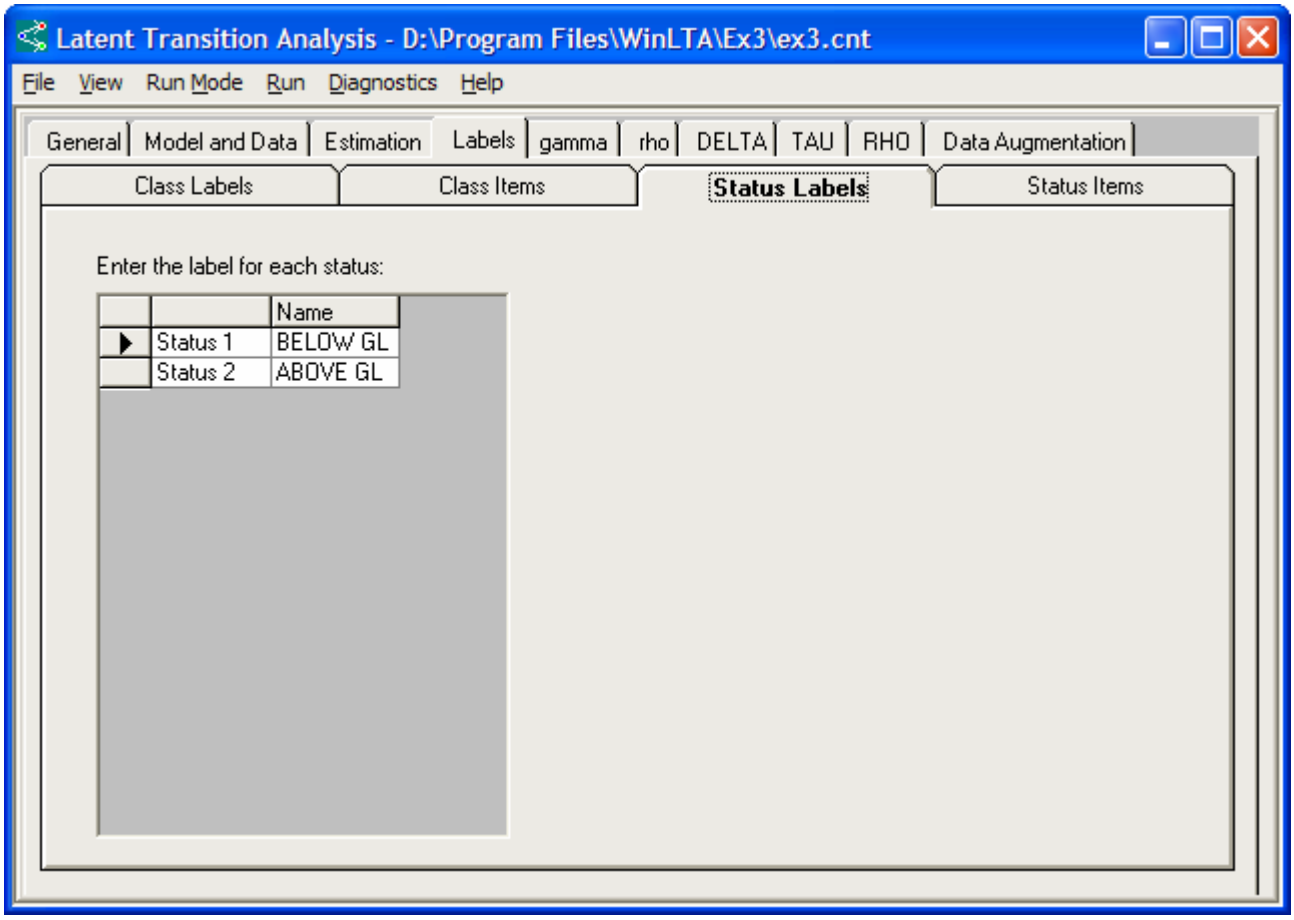



The field descriptions for the Labels—Class Items tab are:

- **Class items:** There are 3 items measuring the latent class, and these items correspond to the three **variables** in the Class Items tab (the rows above). For each of these items, enter a **label**, the **number of response categories**, and a **label for each of the response categories**. In this example, the first variable is named "PROBLM1" and it has 3 response categories. Response category #1 is "NO", response category #2 is "YES", and response category #3 is "UNDETERM." Note that the other two variables each have two response categories.

The third sub-tab is the Status Labels tab.

*Labels—Status Labels tab window*

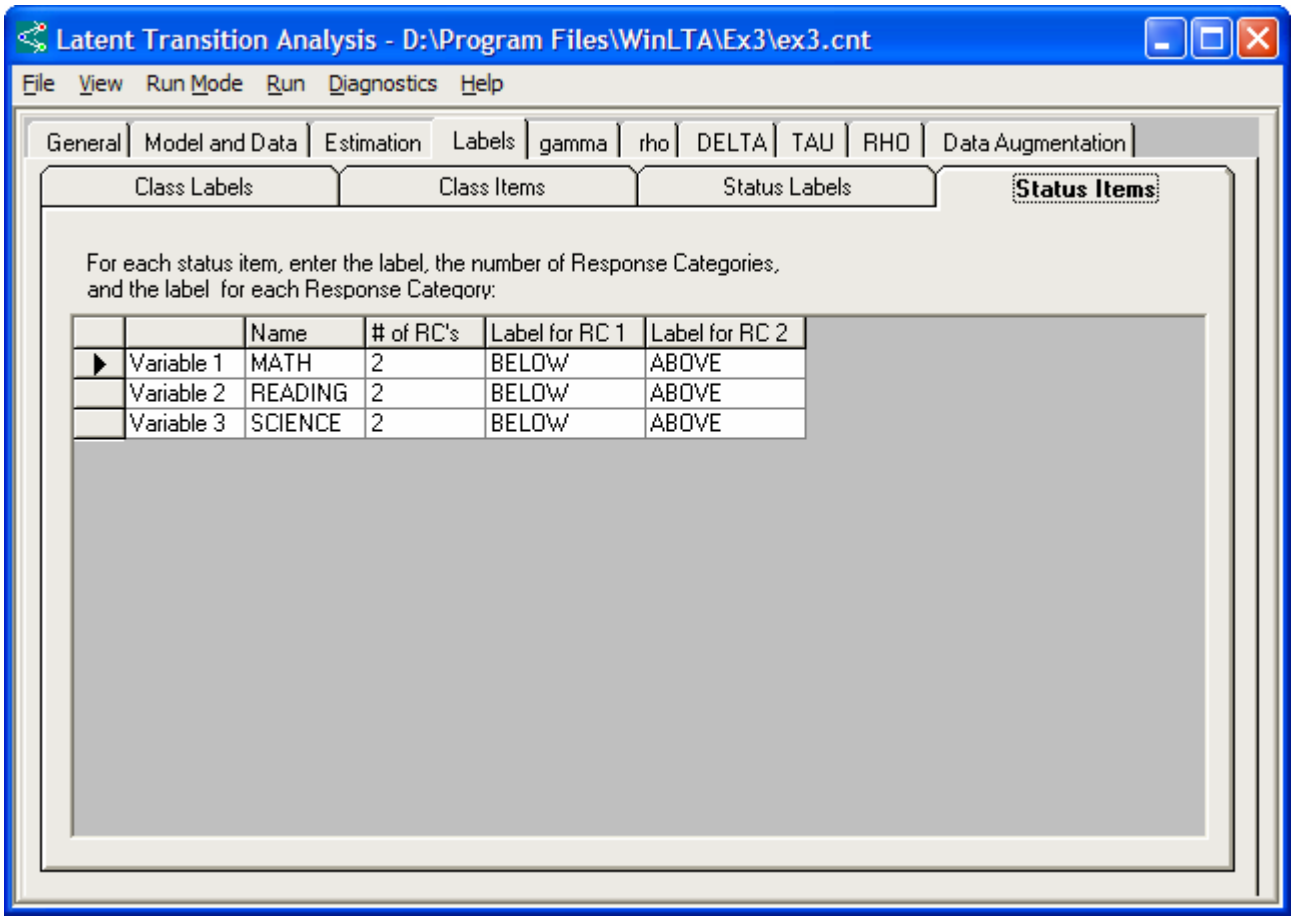



The field descriptions for the Labels—Status Labels tab are:

- This tab asks you to enter a label for each status. There is a limit of 8 characters per label.

The fourth tab within the Labels tab is the Status Items tab.

*Labels—Status Items tab window*

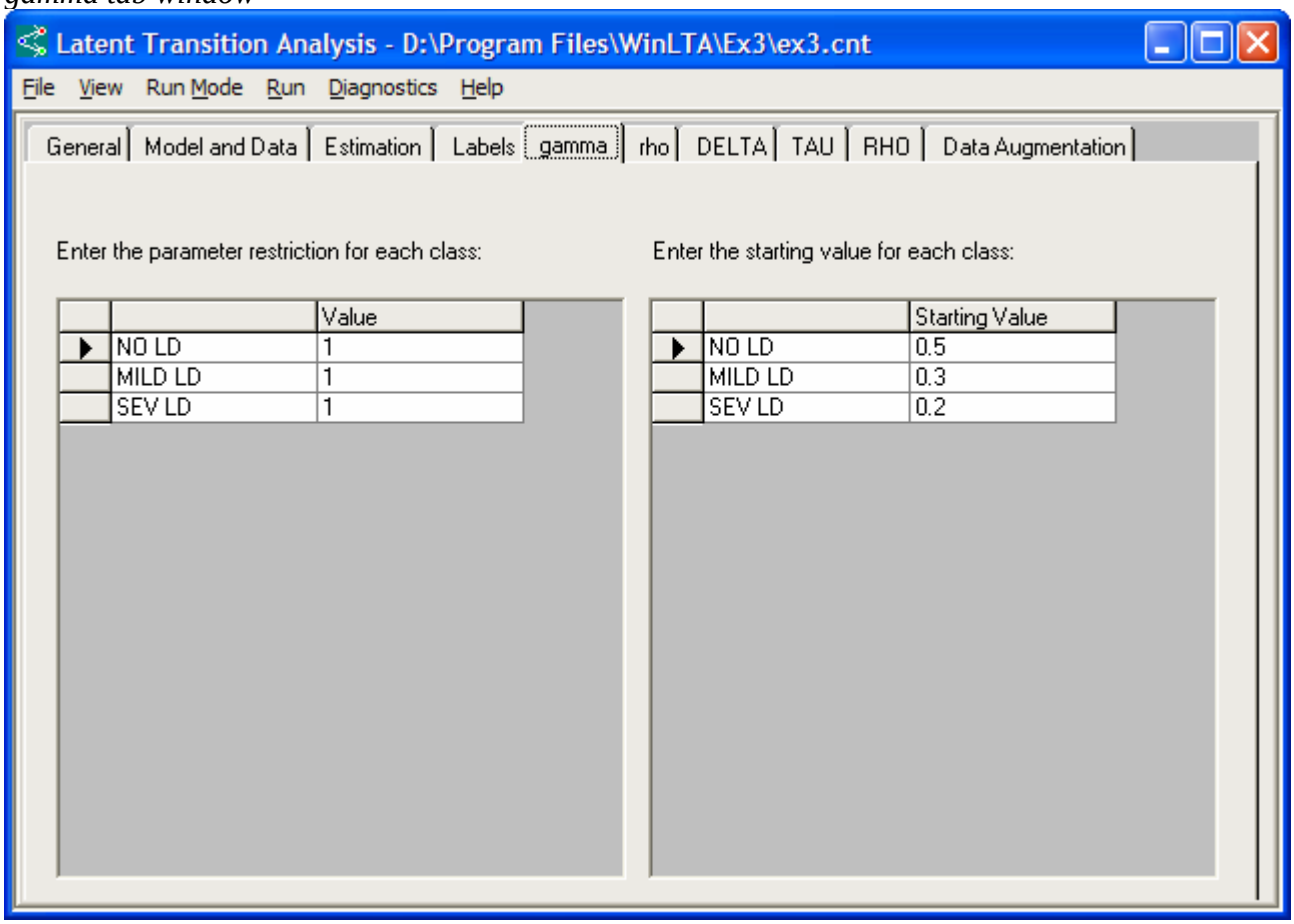



The field descriptions for the Labels—Status Items tab are:

- **Status items:** In the Model and Data tab, you entered the number of items measuring the latent statuses. In this example, there are 3 items. Accordingly, these items are listed as 3 **variables** in the Class Items tab. For each of these items, enter a **label**, the **number of response categories**, and a **label for each of the response categories**. In this example, the first variable is named "MATH" and it has 2 response categories. Response category #1 is named "BELOW" and response category #2 is named "ABOVE."

Having specified general instructions for the model, we now turn to the γ parameters and the gamma tab.

*gamma tab window*



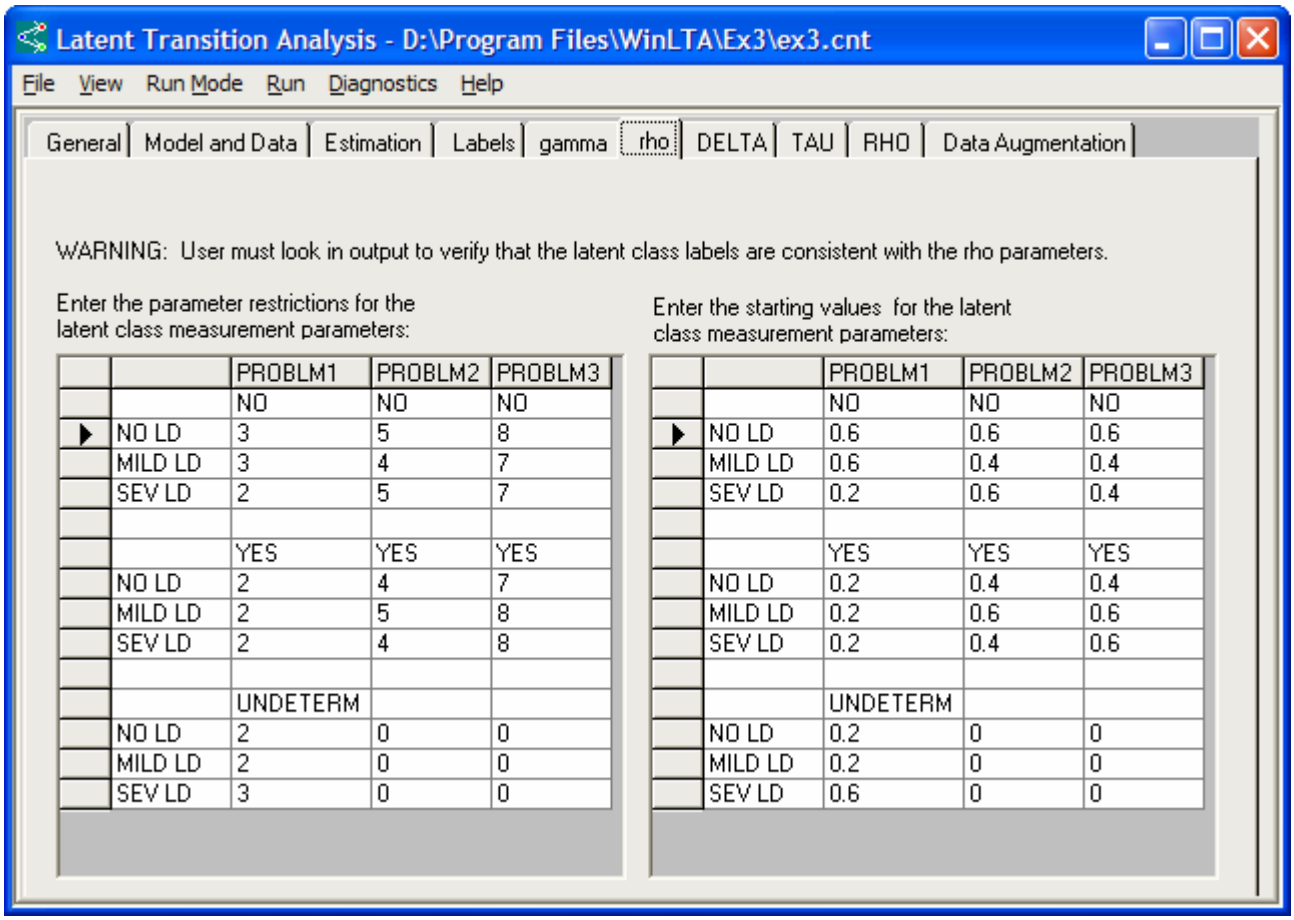

The field descriptions for the gamma tab are:

- **Enter the parameter restrictions for each class:** A parameter can be constrained, estimated freely, or not estimated at all. Enter a "1" if you want the parameter to be estimated freely. Enter a "0" if the parameter will not be estimated at all (i.e., it will be fixed at the starting value). Enter a "2" or greater to indicate that the parameter is constrained. In this example, all gammas are estimated freely.

- **Enter the starting value for each class:** In this column, enter the starting values for each of the latent class probabilities. If any equality constraints have been placed on the parameters (i.e., if you entered 2 or greater in the constraints column), then the starting values should also be equal. The starting values of the gammas must sum to one.

Next, we turn to the rho parameters for the latent classes. These are specified in the rho tab.

*rho tab window*




| | PROBLM1 | PROBLM2 | PROBLM3 |
|---|---|---|---|
| | NO | NO | NO |
| NO LD | 3 | 5 | 8 |
| MILD LD | 3 | 4 | 7 |
| SEV LD | 2 | 5 | 7 |
| | | | |
| | YES | YES | YES |
| NO LD | 2 | 4 | 7 |
| MILD LD | 2 | 5 | 8 |
| SEV LD | 2 | 4 | 8 |
| | | | |
| | UNDETERM | | |
| NO LD | 2 | 0 | 0 |
| MILD LD | 2 | 0 | 0 |
| SEV LD | 3 | 0 | 0 |

| | PROBLM1 | PROBLM2 | PROBLM3 |
|---|---|---|---|
| | NO | NO | NO |
| NO LD | 0.6 | 0.6 | 0.6 |
| MILD LD | 0.6 | 0.4 | 0.4 |
| SEV LD | 0.2 | 0.6 | 0.4 |
| | | | |
| | YES | YES | YES |
| NO LD | 0.2 | 0.4 | 0.4 |
| MILD LD | 0.2 | 0.6 | 0.6 |
| SEV LD | 0.2 | 0.4 | 0.6 |
| | | | |
| | UNDETERM | | |
| NO LD | 0.2 | 0 | 0 |
| MILD LD | 0.2 | 0 | 0 |
| SEV LD | 0.6 | 0 | 0 |

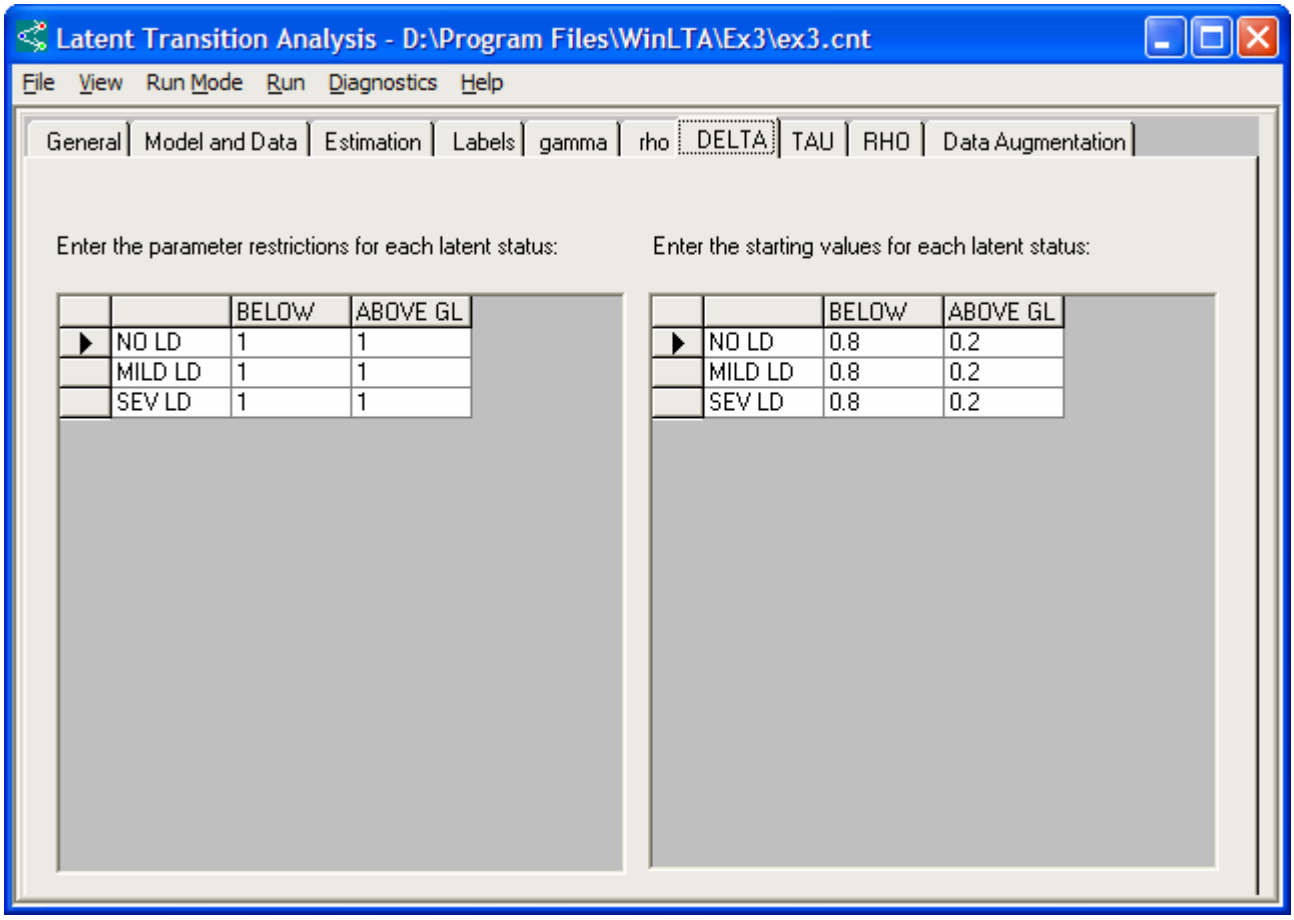
The field descriptions for the rho tab are:

- **Enter the parameter restrictions for latent class measurement parameters:** There is a rho parameter for each latent class (these can be found within the rows of the matrix), for each item (found in the columns of the matrix), and for each response category. Take a look at the restrictions for the response category "NO". Notice that a number of cells contain the numbers 3, 5, and 7. These 3's, 5's, and 7's are constraints and identify three groups of rho parameters that are to be estimated to be equal to each other. The numbers themselves are arbitrary and could be any integer greater than 1. These constraints were placed in order to reduce the number of parameters estimated by the model (see "Identification and Parameter Restrictions" in the manual). Now, look at the parameter restrictions for the second response category, "YES." As the rho parameters for the first response category have been constrained, those for the second response cateogry must be constrained accordingly. Finally, look at the parameter restrictions for the third response category, "UNDETERM." Because the second and third items have only two response categories each, there will be no rho parameters to estimate for the third response category for these items. Therefore, 0's are entered automatically by WinLTA.

- **Enter the starting values for latent class measurement parameters:** First look at the starting values for the response category "NO." For the first item, the probabilities in the matrix for "NO" must sum to one with the probabilities in the matrix for "YES" *and* the matrix for "UNDETERM" or the program will not run. For the second and third items, the probabilites in the matrix for "NO" must sum to one with the probabilities in the matrix for "YES" (zeroes have automatically been entered in the matrix for "UNDETERM" for these items). Starting values for the measurement parameters may be chosen so that they are near the values expected. Choosing starting values that are close to the results reduces the time it takes to run the analysis. However, don't worry too much about choosing starting values; round numbers that sum to one in the appropriate ways are fine.

The DELTA tab is next.

*DELTA tab window*



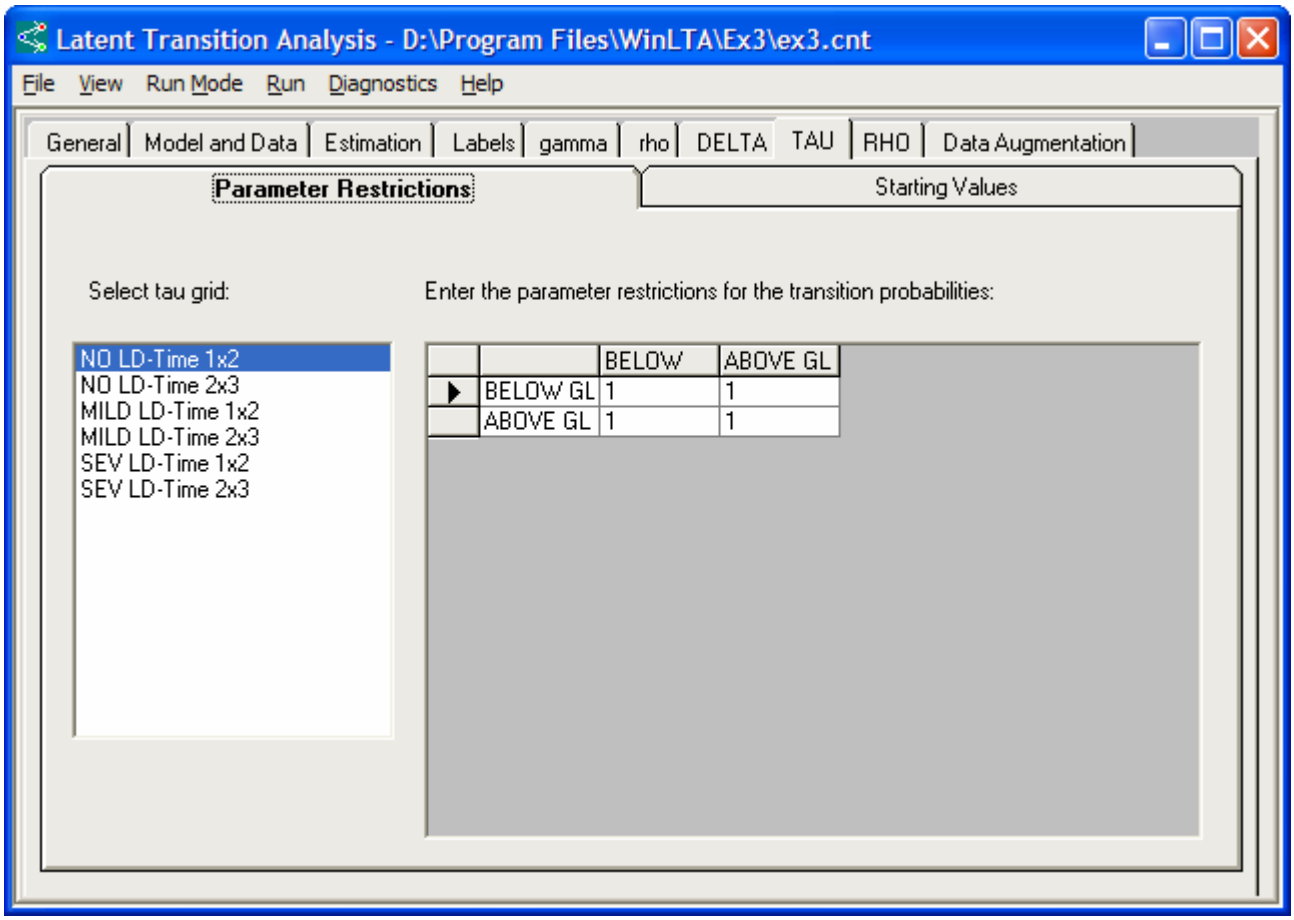

The field descriptions for the DELTA tab are:

- **Enter the parameter restrictions for each latent status:** The delta parameters represent the probabilities of latent status membership at Time 1 conditional on latent class membership. The columns represent the latent statuses and the rows represent the latent classes. Delta parameters can be constrained, estimated freely, or not estimated at all. Enter a "1" if you want the parameter to be estimated freely. Enter a "0" if the parameter will not be estimated (i.e., it will be fixed at the starting value). Enter a "2" or greater to indicate that the parameter is constrained. In this example, all deltas are estimated freely.

- **Enter the starting values for each latent status:** These are the starting values for the delta parameters and they must sum to one within each latent class.

The TAU tab is next. This tab contains two sub-tabs, the Parameter Restrictions tab and the Starting Values tab. We discuss the Parameter Restrictions sub-tab first.

*TAU—Parameter Restrictions tab window*



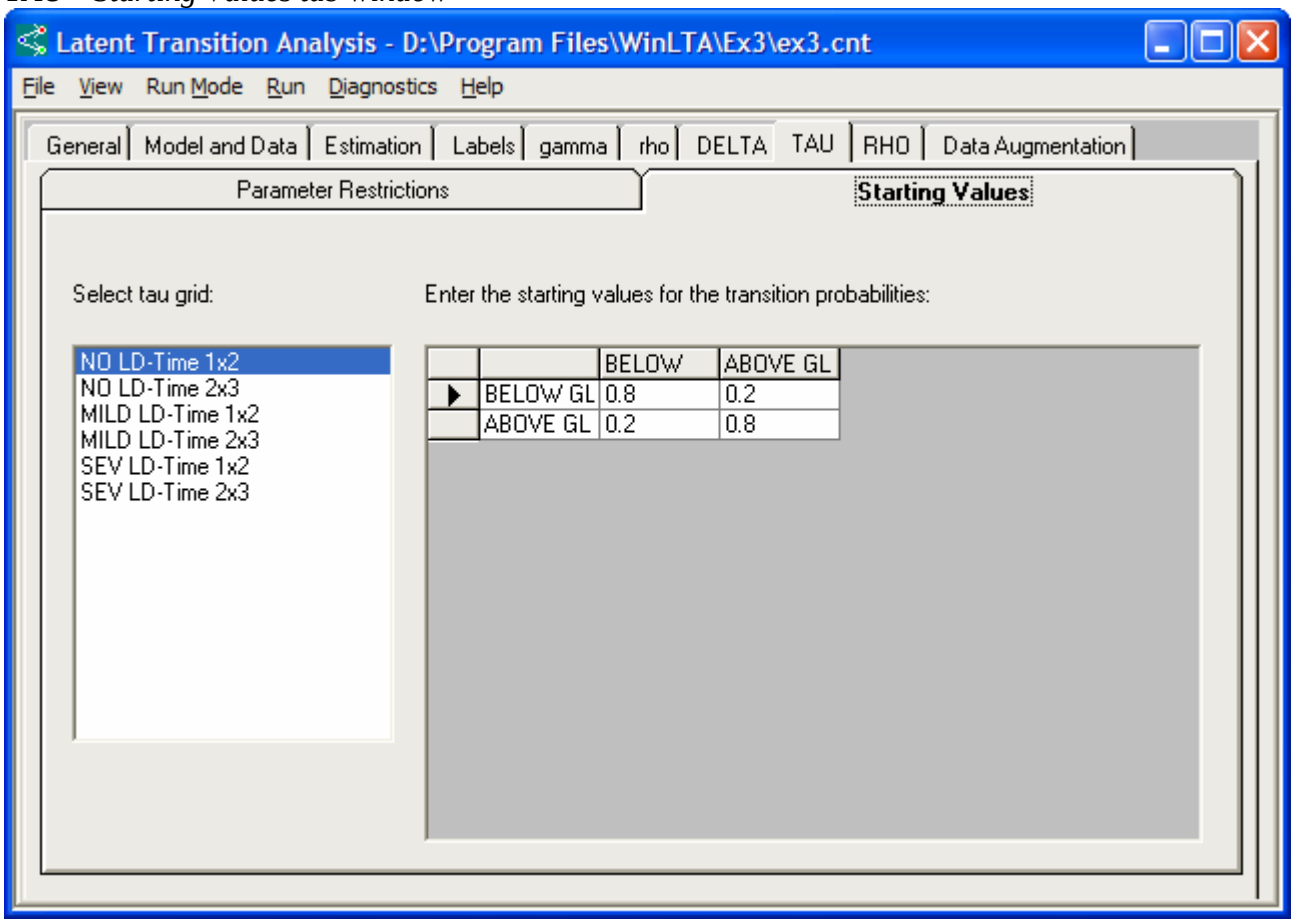

The field descriptions for the TAU—Parameter Restrictions tab are:

- **Select tau grid:** There are *t*-1 transition probability matrices for each latent class, i.e., one for each transition. You can access each of these matrices by clicking one in the left pane of the window.

- **Enter the parameter restrictions for the transition probabilities:** In the grid, enter the restrictions for the tau parameters. There is a row and a column for each latent status. Because there are two latent statuses, each tau matrix is a 2 x 2. In the window shown above, the rows represent the latent status membership at Time 1, and the columns represent the latent status membership at Time 2. In this example, all of the transition probabilities are freely estimated.

The other tab found within the TAU tab is the Starting Values tab, shown below.

*TAU—Starting Values tab window*



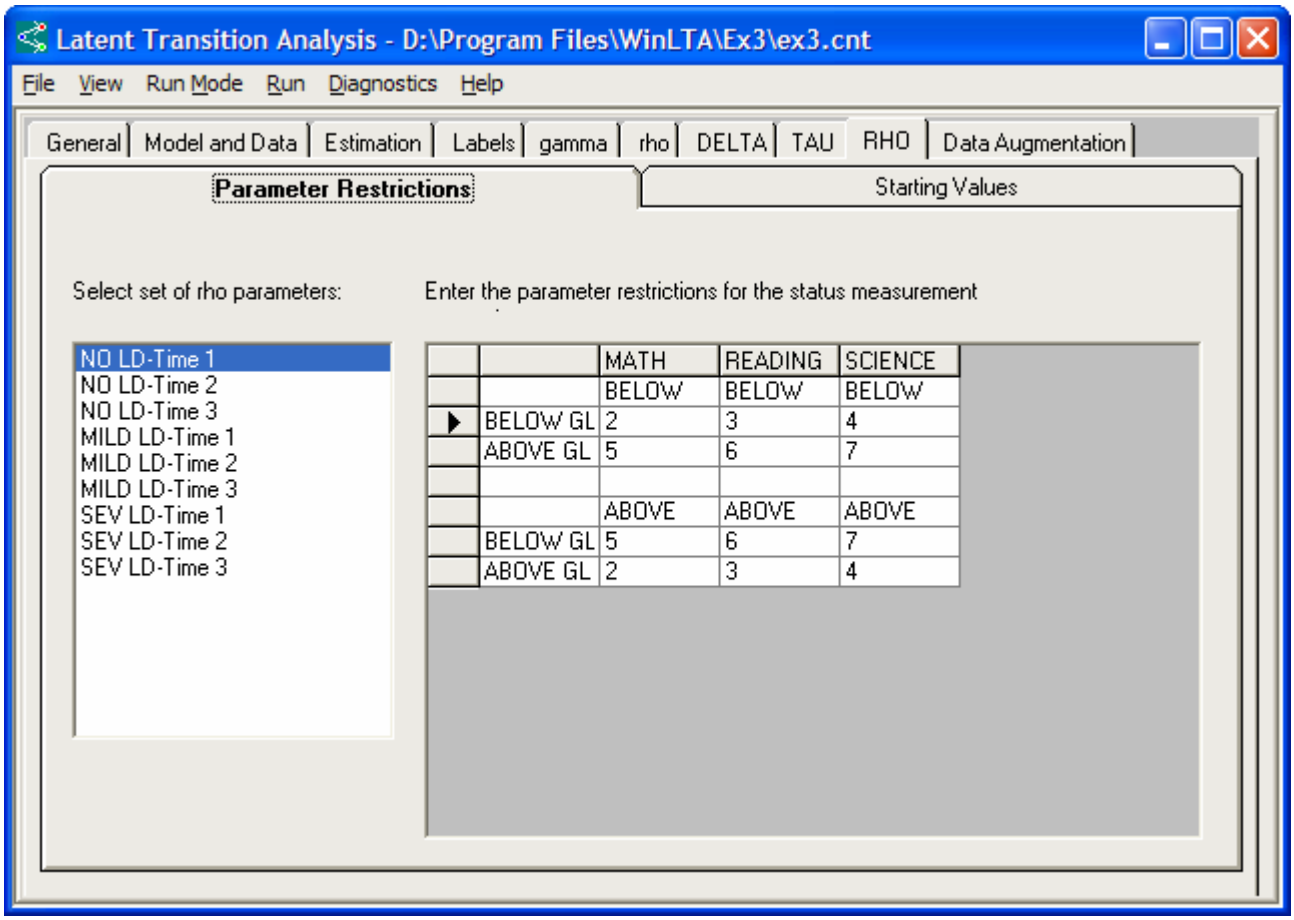

Listed below are the field descriptions for the TAU—Starting Values tab:

- **Select tau grid:** As in the TAU—Parameter Restrictions tab, there is a transition probability matrix for each latent class at each transition. You can access each of these matrices by clicking in the box on the left of the window.

- **Enter the starting values for the transition probabilities:** In the grid, enter the starting values for the tau parameters. In the window shown above for the first latent class, the rows represent the transitions from Time 1 to Time 2 and the columns represent the latent statuses. Each row must sum to one.

The RHO tab is last. Two tabs are also nested within this tab: the Parameter Restrictions tab, shown below, and the Starting Values tab.

*RHO—Parameter Restrictions tab window*




The big rho parameters are the probabilities of a response to an item measuring the dynamic latent variable. These parameters are conditional on latent class and latent status memberships as well as measurement occasion.

The field descriptions for the RHO—Parameter Restrictions tab are:

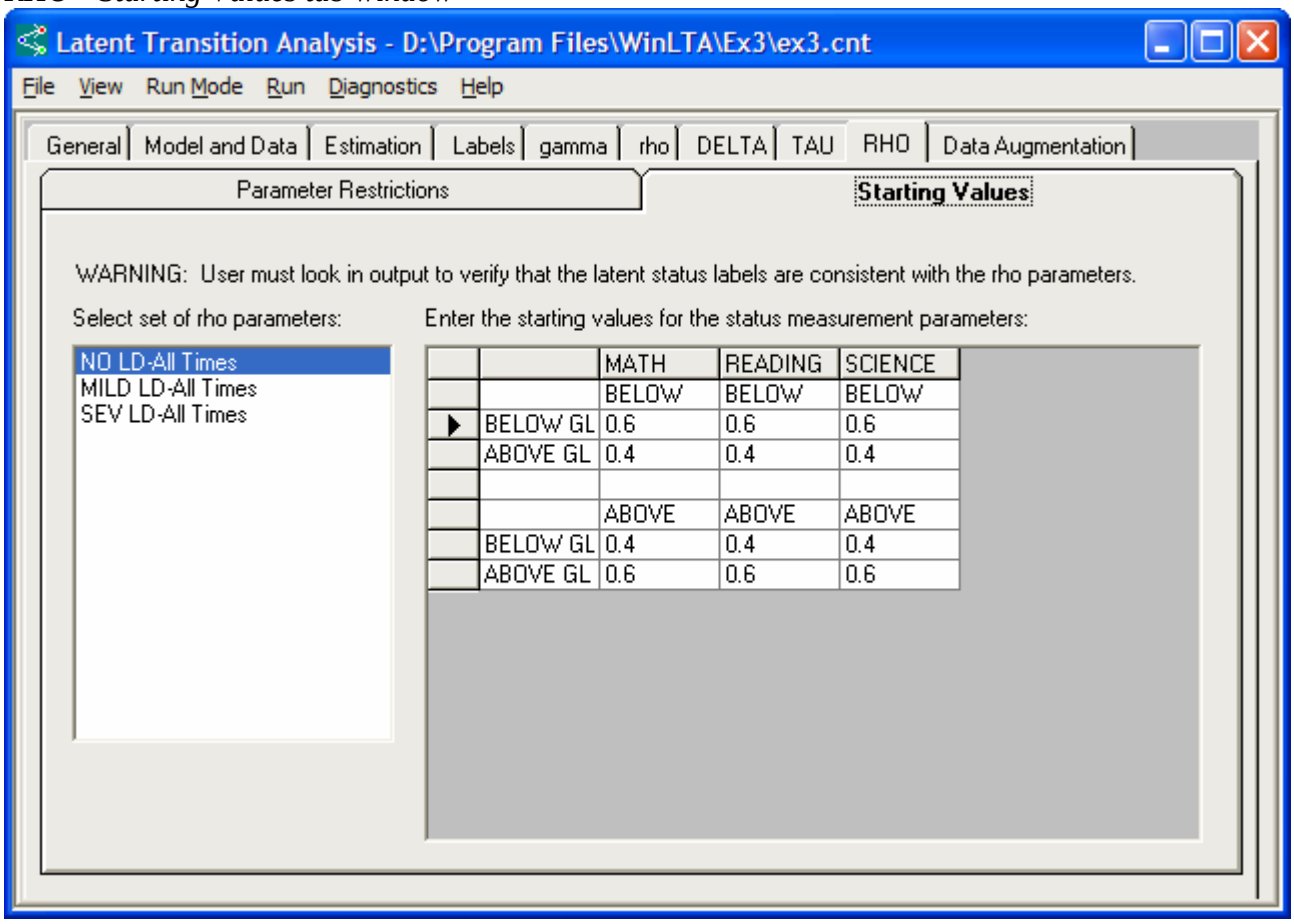
- **Select set of rho parameters:** To enter the parameter restrictions for the different latent classes at different times, click in the box to the left of the window.

- **Enter the parameter restrictions for the status measurement parameters:** In the window shown above rho parameter restrictions are displayed for the NO LD latent class, Time 1. The upper matrix contains the parameter restrictions for the first response category, and the lower matrix contains the parameter restrictions for the second response category. If you were to examine the parameter restrictions for the remaining times and latent classes (by clicking in the desired group/time combination in the box on the left side of the screen) you would see that in this example all of the rho parameters have been constrained to be equal

across time and across latent class. Because of the parameter restrictions, only six rho parameters for the dynamic latent variable are estimated.

The Starting Values sub-tab for the RHO tab is next.

*RHO—Starting Values tab window*




These are the starting values for the rho parameters for items measuring the dynamic latent variable, conditional on latent status, latent class, and time.

The field descriptions for the RHO—Starting Values tab are:

- **Select set of rho parameters:** The starting values for the rho parameters are required only for the RHO matrices at Time 1. Starting values for separate times are assumed to be equal to those entered for Time 1. Click on the different latent classes to enter the starting values for each.

- **Enter the starting values for the status measurement parameters:** The upper matrix contains the starting values for the first response category, and the lower matrix contains the starting values for the second response category. Within the matrices, the columns represent each of the 3 items, and the rows represent each of the 2 latent statuses.

# Saving Your Work and Running WinLTA

- **Saving the control file:** In WinLTA, click on File, and then Save. If this is the first time you have saved this file, a Save As dialog box will appear. In this box you can choose the location of the file and you will be required to enter a filename. By default, the file will be saved with the file extension .cnt.

- **To run WinLTA:** Once the information is completely entered into the control file, click on Run, and then Run EM. EM will begin running automatically. If you have not saved the current version of the control file, you will see a dialog box that asks you if you would like to save before proceeding. Choosing Yes will save the file and run EM automatically. Choosing No will run EM without saving the file. Choosing Cancel will allow you to return to the control file without running EM.

    - Once EM begins running, a separate dialog box entitled "LTA EM Run" will appear on your screen and WinLTA will automatically be minimized. This dialog box tells you the status of the EM run as well as the date and time the run began and finished. The box also has two buttons: Abort and Get Info. Pressing the Abort button during the run will cancel the run. Pressing Get Info gives you the iteration number and the MAD at the time shown. This information is also updated every 5 seconds. Once the run is finished, the Abort button changes to Close. When you press the Close button, WinLTA will automatically be restored as the active window. You can still access WinLTA on your taskbar without pressing the Close button, but Close must be pressed before another EM run can be started.

- **Viewing the WinLTA outfile:** Once the EM run is completed, you can view the output file by clicking on View, and Current LTA Outfile (if you would like to view an older saved outfile, click on Choose LTA Outfile). This will bring up the output file that corresponds with the last EM run.

# The WinLTA Output File

The following is an example of an output file from the WinLTA program. The reference numbers that have been added to the output correspond to the endnotes that follow.

1 PROGRAM STARTED: Fri Mar 29 13:07:17 2002

```
* DATA SET IS TEST3R
* STATIC LATENT VARIABLE WITH THREE CLASSES
* DYNAMIC LATENT VARIABLE WITH TWO STATUSES
* THREE TIMES
* THIS IS "RANDOM" DATA
```

**********

2 INFORMATION ABOUT THIS JOB:

RUN TYPE: PARAMETER ESTIMATION BY EM

CONTROL DATA READ FROM FILE:
D:\WinLTA\Ex3\ex3.cnt

DATA ANALYZED IN THIS RUN READ FROM FILE:
.\Ex3\ex3.dat

OUTPUT SAVED IN FILE:
.\Ex3\ex3.out

PARAMETER ESTIMATES SAVED IN FILE:
.\Ex3\ex3.est

| | |
|---|---|
| STATIC LATENT VARIABLE | YES |
| NUMBER OF LATENT CLASSES | 3 |
| NUMBER OF MANIFEST ITEMS | 3 |
| DYNAMIC LATENT VARIABLE | YES |
| NUMBER OF LATENT STATUSES | 2 |
| NUMBER OF OCCASIONS OF MEASUREMENT | 3 |
| NUMBER OF MANIFEST ITEMS PER OCCASION | 3 |
| TYPE OF PROCESS | FIRST-ORDER |
| NUMBER OF SUBJECTS | 2000 |
| NUMBER OF UNIQUE RESPONSE PATTERNS | 1219 |
| MAXIMUM NUBMER OF ITERATIONS | 100 |
| CONVERGENCE CRITERION | .00000010000000 |
| MISSING DATA IN RESPONSE PATTERNS | NO |
| PRINT RESIDUALS | NO |

**********

3 THE FOLLOWING PARAMETER RESTRICTIONS HAVE BEEN SPECIFIED
WHERE 0=FIXED TO START VALUE
1=FREE
2 OR GREATER MEANS CONSTRAINED EQUAL TO ANY OTHER
PARAMETER WITH THE SAME DESIGNATION

**********

4 LITTLE RHO PARAMETERS
LITTLE RHOS ARE PROBABILITIES OF RESPONSES
TO ITEMS MEASURING THE STATIC LATENT VARIABLE
CONDITIONAL ON LATENT CLASS MEMBERSHIP

RESPONSE CATEGORY 1

| | P N R O O B L M 1 | P N R O O B L M 2 | P N R O O B L M 3 |
|---|---|---|---|
| NO LD | 3 | 5 | 8 |
| MILD LD | 3 | 4 | 7 |
| SEV LD | 2 | 5 | 7 |

RESPONSE CATEGORY 2

| | P Y R E O S B L M 1 | P Y R E O S B L M 2 | P Y R E O S B L M 3 |
|---|---|---|---|
| NO LD | 2 | 4 | 7 |
| MILD LD | 2 | 5 | 8 |
| SEV LD | 2 | 4 | 8 |

RESPONSE CATEGORY 3

| | P U R N O D B E L T M E 1 R M | P R O B L M 2 | P R O B L M 3 |
|---|---|---|---|
| NO LD | 2 | 0 | 0 |
| MILD LD | 2 | 0 | 0 |
| SEV LD | 3 | 0 | 0 |

**********

5 BIG RHO PARAMETER RESTRICTIONS

```
 BIG RHOS ARE PROBABILITIES OF RESPONSE
 TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
 CONDITIONAL ON LATENT STATUS, LATENT CLASS, AND TIME

        6BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "NO
LD   " AT TIME  1

          RESPONSE CATEGORY  1

         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7

          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

        7BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "NO
LD   " AT TIME  2

          RESPONSE CATEGORY  1

         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7

          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

        8BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "NO
LD   " AT TIME  3

          RESPONSE CATEGORY  1

         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7

          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

        9BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "MILD
LD " AT TIME  1

          RESPONSE CATEGORY  1

         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7
```

```
          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

       10 BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "MILD
LD " AT TIME  2

          RESPONSE CATEGORY  1

         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7

          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

       11 BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "MILD
LD " AT TIME  3

          RESPONSE CATEGORY  1

         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7

          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

       12 BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "SEV
LD  " AT TIME  1

          RESPONSE CATEGORY  1

         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7

          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

       13 BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "SEV
LD  " AT TIME  2

          RESPONSE CATEGORY  1
```

```
         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7

          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

        14BIG RHO PARAMETER RESTRICTIONS FOR LATENT CLASS "SEV
LD  " AT TIME  3

          RESPONSE CATEGORY  1

         | M B | R B | S B |
         | A E | E E | C E |
         | T L | A L | I L |
         | H O | D O | E O |
         |   W | I W | N W |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   2     3     4
 ABOVE GL   5     6     7

          RESPONSE CATEGORY  2

         | M A | R A | S A |
         | A B | E B | C B |
         | T O | A O | I O |
         | H V | D V | E V |
         |   E | I E | N E |
         |     | N   | C   |
         |     | G   | E   |
         |     |     |     |
 BELOW GL   5     6     7
 ABOVE GL   2     3     4

 ************************************************

15GAMMA PARAMETER RESTRICTIONS
 GAMMAS ARE UNCONDITIONAL PROBABILITIES OF MEMBERSHIP
 IN EACH LATENT CLASS OF THE STATIC LATENT VARIABLE

 NO LD       1
 MILD LD     1
 SEV LD      1

 ************************************************

16DELTA PARAMETER RESTRICTIONS
 DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP
  CONDITIONAL ON LATENT CLASS


 DELTA PARAMETER RESTRICTIONS FOR LATENT CLASS "NO LD   "

           TIME 1
 BELOW GL    1
 ABOVE GL    1


 DELTA PARAMETER RESTRICTIONS FOR LATENT CLASS "MILD LD "

           TIME 1
 BELOW GL    1
 ABOVE GL    1


 DELTA PARAMETER RESTRICTIONS FOR LATENT CLASS "SEV LD  "

           TIME 1
 BELOW GL    1
 ABOVE GL    1

 ************************************************

 TAU PARAMETER RESTRICTIONS
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1
(COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)
 AND ON LATENT CLASS MEMBERSHIP



17TRANSITION PROBABILITIES FOR LATENT CLASS "NO LD   "

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
```

```
        |  B |  A |
        |  E |  B |
        |  L |  O |
        |  O |  V |
        |  W |  E |
        |    |    |
        |  G |  G |
        |  L |  L |
BELOW GL   1    1
ABOVE GL   1    1

ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

        |  B |  A |
        |  E |  B |
        |  L |  O |
        |  O |  V |
        |  W |  E |
        |    |    |
        |  G |  G |
        |  L |  L |
BELOW GL   1    1
ABOVE GL   1    1

18 TRANSITION PROBABILITIES FOR LATENT CLASS "MILD LD "

ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

        |  B |  A |
        |  E |  B |
        |  L |  O |
        |  O |  V |
        |  W |  E |
        |    |    |
        |  G |  G |
        |  L |  L |
BELOW GL   1    1
ABOVE GL   1    1

ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

        |  B |  A |
        |  E |  B |
        |  L |  O |
        |  O |  V |
        |  W |  E |
        |    |    |
        |  G |  G |
        |  L |  L |
BELOW GL   1    1
ABOVE GL   1    1

19 TRANSITION PROBABILITIES FOR LATENT CLASS "SEV LD  "

ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

        |  B |  A |
        |  E |  B |
        |  L |  O |
        |  O |  V |
        |  W |  E |
        |    |    |
        |  G |  G |
        |  L |  L |
BELOW GL   1    1
ABOVE GL   1    1

ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

        |  B |  A |
        |  E |  B |
        |  L |  O |
        |  O |  V |
        |  W |  E |
        |    |    |
        |  G |  G |
        |  L |  L |
BELOW GL   1    1
ABOVE GL   1    1

************************************************

      20 START VALUES

************************************************

21 LITTLE RHO PARAMETERS
LITTLE RHOS ARE PROBABILITIES OF RESPONSES
TO ITEMS MEASURING THE STATIC LATENT VARIABLE
CONDITIONAL ON LATENT CLASS MEMBERSHIP

         RESPONSE CATEGORY  1

       | P N | P N | P N |
       | R O | R O | R O |
       | O   | O   | O   |
       | B   | B   | B   |
       | L   | L   | L   |
       | M   | M   | M   |
       | 1   | 2   | 3   |
```

```
        |     |     |     |
NO LD    0.600 0.600 0.600
MILD LD  0.600 0.400 0.400
SEV LD   0.200 0.600 0.400

         RESPONSE CATEGORY  2

        | P Y | P Y | P Y |
        | R E | R E | R E |
        | O S | O S | O S |
        | B   | B   | B   |
        | L   | L   | L   |
        | M   | M   | M   |
        | 1   | 2   | 3   |
        |     |     |     |
NO LD    0.200 0.400 0.400
MILD LD  0.200 0.600 0.600
SEV LD   0.200 0.400 0.600

         RESPONSE CATEGORY  3

        | P U | P   | P   |
        | R N | R   | R   |
        | O D | O   | O   |
        | B E | B   | B   |
        | L T | L   | L   |
        | M E | M   | M   |
        | 1 R | 2   | 3   |
        |   M |     |     |
NO LD    0.200 0.000 0.000
MILD LD  0.200 0.000 0.000
SEV LD   0.600 0.000 0.000


 ************************************************

22BIG RHO PARAMETERS
 BIG RHOS ARE PROBABILITIES OF RESPONSES
 TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
 CONDITIONAL ON LATENT STATUS, LATENT CLASS, AND TIME

       23RHO PARAMETERS FOR LATENT CLASS "NO LD   " AT TIME  1

         RESPONSE CATEGORY  1

        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

       24RHO PARAMETERS FOR LATENT CLASS "NO LD   " AT TIME  2

         RESPONSE CATEGORY  1

        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

       25RHO PARAMETERS FOR LATENT CLASS "NO LD   " AT TIME  3

         RESPONSE CATEGORY  1

        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
```

```
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

       26RHO PARAMETERS FOR LATENT CLASS "MILD LD " AT TIME  1

         RESPONSE CATEGORY  1

        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

       27RHO PARAMETERS FOR LATENT CLASS "MILD LD " AT TIME  2

         RESPONSE CATEGORY  1

        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

       28RHO PARAMETERS FOR LATENT CLASS "MILD LD " AT TIME  3

         RESPONSE CATEGORY  1

        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

       29RHO PARAMETERS FOR LATENT CLASS "SEV LD  " AT TIME  1

         RESPONSE CATEGORY  1
```

```
        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

30
       RHO PARAMETERS FOR LATENT CLASS "SEV LD  " AT TIME  2

         RESPONSE CATEGORY  1

        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

31
       RHO PARAMETERS FOR LATENT CLASS "SEV LD  " AT TIME  3

         RESPONSE CATEGORY  1

        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.600 0.600 0.600
ABOVE GL 0.400 0.400 0.400

         RESPONSE CATEGORY  2

        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.400 0.400 0.400
ABOVE GL 0.600 0.600 0.600

 ************************************************

32
       GAMMA PARAMETERS
 GAMMAS ARE UNCONDITIONAL PROBABILITIES OF MEMBERSHIP IN EACH
LATENT CLASS
 OF THE STATIC LATENT VARIABLE

 NO LD     0.500
 MILD LD   0.300
 SEV LD    0.200

 ************************************************

33
       DELTA PARAMETERS
 DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP
  CONDITIONAL ON LATENT CLASS


 DELTA PARAMETERS FOR LATENT CLASS "NO LD   "

           TIME 1
 BELOW GL  0.800
 ABOVE GL  0.200
```

```
 DELTA PARAMETERS FOR LATENT CLASS "MILD LD "

          TIME 1
 BELOW GL  0.800
 ABOVE GL  0.200


 DELTA PARAMETERS FOR LATENT CLASS "SEV LD  "

          TIME 1
 BELOW GL  0.800
 ABOVE GL  0.200

 ************************************************

34 TAU PARAMETERS
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1
(COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)
  AND ON LATENT CLASS MEMBERSHIP

35 TRANSITION PROBABILITIES FOR LATENT CLASS "NO LD   "

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.800 0.200
 ABOVE GL 0.200 0.800

36 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.600 0.400
 ABOVE GL 0.200 0.800

37 TRANSITION PROBABILITIES FOR LATENT CLASS "MILD LD "

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.900 0.100
 ABOVE GL 0.200 0.800

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.800 0.200
 ABOVE GL 0.200 0.800

38 TRANSITION PROBABILITIES FOR LATENT CLASS "SEV LD  "

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.800 0.200
 ABOVE GL 0.200 0.800

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
```

```
        |  W  |  E  |
        |     |     |
        |  G  |  G  |
        |  L  |  L  |
 BELOW GL 0.900 0.100
 ABOVE GL 0.100 0.900

 ************************************************

39 ITERATION HISTORY

 ************************************************

 STARTING G-SQUARED=  5817.030

ITER-   MAD         ITER-   MAD         ITER-   MAD
ATION               ATION               ATION

    1  .0216743770      2  .0254547088      3  .0290287166
    4  .0291777898      5  .0235909531      6  .0169352653
    7  .0116668591      8  .0077956263      9  .0051063318
   10  .0033821822     11  .0023330447     12  .0016780086
   13  .0012568703     14  .0009510537     15  .0007268517
   16  .0005666671     17  .0004530991     18  .0003632299
   19  .0002920079     20  .0002353332     21  .0001900697
   22  .0001538358     23  .0001249487     24  .0001017045
   25  .0000829699     26  .0000677976     27  .0000554958
   28  .0000455096     29  .0000374482     30  .0000311602
   31  .0000261222     32  .0000219596     33  .0000185139
   34  .0000156668     35  .0000133019     36  .0000113286
   37  .0000097013     38  .0000083746     39  .0000072506
   40  .0000062982     41  .0000054885     42  .0000047955
   43  .0000042189     44  .0000037238     45  .0000032931
   46  .0000029174     47  .0000025908     48  .0000023195
   49  .0000020781     50  .0000018630     51  .0000016712
   52  .0000014999     53  .0000013469     54  .0000012099
   55  .0000010873     56  .0000009775     57  .0000008790
   58  .0000007907     59  .0000007114     60  .0000006402
   61  .0000005762     62  .0000005188     63  .0000004671
   64  .0000004206     65  .0000003788     66  .0000003412
   67  .0000003074     68  .0000002769     69  .0000002495
   70  .0000002248     71  .0000002026     72  .0000001826
   73  .0000001645     74  .0000001483     75  .0000001337
   76  .0000001205     77  .0000001086     78  .0000000979


 ************************************************

40 MODEL FIT

 G-Squared Test of Model Fit:             3595.043
 Degrees of Freedom:                         6120

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  **WARNING**: BE SURE TO INTERPRET THE LATENT CLASSES
CAREFULLY
               BASED ON THE ESTIMATED RHO PARAMETERS REPORTED
BELOW.
               YOU MAY WISH TO CHANGE THE LABELS YOU PREVIOUSLY
ASSIGNED
               TO THE LATENT CLASSES IN ORDER TO MAKE THEM
               CONSISTENT WITH YOUR INTERPRETATION.

 ************************************************

41 LITTLE RHO PARAMETERS
 LITTLE RHOS ARE PROBABILITIES OF RESPONSES
 TO ITEMS MEASURING THE STATIC LATENT VARIABLE
 CONDITIONAL ON LATENT CLASS MEMBERSHIP

          RESPONSE CATEGORY  1

         | P N | P N | P N |
         | R O | R O | R O |
         | O   | O   | O   |
         | B   | B   | B   |
         | L   | L   | L   |
         | M   | M   | M   |
         | 1   | 2   | 3   |
         |     |     |     |
 NO LD    0.811 0.798 0.792
 MILD LD  0.811 0.202 0.208
 SEV LD   0.095 0.798 0.208

          RESPONSE CATEGORY  2

         | P Y | P Y | P Y |
         | R E | R E | R E |
         | O S | O S | O S |
         | B   | B   | B   |
         | L   | L   | L   |
         | M   | M   | M   |
         | 1   | 2   | 3   |
         |     |     |     |
 NO LD    0.095 0.202 0.208
 MILD LD  0.095 0.798 0.792
 SEV LD   0.095 0.202 0.792

          RESPONSE CATEGORY  3

         | P U | P   | P   |
         | R N | R   | R   |
         | O D | O   | O   |
         | B E | B   | B   |
```

| | L T M 1 M | L M 2 | L M 3 |
|---|---|---|---|
| NO LD | 0.095 | 0.000 | 0.000 |
| MILD LD | 0.095 | 0.000 | 0.000 |
| SEV LD | 0.811 | 0.000 | 0.000 |

**WARNING**: BE SURE TO INTERPRET THE LATENT STATUSES CAREFULLY
BASED ON THE ESTIMATED RHO PARAMETERS REPORTED BELOW.
YOU MAY WISH TO CHANGE THE LABELS YOU PREVIOUSLY ASSIGNED
TO THE LATENT STATUSES IN ORDER TO MAKE THEM
CONSISTENT WITH YOUR INTERPRETATION.

**********

42 IG RHO PARAMETERS
BIG RHOS ARE PROBABILITIES OF RESPONSES
TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
CONDITIONAL ON LATENT STATUS, LATENT CLASS, AND TIME

43 RHO PARAMETERS FOR LATENT CLASS "NO LD " AT TIME 1

RESPONSE CATEGORY 1

| | M A B E T L H O W | R A B E L A D O I N G | S A B E L I E O N C E |
|---|---|---|---|
| BELOW GL | 0.801 | 0.802 | 0.805 |
| ABOVE GL | 0.199 | 0.198 | 0.195 |

RESPONSE CATEGORY 2

| | M A B E T O H V E | R A B E O A D V I N G | S A B E O I E V N C E |
|---|---|---|---|
| BELOW GL | 0.199 | 0.198 | 0.195 |
| ABOVE GL | 0.801 | 0.802 | 0.805 |

44 RHO PARAMETERS FOR LATENT CLASS "NO LD " AT TIME 2

RESPONSE CATEGORY 1

| | M A B E T L H O W | R A B E L A D O I N G | S A B E L I E O N C E |
|---|---|---|---|
| BELOW GL | 0.801 | 0.802 | 0.805 |
| ABOVE GL | 0.199 | 0.198 | 0.195 |

RESPONSE CATEGORY 2

| | M A B E T O H V E | R A B E O A D V I N G | S A B E O I E V N C E |
|---|---|---|---|
| BELOW GL | 0.199 | 0.198 | 0.195 |
| ABOVE GL | 0.801 | 0.802 | 0.805 |

45 RHO PARAMETERS FOR LATENT CLASS "NO LD " AT TIME 3

RESPONSE CATEGORY 1

| | M A B E T L H O W | R A B E L A D O I N G | S A B E L I E O N C E |
|---|---|---|---|
| BELOW GL | 0.801 | 0.802 | 0.805 |
| ABOVE GL | 0.199 | 0.198 | 0.195 |

RESPONSE CATEGORY 2

| | M A B E T O H V E | R A B E O A D V I N G | S A B E O I E V N C E |
|---|---|---|---|

```
BELOW GL 0.199 0.198 0.195
ABOVE GL 0.801 0.802 0.805
```

46 RHO PARAMETERS FOR LATENT CLASS "MILD LD " AT TIME 1

RESPONSE CATEGORY 1

| M B | R B | S B |
|---|---|---|
| A E | E E | C E |
| T L | A L | I L |
| H O | D O | E O |
| W | I W | N W |
| | N | C |
| | G | E |

```
BELOW GL 0.801 0.802 0.805
ABOVE GL 0.199 0.198 0.195
```

RESPONSE CATEGORY 2

| M A | R A | S A |
|---|---|---|
| A B | E B | C B |
| T O | A O | I O |
| H V | D V | E V |
| E | I E | N E |
| | N | C |
| | G | E |

```
BELOW GL 0.199 0.198 0.195
ABOVE GL 0.801 0.802 0.805
```

47 RHO PARAMETERS FOR LATENT CLASS "MILD LD " AT TIME 2

RESPONSE CATEGORY 1

| M B | R B | S B |
|---|---|---|
| A E | E E | C E |
| T L | A L | I L |
| H O | D O | E O |
| W | I W | N W |
| | N | C |
| | G | E |

```
BELOW GL 0.801 0.802 0.805
ABOVE GL 0.199 0.198 0.195
```

RESPONSE CATEGORY 2

| M A | R A | S A |
|---|---|---|
| A B | E B | C B |
| T O | A O | I O |
| H V | D V | E V |
| E | I E | N E |
| | N | C |
| | G | E |

```
BELOW GL 0.199 0.198 0.195
ABOVE GL 0.801 0.802 0.805
```

48 RHO PARAMETERS FOR LATENT CLASS "MILD LD " AT TIME 3

RESPONSE CATEGORY 1

| M B | R B | S B |
|---|---|---|
| A E | E E | C E |
| T L | A L | I L |
| H O | D O | E O |
| W | I W | N W |
| | N | C |
| | G | E |

```
BELOW GL 0.801 0.802 0.805
ABOVE GL 0.199 0.198 0.195
```

RESPONSE CATEGORY 2

| M A | R A | S A |
|---|---|---|
| A B | E B | C B |
| T O | A O | I O |
| H V | D V | E V |
| E | I E | N E |
| | N | C |
| | G | E |

```
BELOW GL 0.199 0.198 0.195
ABOVE GL 0.801 0.802 0.805
```

49 RHO PARAMETERS FOR LATENT CLASS "SEV LD " AT TIME 1

RESPONSE CATEGORY 1

| M B | R B | S B |
|---|---|---|
| A E | E E | C E |
| T L | A L | I L |
| H O | D O | E O |
| W | I W | N W |
| | N | C |
| | G | E |

```
BELOW GL 0.801 0.802 0.805
ABOVE GL 0.199 0.198 0.195
```

RESPONSE CATEGORY 2

| M A | R A | S A |
|---|---|---|
| A B | E B | C B |

```
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.199 0.198 0.195
ABOVE GL 0.801 0.802 0.805
```

50 RHO PARAMETERS FOR LATENT CLASS "SEV LD  " AT TIME  2

RESPONSE CATEGORY  1

```
        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.801 0.802 0.805
ABOVE GL 0.199 0.198 0.195
```

RESPONSE CATEGORY  2

```
        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.199 0.198 0.195
ABOVE GL 0.801 0.802 0.805
```

51 RHO PARAMETERS FOR LATENT CLASS "SEV LD  " AT TIME  3

RESPONSE CATEGORY  1

```
        | M B | R B | S B |
        | A E | E E | C E |
        | T L | A L | I L |
        | H O | D O | E O |
        |   W | I W | N W |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.801 0.802 0.805
ABOVE GL 0.199 0.198 0.195
```

RESPONSE CATEGORY  2

```
        | M A | R A | S A |
        | A B | E B | C B |
        | T O | A O | I O |
        | H V | D V | E V |
        |   E | I E | N E |
        |     | N   | C   |
        |     | G   | E   |
        |     |     |     |
BELOW GL 0.199 0.198 0.195
ABOVE GL 0.801 0.802 0.805
```

**********

52 GAMMA PARAMETERS

GAMMAS ARE UNCONDITIONAL PROBABILITIES OF MEMBERSHIP IN EACH LATENT CLASS
OF THE STATIC LATENT VARIABLE

| | |
|---|---|
| NO LD | 0.385 |
| MILD LD | 0.416 |
| SEV LD | 0.199 |

**********

53 DELTA PARAMETERS

DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP CONDITIONAL ON LATENT CLASS

DELTA PARAMETERS FOR LATENT CLASS "NO LD   "

| | TIME 1 | TIME 2 | TIME 3 |
|---|---|---|---|
| BELOW GL | 0.554 | 0.527 | 0.626 |
| ABOVE GL | 0.446 | 0.473 | 0.374 |

DELTA PARAMETERS FOR LATENT CLASS "MILD LD "

| | TIME 1 | TIME 2 | TIME 3 |
|---|---|---|---|
| BELOW GL | 0.699 | 0.592 | 0.589 |
| ABOVE GL | 0.301 | 0.408 | 0.411 |

DELTA PARAMETERS FOR LATENT CLASS "SEV LD  "

| | TIME 1 | TIME 2 | TIME 3 |
|---|---|---|---|
| BELOW GL | 0.641 | 0.566 | 0.580 |
| ABOVE GL | 0.359 | 0.434 | 0.420 |

**********

```
54 TAU PARAMETERS
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1
(COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)
  AND ON LATENT CLASS MEMBERSHIP

55 TRANSITION PROBABILITIES FOR LATENT CLASS "NO LD   "

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.627 0.373
 ABOVE GL 0.402 0.598

56 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.831 0.169
 ABOVE GL 0.398 0.602

57 TRANSITION PROBABILITIES FOR LATENT CLASS "MILD LD "

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.719 0.281
 ABOVE GL 0.296 0.704

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.703 0.297
 ABOVE GL 0.423 0.577

58 TRANSITION PROBABILITIES FOR LATENT CLASS "SEV LD  "

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.653 0.347
 ABOVE GL 0.409 0.591

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

         |  B  |  A  |
         |  E  |  B  |
         |  L  |  O  |
         |  O  |  V  |
         |  W  |  E  |
         |     |     |
         |  G  |  G  |
         |  L  |  L  |
 BELOW GL 0.764 0.236
 ABOVE GL 0.340 0.660

 PROGRAM FINISHED: Fri Mar 29 13:07:18 2002
 ELAPSED TIME:    0 HOURS,    0 MINUTES,    1 SECONDS.
```

# Explanation of the WinLTA Output File for Example 3

The following sections refer to output given by the program using the example latent status control file. The first sections of the output contain a listing of the parameter restrictions, starting values, and other information entered in the program control file. Following that is the iteration history and then the parameter estimates. In this example, residuals were not requested.

**Program Control File Information**

**1** The title lines and comments entered in the General tab will be printed first.

**2** Basic information from the Model and Data tab and the Estimation tab is echoed back in the first section of the output file. The filenames for the control file, the data, and the output are shown first. The next lines include the number of latent classes, number of latent statuses, number of items (for statuses and classes), number of participants, number of observed response patterns, maximum number of iterations allowed, convergence criterion, and whether there is missing data in the response patterns. Finally, there is a line stating whether or not residuals will be printed.

**Parameter Restrictions**

**3** This section contains a listing of the user-specified parameter restrictions.

**4** In this section parameter restrictions for the little rho parameters (for items measuring the static latent variable) are printed. These little rho parameters are conditional on latent class membership. The little rho parameter restrictions are sectioned by response categories.

**5** In this section parameter restrictions for the big rho parameters (for items measuring the dynamic latent variable) are printed. These rho parameters are conditional on latent status, latent class, and time. The big rho parameter restrictions are sectioned by response categories, latent class, and time.

**6** These user-specified rho parameter restrictions are for the first latent class at Time 1. The first section contains the restrictions for the first response category.

**7** These user-specified rho parameter restrictions are for the first latent class at Time 2.

**8** These user-specified rho parameter restrictions are for the first latent class at Time 3.

**9** These user-specified rho parameter restrictions are for the second latent class at Time 1.

**10** These user-specified rho parameter restrictions are for the second latent class at Time 2.

[11] These user-specified rho parameter restrictions are for the second latent class at Time 3.

[12] These user-specified rho parameter restrictions are for the third latent class at Time 1.

[13] These user-specified rho parameter restrictions are for the third latent class at Time 2.

[14] These user-specified rho parameter restrictions are for the third latent class at Time 3.

[15] In this section, user-specified parameter restrictions for the gamma parameters are printed.

[16] In this section, user-specified parameter restrictions for the delta parameters are printed.

[17] In this section, parameter restrictions for the tau parameters for latent class 1 are printed.

[18] In this section, parameter restrictions for the tau parameters for latent class 2 are printed.

[19] In this section, parameter restrictions for the tau parameters for latent class 3 are printed.

**Starting Values**

[20] This section contains a listing of user-specified starting values for the parameters.

[21] These are the user-specified starting values for the little rho parameters (for items measuring the static latent variable).

[22] These are the user-specified starting values for the big rho parameters (for items measuring the dynamic latent variable).

[23] These are the user-specified starting values for the big rho parameters for the first latent class at Time 1.

[24] These are the user-specified starting values for the big rho parameters for the first latent class at Time 2. These values were not entered in the RHO—Starting Values tab. Only Time 1 values for the big rho parameters were entered by the user. The program automatically assumes that the values for the rho parameters will all be started equal across times.

[25] Time 3 values were not entered by the user. See [24] for explanation.

[26] These are the user-specified starting values for the big rho parameters for the second latent class at Time 1.

[27] Time 2 values were not entered by the user. See [24] for explanation.

**28** Time 3 values were not entered by the user. See **24** for explanation.

**29** These are the user-specified starting values for the big rho parameters for the third latent class at Time 1.

**30** Time 2 values were not entered by the user. See **24** for explanation.

**31** Time 3 values were not entered by the user. See **24** for explanation.

**32** In this section, the user-specified starting values for the gamma parameters are printed.

**33** In this section, the user-specified starting values for the delta parameters are printed.

**34** In this section, the user-specified starting values for the tau parameters are printed.

**35** In this section, the user-specified starting values for the tau parameters for latent class 1 are printed. These starting values are for the transition between Time 1 and Time 2.

**36** In this section, the user-specified starting values for the tau parameters for latent class 1 are printed. These starting values are for the transition between Time 2 and Time 3.

**37** In this section, the user-specified starting values for the tau parameters for latent class 2 are printed. The first four starting values are for the transition between Time 1 and Time 2, and the second four starting values are for the transition between Time 2 and Time 3.

**38** These are the user-specified starting values for the tau parameters for latent class 3.

**Iteration History**

**39** After each iteration, the iteration number and the Mean Absolute Deviation (MAD) are printed.

**40** The final $G^2$ reflects the fit of the model, with degrees of freedom equal to the number of response patterns minus the number of parameters estimated minus one.

**Parameter Estimates**

The estimates for the parameters are printed in the next sections of output.

Little Rho Parameters

**41** These are the little rho parameter estimates for the items measuring the static latent variable conditional on latent class membership. The probability of responding "1" (no) to item 2

(problem #2), given membership in latent class 3 (severe learning disability) is 0.798. The probability of a "3" (undeterm) response to item 1 (problem #1) given membership in latent class 1 (no learning disability) is 0.095.

Big Rho Parameters

**42** The big rho parameters are the probabilities of a particular item response conditional on latent status, latent class, and time.

**43** This section is for latent class 1 (no learning disability), Time 1. In this example, response category 1 denotes at or below grade level and 2 denotes above grade level, thus, the first latent status (at or below grade level) is characterized by being at or below grade level on all three items (response category 1 probabilities are high), and the second latent status (above grade level) is characterized by being above grade level on all three items (response category 2 probabilities are high). The probability of a "1" response to item 2 given membership in latent status 1 and latent class 1 at Time 1 was 0.802. The probability of responding "2" to item 3 given membership in latent status 2 and latent class 1 at Time 1 was 0.805.

**44** This section is for latent class 1, Time 2. These big rho parameters were constrained to be equal across time; the parameter estimates will be the same for Times 1, 2, and 3.

**45** This section is for latent class 1, Time 3. These big rho parameters were constrained to be equal across time; the parameter estimates will be the same for all three times.

**46** These are the big rho parameter estimates for latent class 2 at Time 1. The big rho probabilities were constrained to be equal across time and across latent classes.

**47** This section is for latent class 2, Time 2. These big rho parameters were constrained to be equal across time and across latent class; the parameter estimates will be the same for Time 1, Time 2, and Time 3 and for latent class 1, 2, and 3.

**48** This section is for latent class 2, Time 3. These big rho parameters were constrained to be equal across time and across latent class; the parameter estimates will be the same for Time 1, Time 2, and Time 3 and for latent class 1, 2, and 3.

**49** Big rho parameter estimates for latent class 3, Time 1.

**50** Big rho parameter estimates for latent class 3, Time 2.

**51** Big rho parameter estimates for latent class 3, Time 3.

Gamma Parameters

**52** The estimates for the gamma parameters are the unconditional probabilities of latent class membership. For example, the unconditional probability of having no learning disability (latent

class 1) was estimated at 0.385, and the probability of having a mild learning disability (latent class 2) was 0.416.

Delta Parameters

**53** The estimates for the delta parameters are the probabilities of latent status membership, conditional on latent class and time. For example, the probability of being in the below grade level latent status at Time 1 conditional on membership in the mild learning disability latent class was estimated at 0.699. Given membership in the no learning disability latent class, the probability of being in above grade level latent status at Time 3 was estimated at 0.374; i.e. 37.4% of participants who had no learning disability were below grade level at the end of the school year.

Tau Parameters

There is a set of two transition probability matrices for each latent class. The first matrix models the Time 1 to Time 2 transitions and the second matrix models the Time 2 to Time 3 transitions. If there were an additional wave of measurement, then there would be a third matrix for each latent class, which would model the Time 3 to Time 4 transitions.

**54** The tau parameters are the probabilities of being in a particular latent status at Time T+1 given membership in another given latent status at Time T, conditional on latent class membership.

**55** These are the Time 1 to Time 2 transition probability estimates for the first latent class. For example, given membership in the no learning disability latent class, the probability of being in the above grade level latent status at Time 2 given membership in the below grade level latent status at Time 1 is 0.373. That is, given that a participant has no learning disability, the probability of being above grade level at mid-year given that the participant was at or below grade level at the beginning of the year is 0.373.

**56** These are the Time 2 to Time 3 transition probability estimates for the first latent class. For example, given membership in the no learning disability latent class, the probability of being in below grade level latent status at Time 3 given membership in the above grade level latent status at Time 2 is 0.398. That is, given that a participant has no learning disability, the probability of being at or below grade level at mid-year given that the participant was above grade level at the beginning of the year is 0.398.

**57** These are the Time 1 to Time 2 and Time 2 to Time 3 transition probability estimates for the second latent class. For example, given membership in the mild learning disability latent class, the probability of being in the above grade level latent status at Time 2 given membership in the above grade level latent status at Time 1 is 0.704. Given membership in the mild learning disability latent class, the probability of being in the below grade level latent status at Time 3 given membership in the below grade level latent status at Time 2 is 0.703.

**58** These are the transition probability estimates for the third latent class. Given that a participant has a severe learning disability (latent class 3), the probability of being above grade level at mid-year given membership in latent status 1 (at or below grade level) at the beginning of the year is 0.347.

**Response Patterns and Statistics**

If requested by the option in the General tab, response patterns and residuals are printed. These were not requested in this example. For an example in which residuals are printed, see Example 2.

# Example 4

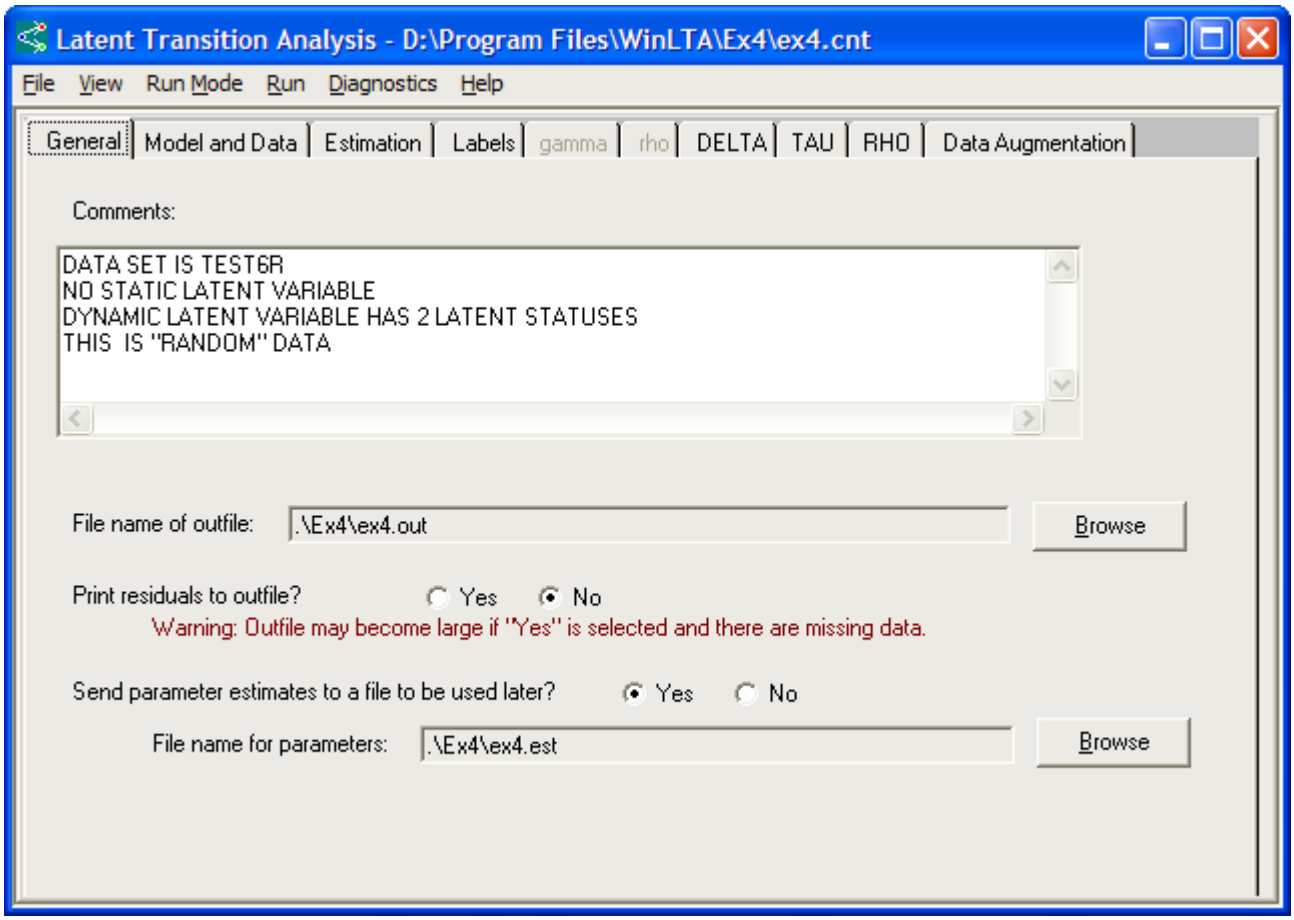
## Second Order, Five Time, Two Latent Status Example

# Example 4

This example is a second-order latent transition problem involving 5 times. These data are artificial, but we will assume that the sample involves 2000 schizophrenic patients. A psychologist answers three questions about each patient regarding psychotic symptoms (hallucination, paranoia, delusion). The response categories for each item will thus be either "yes" (symptom is apparent) or "no" (symptom is not apparent). These items will be measured once a year over a five year period. The two latent statuses are actively psychotic and not actively psychotic. Because this is a second-order model, we are allowing latent status membership at a particular time to be conditional on not only latent status membership at the immediately previous time, but on the time before that as well. In other words, latent status membership at time $t$+2 is conditional on latent status membership at time $t$+1 AND on latent status membership at time $t$.

If you would like to open the control file for this example in WinLTA, click on File, Open Control File, and choose the folder for Example 4. Then open the file called ex4.cnt.

*General tab window*

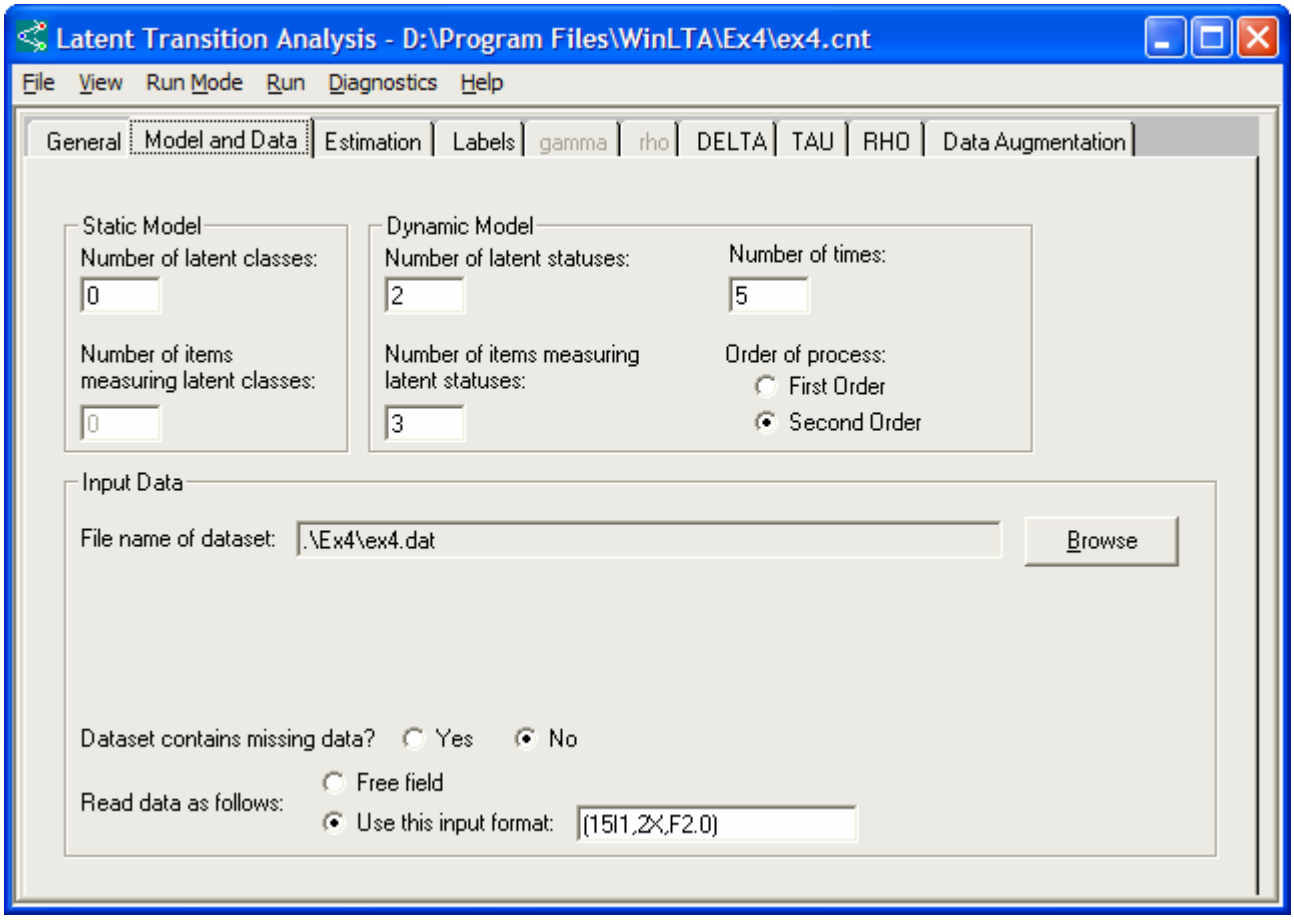



The field descriptions for the General tab are:

- **Comments:** Enter any titles and comments here. These will be the first lines in the output.
- **File name of outfile:** Specify the file in which the output will be saved by pressing the browse button.
- **Print residuals to outfile?:** You may choose to include residuals at the end of the output file.
- **Send parameter estimates to a file to be used later?:** Choosing yes for this option saves the parameter estimates to a separate file. This file can be used for crossvalidation or to begin another run. Specify this filename by pressing the browse button to call up a Save As dialog box.

The Model and Data tab is shown next.

*Model and Data tab window*




The field descriptions for the Model and Data tab are:

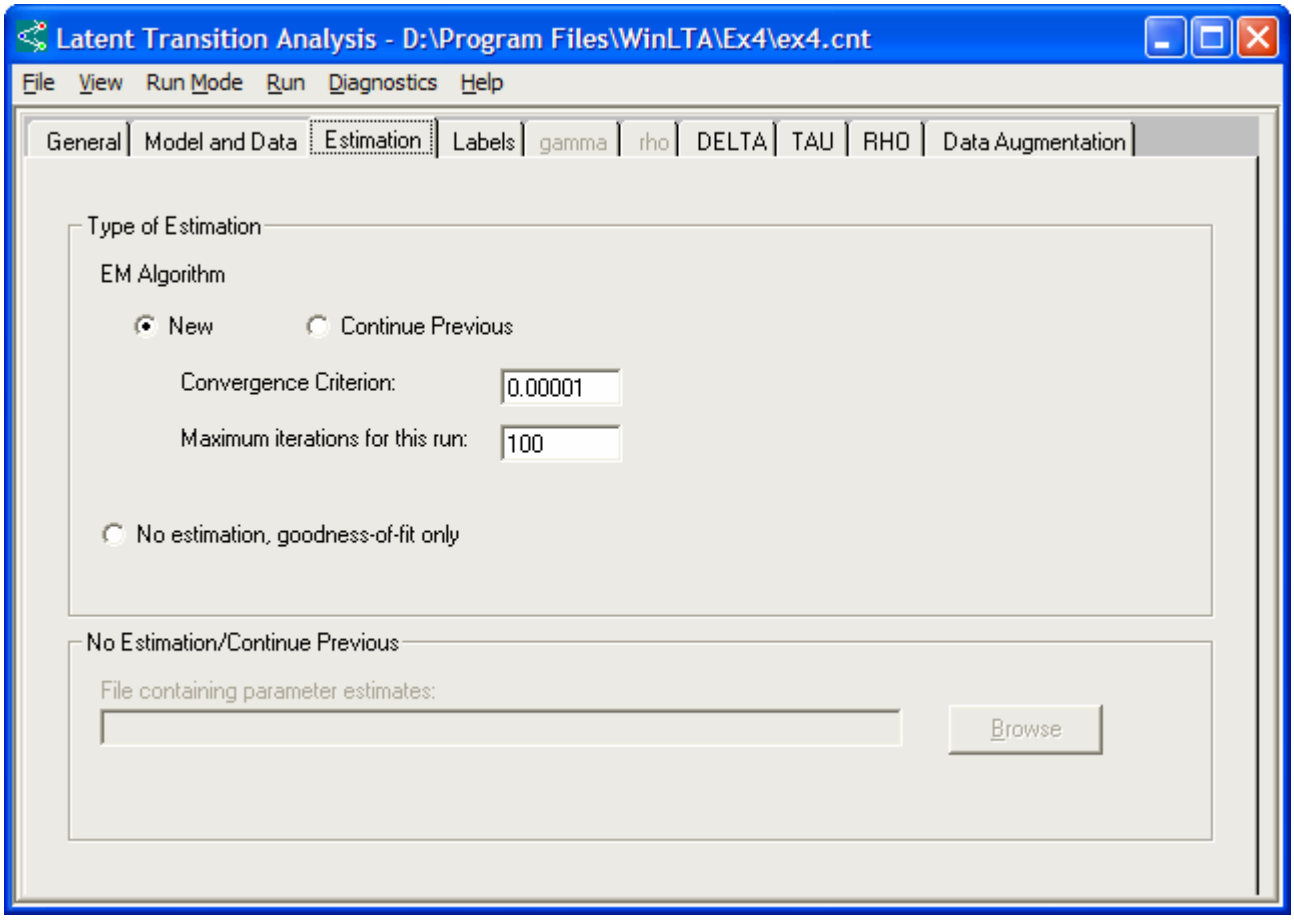
- **Static Model:** There are no latent classes in this example, therefore 0's have been entered in this section.
  - **Number of latent classes:** 0
- **Number of items measuring latent classes:** 0

- **Dynamic Model:** This section contains information about the dynamic latent variable.
  - **Number of latent statuses:** There are 2 latent statuses in this example: (1) actively psychotic and (2) not actively psychotic.
  - **Number of items measuring latent statuses:** 3
- **Number of times:** 5
- **Order of process:** Second order. In a second order problem, the transitions are conditional on the previous two times.
- **Input Data:**
  - **File name of dataset:** Specify the filename by pressing the browse button.
- **Dataset contains missing data?:** There are no missing data.

**Read data as follows:** This option allows you to specify free-field or fixed-format. See an earlier example or the WinLTA help file for further discussion of these two options.

The Estimation tab is discussed next.

*Estimation tab window*

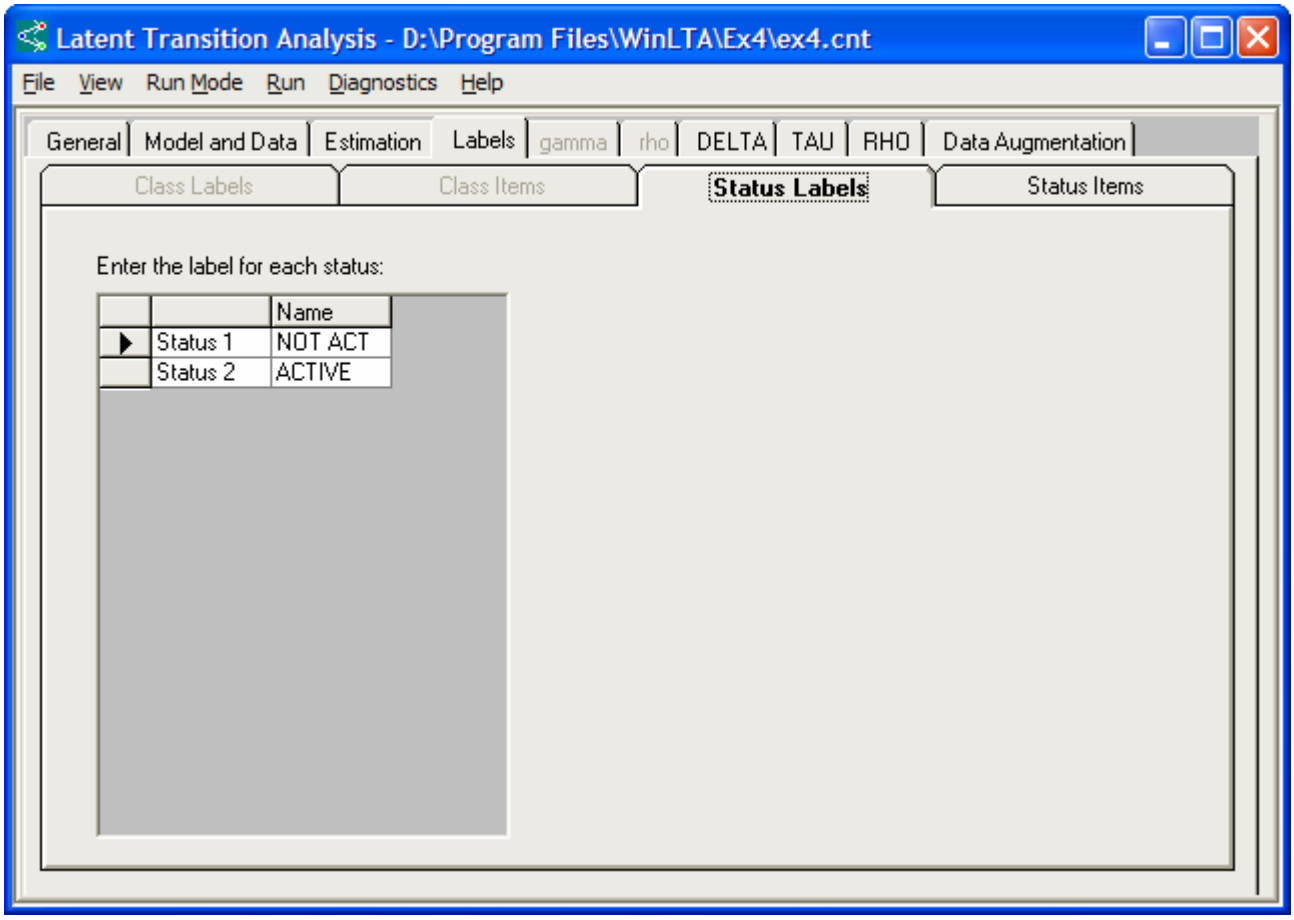



The field descriptions for the Estimation tab are:

- **Type of estimation:**
- **EM Algorithm:**
  - **New/Continue Previous:** For new runs, select New. Select Continue Previous only when you want to continue a run that previously failed to converge. (See "How to Continue a Run That Did Not Converge" in the manual.)
  - **Convergence Criterion:** This is the MAD value at which the program will converge. The program default is $10^{-5}$.
  - **Maximum iterations for this run:** 100
- **No estimation, goodness-of-fit only:** Choose this option to fit a set of parameter estimates to the current data set. (See "How to Crossvalidate" in the manual.)
  - **File containing parameter estimates:** Specify the name of the file containing the parameter estimates by pressing the browse button.

Next is the Labels tab. There are four tabs nested within the Labels tab, but as there are no latent classes in this example, the first two tabs are not used. Latent transition models require information to be entered are the Status Labels tab and the Status Items tab. The Status Labels tab is shown below.

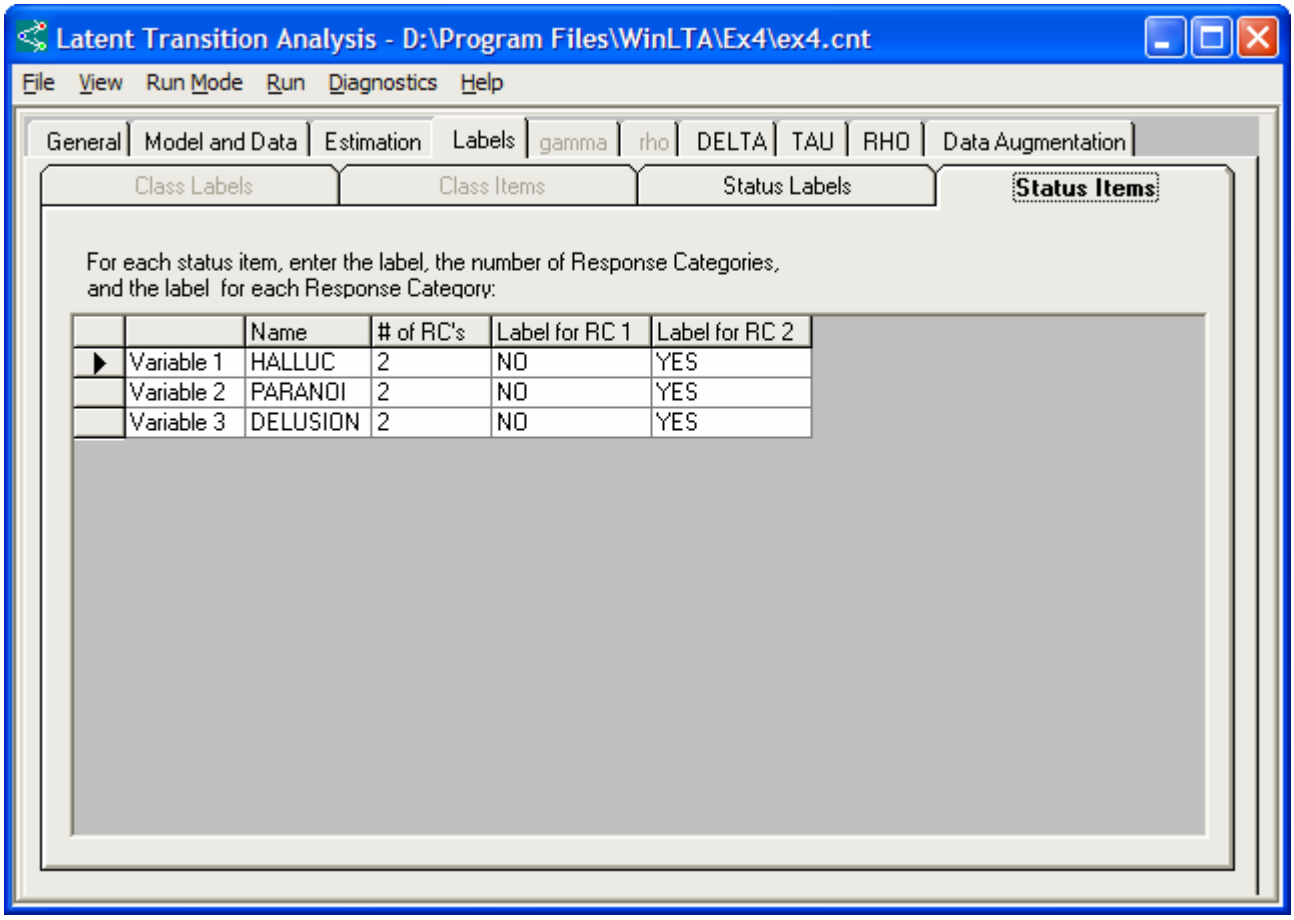
*Labels—Status Labels tab window*




On the Labels—Status Labels you enter the names to be used for the latent statuses. There is a limit of 8 characters per label.

The other tab that is accessible within the Labels tab is the Status Items tab.

*Labels—Status Items tab window*

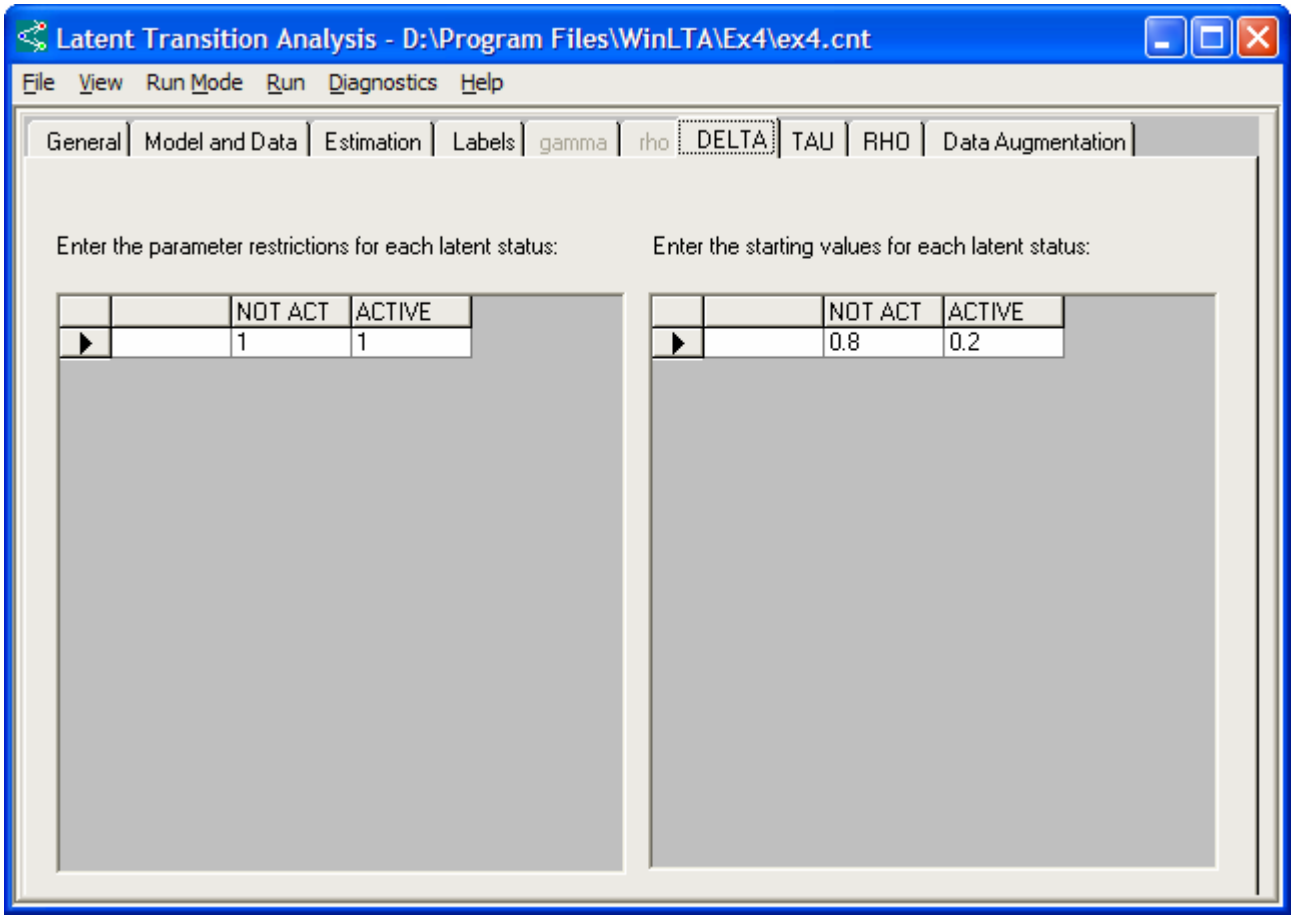



The field descriptions for the Labels—Status Items tab are:

- **Status items:** The first column contains identifying names for the manifest latent status indicators. The next column contains the number of response categories for each variable. The next columns contain labels for the response categories of each variable.

The first parameter estimates we will discuss are the deltas.

*DELTA tab window*



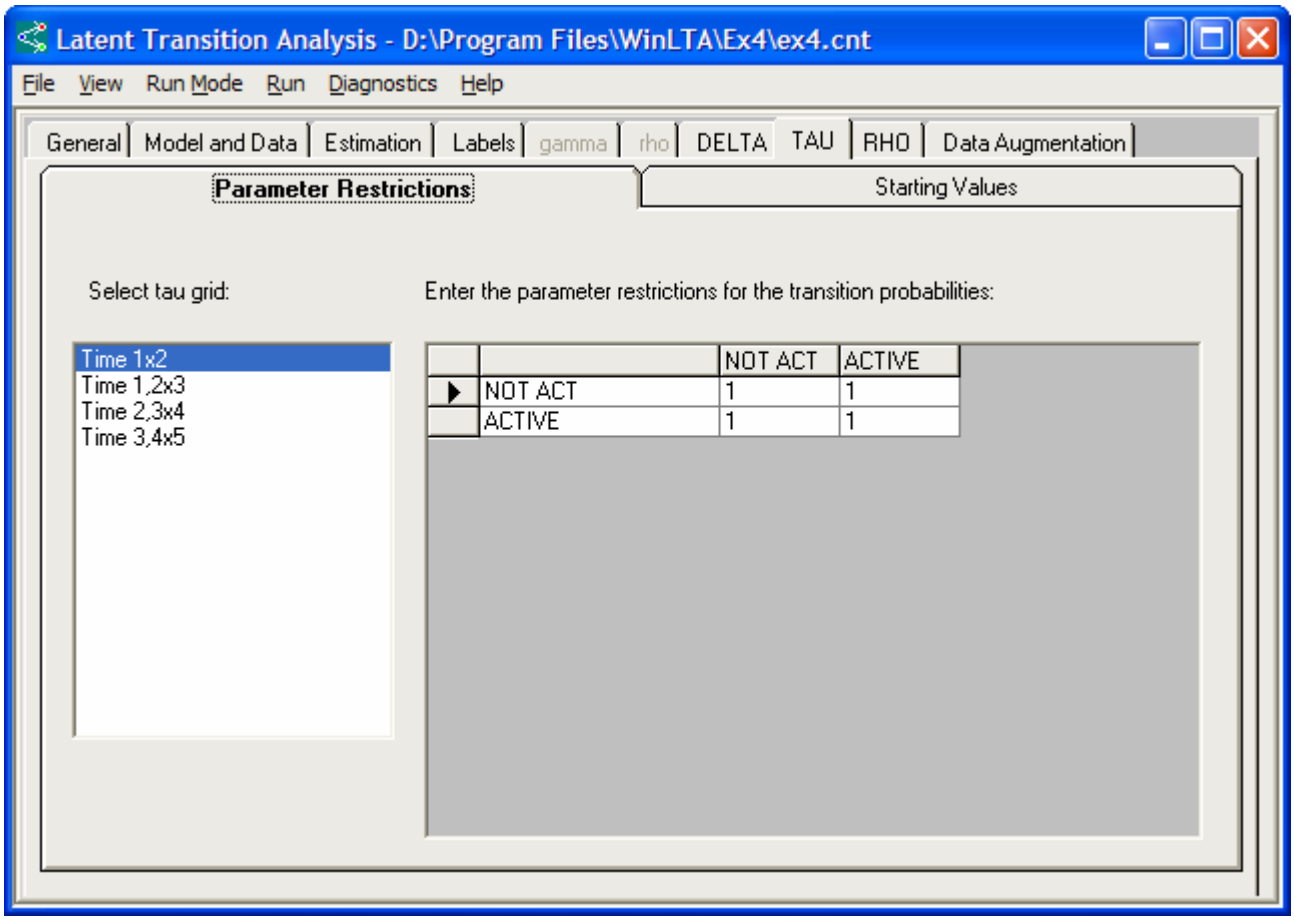

The field descriptions for the DELTA tab are:

- **Enter the parameter restrictions for each latent status:** The left side of this tab provides space for parameter restrictions on the delta estimates. Delta parameters can be constrained, estimated freely, or fixed at the start value. Enter a "1" if you want the parameter to be estimated freely. Enter a "0" if the parameter will be fixed at the start value. Enter a "2" or greater to indicate that the parameter is constrained. In this example, all deltas are estimated freely.

- **Enter the starting values for each latent status:** These are the starting values for the delta parameters and they must sum to one.

Next, we consider the TAU tab. Within this tab, there is a Parameter Restrictions tab and a Starting Values tab.

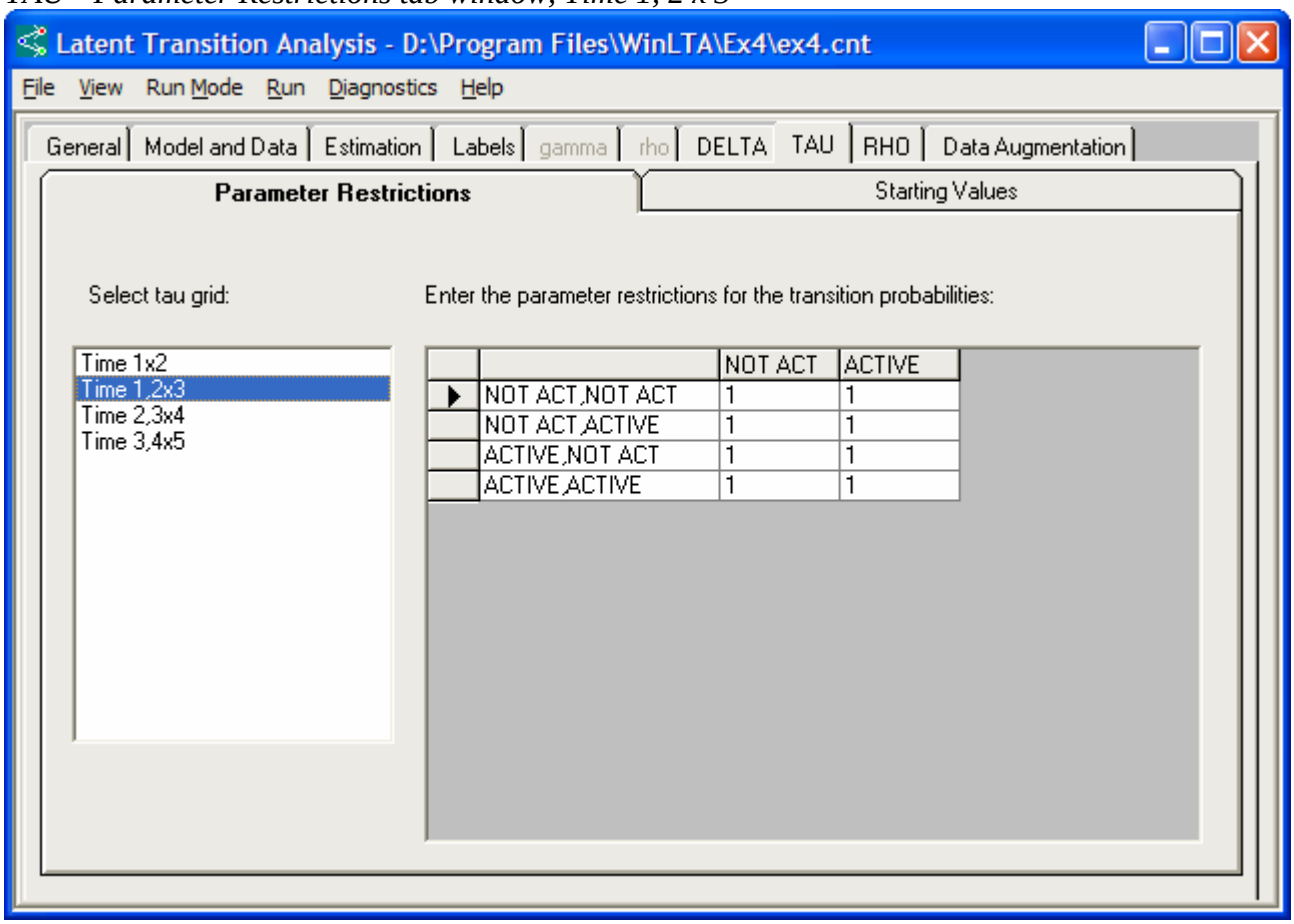
*TAU—Parameter Restrictions tab window*




The field descriptions for the TAU-Parameter Restrictions tab are:

- **Select tau grid:** There are four tau grids, representing the combinations of times in the second order model. You can select each of these matrices by clicking in the box on the left of the window. The above image shows the tau matrix for the transitions between Time 1 and Time 2. The next image shows a second-order tau matrix.

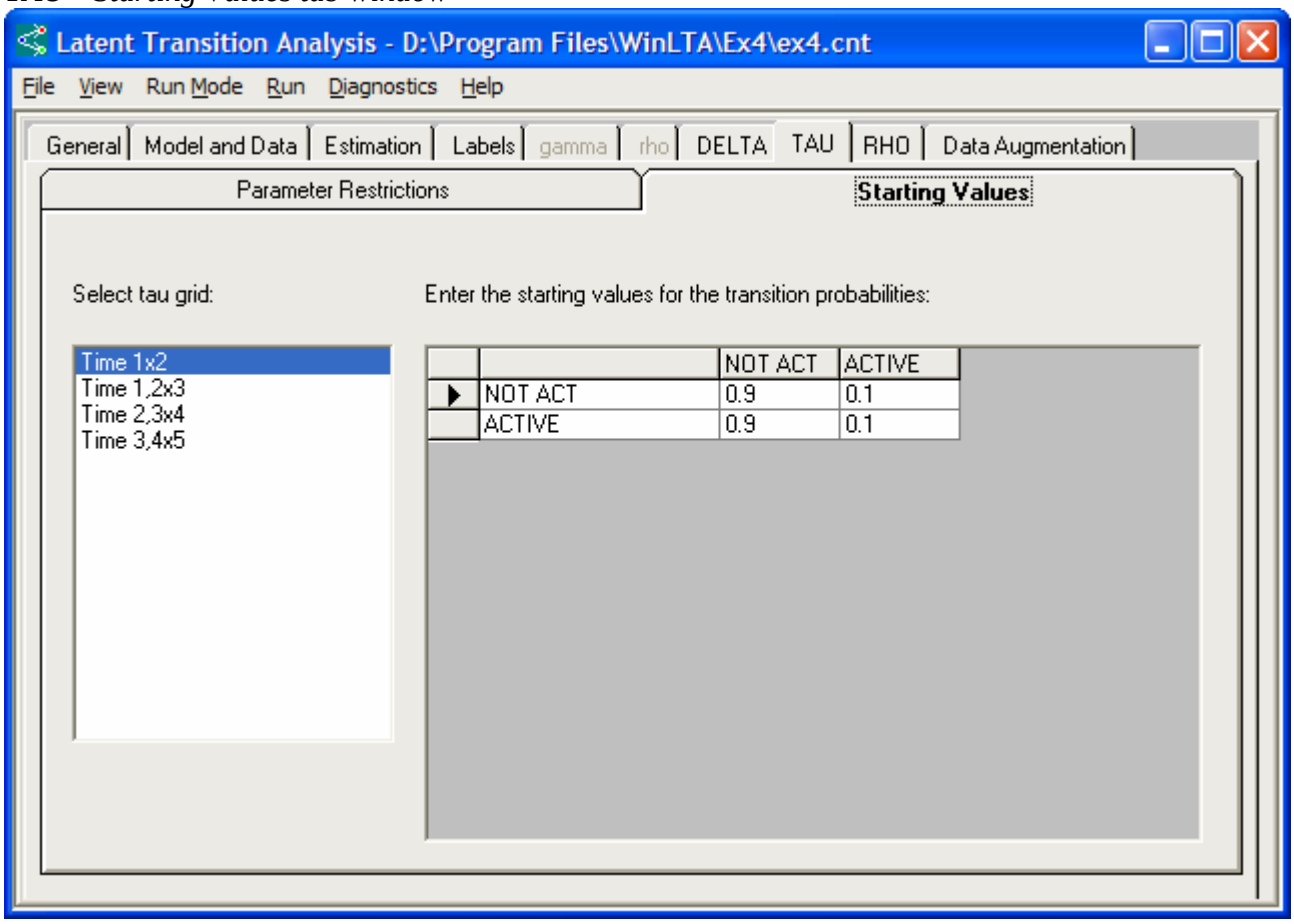
*TAU—Parameter Restrictions tab window, Time 1, 2 x 3*




- **Enter the parameter restrictions for the transition probabilities:** In the grid, enter the restrictions for the tau parameters. In this example, all of the transition probabilities will be freely estimated.
  - The first set of tau restrictions shown is for the transitions between Time 1 and Time 2. The rows represent latent status membership at Time 1, and the columns represent latent status membership at Time 2.
  - The second set of tau restrictions (pictured immediately above) represents the Time 2 to Time 3 transitions. However, because this is a second order model, the rows represent latent status membership at Time 1 and Time 2, and the columns represent latent status membership at Time 3. Given membership in latent status 1 at Time 1 and latent status 1 at Time 2, the Time 3 probabilities of latent status membership unconstrained. The rows are the Time 1 and Time 2 latent status membership combinations.
  - The third set of second order tau restrictions represents the Time 2 and Time 3 to Time 4 transitions and the fourth set of tau restrictions represents the Time 3 and Time 4 to Time 5 transitions.

The other tab found within the TAU tab is the TAU—Starting Values tab.

*TAU—Starting Values tab window*




The field descriptions for the TAU—Starting Values tab are:

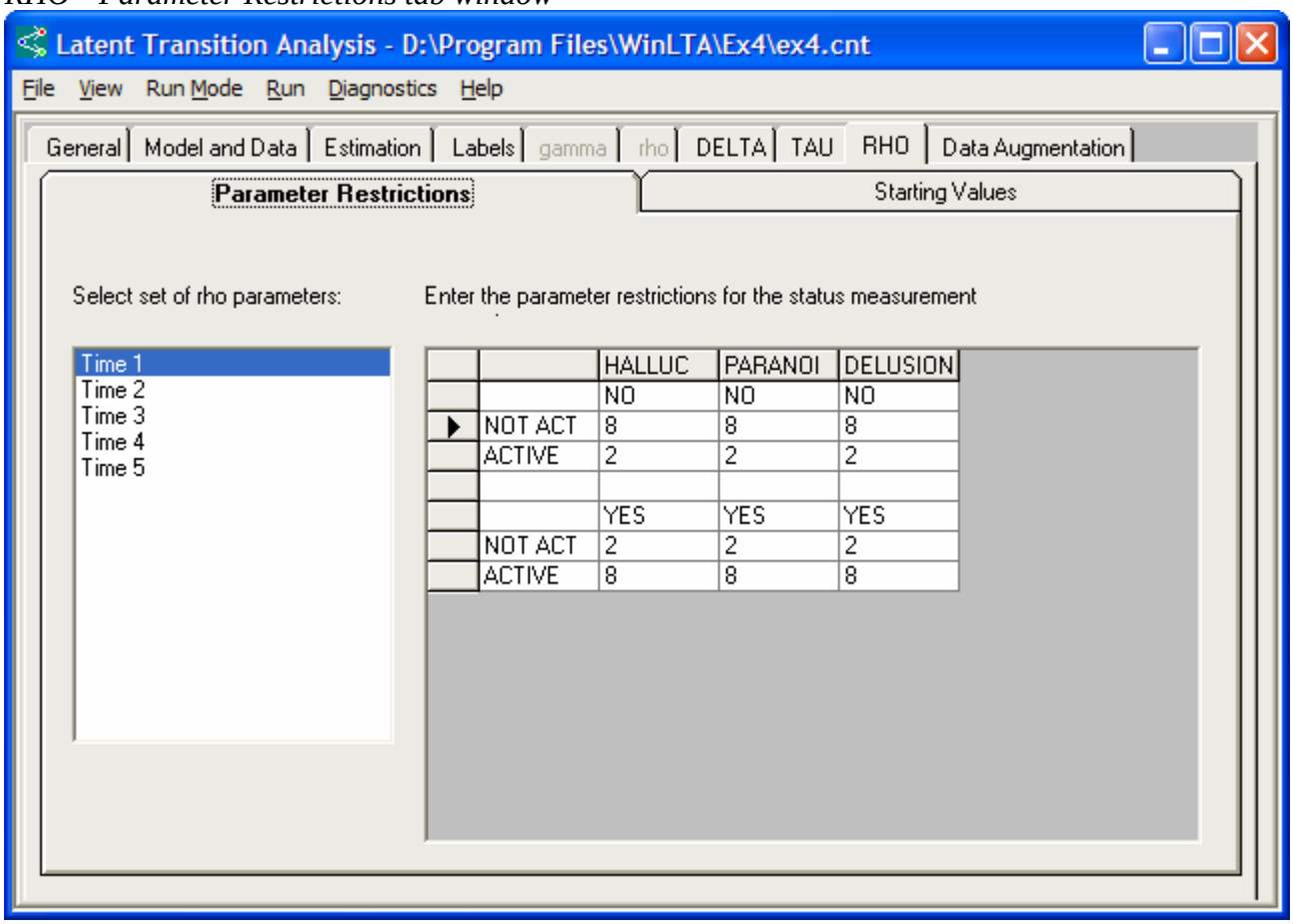
- **Select tau grid:** As in the TAU—Parameter Restrictions tab, there are four tau grids that represent the combinations of times in the second-order model. You can access each of these matrices by clicking in the box on the left of the window.

- **Enter the starting values for the transition probabilities:** This is where the starting values for the tau parameters must be entered. Starting values must be provided for every transition probability matrix. Each element must be a probability and each row must sum to one.
  - The first matrix of starting values is for the Time 1 to Time 2 transitions.
  - The second matrix of starting values is for the Time 2 to Time 3 transition. The first row of this matrix (not shown, but it is contained in the control file in the example 4 folder of the WinLTA distribution) represents the Time 3 latent status membership conditional on membership in latent status 1 at both Times 1 and 2. The other rows represent the other Time 1 and Time 2 latent status membership combinations.

- The third set of starting values represents the Time 3 to Time 4 second-order transition probabilities and the fourth set of starting values represents the Time 4 to Time 5 second-order transition probabilities.

The RHO tab is the last tab. This tab contains two tabs: the Parameter Restrictions tab (shown below), and the Starting Values tab.

*RHO—Parameter Restrictions tab window*




There is no difference in the rho parameters for a second-order and a first-order model. The parameter restrictions and starting values are set up identically. There are 5 times and 2 response categories, so there will be 10 sets of 2x3 rho parameter restriction matrices, for a total of 120 rho parameters.

The field descriptions for the RHO—Parameter Restrictions tab are:

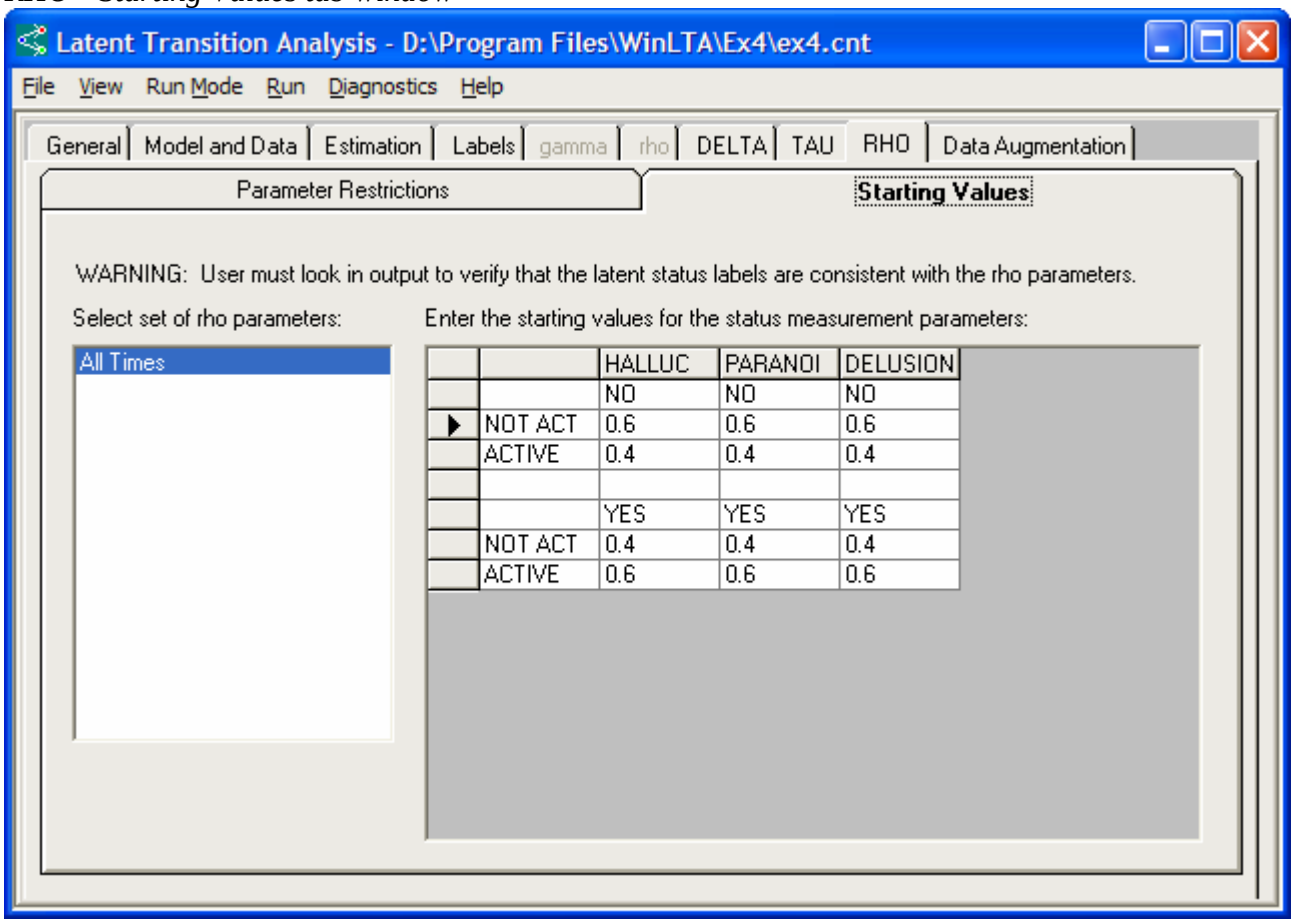
- **Select set of rho parameters:** There is a set of rho parameters for each occasion of measurement. Select the times by clicking in the box to the left of the window.

- **Enter the parameter restrictions for the status measurement parameters:** In the previous screen shot, the upper matrix contains the parameter restrictions for the first

response category for Time 1, and the lower matrix contains the parameter restrictions for the second response category for Time 1.

The last tab is the Starting Values tab.

*RHO—Starting Values tab window*




The field descriptions for the RHO—Starting Values tab are:

- **Select set of rho parameters:** Select the set of starting values to edit on the left. If there were latent classes, there would be multiple sets of rhos shown.
- **Enter the starting values for the status measurement parameters:** Input the starting values (probabilities) here. Remember they must sum to one.

# Saving Your Work and Running WinLTA

- **Saving the control file:** In WinLTA, click on File, and then Save. If this is the first time you have saved this file, a Save As dialog box will appear. In this box you can choose the location of the file and you will be required to enter a filename. By default, the file will be saved with the file extension .cnt.

- **To run WinLTA:** Once the information is completely entered into the control file, click on Run, and then Run EM. EM will begin running automatically. If you have not saved the current version of the control file, you will see a dialog box that asks you if you would like to save before proceeding. Choosing Yes will save the file and run EM automatically. Choosing No will run EM without saving the file. Choosing Cancel will allow you to return to the control file without running EM.

    - Once EM begins running, a separate dialog box entitled "LTA EM Run" will appear on your screen and WinLTA will automatically be minimized. This dialog box tells you the status of the EM run as well as the date and time the run began and finished. The box also has two buttons: Abort and Get Info. Pressing the Abort button during the run will cancel the run. Pressing Get Info gives you the iteration number and the MAD at the time shown. This information is also updated every 5 seconds. Once the run is finished, the Abort button changes to Close. When you press the Close button, WinLTA will automatically be restored as the active window. You can still access WinLTA on your taskbar without pressing the Close button, but Close must be pressed before another EM run can be started.

- **Viewing the WinLTA outfile:** Once the EM run is completed, you can view the output file by clicking on View, and Current LTA Outfile (if you would like to view an older saved outfile, click on Choose LTA Outfile). This will bring up the output file that corresponds with the last EM run.

# The WinLTA Output File

The following is an example of an output file from the WinLTA program. The endnote reference numbers that have been added to the output correspond to the endnotes that follow.

```
1PROGRAM STARTED:       Fri Mar 29 16:12:29 2002

* DATA SET IS TEST6R
* NO STATIC LATENT VARIABLE
* DYNAMIC LATENT VARIABLE HAS 2 LATENT STATUSES
* THIS  IS "RANDOM" DATA

 ************************************************

2INFORMATION ABOUT THIS JOB:

 RUN TYPE: PARAMETER ESTIMATION BY EM

 CONTROL DATA READ FROM FILE:
D:\WinLTA\Ex4\ex4.cnt

 DATA ANALYZED IN THIS RUN READ FROM FILE:
.\Ex4\ex4.dat

 OUTPUT SAVED IN FILE:
.\Ex4\ex4.out

 PARAMETER ESTIMATES SAVED IN FILE:
.\Ex4\ex4.est


 STATIC LATENT VARIABLE                     NO

 DYNAMIC LATENT VARIABLE                   YES
 NUMBER OF LATENT STATUSES                   2
 NUMBER OF OCCASIONS OF MEASUREMENT          5
 NUMBER OF MANIFEST ITEMS PER OCCASION       3
 TYPE OF PROCESS                  SECOND-ORDER

 NUMBER OF SUBJECTS                       2000
 NUMBER OF UNIQUE RESPONSE PATTERNS       1667
 MAXIMUM NUBMER OF ITERATIONS              100
 CONVERGENCE CRITERION         .00001000000000
 MISSING DATA IN RESPONSE PATTERNS           NO
 PRINT RESIDUALS                             NO

 ************************************************


3THE FOLLOWING PARAMETER RESTRICTIONS HAVE BEEN SPECIFIED
 WHERE 0=FIXED TO START VALUE
       1=FREE
       2 OR GREATER MEANS CONSTRAINED EQUAL TO ANY OTHER
         PARAMETER WITH THE SAME DESIGNATION

 ************************************************

4BIG RHO PARAMETER RESTRICTIONS
 BIG RHOS ARE PROBABILITIES OF RESPONSE
 TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
 CONDITIONAL ON LATENT STATUS AND TIME

          BIG RHO PARAMETER RESTRICTIONS FOR TIME  1

          RESPONSE CATEGORY  1

          | H N | P N | D N |
          | A O | A O | E O |
          | L   | R   | L   |
          | L   | A   | U   |
          | U   | N   | S   |
          | C   | O   | I   |
          |     | I   | O   |
          |     |     | N   |
NOT ACT     8     8     8
ACTIVE      2     2     2

          RESPONSE CATEGORY  2

          | H Y | P Y | D Y |
          | A E | A E | E E |
          | L S | R S | L S |
          | L   | A   | U   |
          | U   | N   | S   |
          | C   | O   | I   |
          |     | I   | O   |
          |     |     | N   |
NOT ACT     2     2     2
ACTIVE      8     8     8

         5BIG RHO PARAMETER RESTRICTIONS FOR TIME  2

          RESPONSE CATEGORY  1

          | H N | P N | D N |
          | A O | A O | E O |
          | L   | R   | L   |
          | L   | A   | U   |
          | U   | N   | S   |
          | C   | O   | I   |
          |     | I   | O   |
          |     |     | N   |
NOT ACT     8     8     8
ACTIVE      2     2     2

          RESPONSE CATEGORY  2

          | H Y | P Y | D Y |
          | A E | A E | E E |
          | L S | R S | L S |
```

```
        | L   | A   | U   |
        | U   | N   | S   |
        | C   | O   | I   |
        |     | I   | O   |
        |     |     | N   |
NOT ACT    2     2     2
ACTIVE     8     8     8
```

6 BIG RHO PARAMETER RESTRICTIONS FOR TIME  3

RESPONSE CATEGORY  1

```
        | H N | P N | D N |
        | A O | A O | E O |
        | L   | R   | L   |
        | L   | A   | U   |
        | U   | N   | S   |
        | C   | O   | I   |
        |     | I   | O   |
        |     |     | N   |
NOT ACT    8     8     8
ACTIVE     2     2     2
```

RESPONSE CATEGORY  2

```
        | H Y | P Y | D Y |
        | A E | A E | E E |
        | L S | R S | L S |
        | L   | A   | U   |
        | U   | N   | S   |
        | C   | O   | I   |
        |     | I   | O   |
        |     |     | N   |
NOT ACT    2     2     2
ACTIVE     8     8     8
```

7 BIG RHO PARAMETER RESTRICTIONS FOR TIME  4

RESPONSE CATEGORY  1

```
        | H N | P N | D N |
        | A O | A O | E O |
        | L   | R   | L   |
        | L   | A   | U   |
        | U   | N   | S   |
        | C   | O   | I   |
        |     | I   | O   |
        |     |     | N   |
NOT ACT    8     8     8
ACTIVE     2     2     2
```

RESPONSE CATEGORY  2

```
        | H Y | P Y | D Y |
        | A E | A E | E E |
        | L S | R S | L S |
        | L   | A   | U   |
        | U   | N   | S   |
        | C   | O   | I   |
        |     | I   | O   |
        |     |     | N   |
NOT ACT    2     2     2
ACTIVE     8     8     8
```

8 BIG RHO PARAMETER RESTRICTIONS FOR TIME  5

RESPONSE CATEGORY  1

```
        | H N | P N | D N |
        | A O | A O | E O |
        | L   | R   | L   |
        | L   | A   | U   |
        | U   | N   | S   |
        | C   | O   | I   |
        |     | I   | O   |
        |     |     | N   |
NOT ACT    8     8     8
ACTIVE     2     2     2
```

RESPONSE CATEGORY  2

```
        | H Y | P Y | D Y |
        | A E | A E | E E |
        | L S | R S | L S |
        | L   | A   | U   |
        | U   | N   | S   |
        | C   | O   | I   |
        |     | I   | O   |
        |     |     | N   |
NOT ACT    2     2     2
ACTIVE     8     8     8
```

**********

9 DELTA PARAMETER RESTRICTIONS
DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP

```
          TIME 1
NOT ACT     1
ACTIVE      1
```

**********

10 TAU PARAMETER RESTRICTIONS

```
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1
(COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIMES T-1 AND T
(ROWS)



  TRANSITION PROBABILITIES

11 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  N |  A |
         |  O |  C |
         |  T |  T |
         |    |  I |
         |  A |  V |
         |  C |  E |
         |  T |    |
         |    |    |
 NOT ACT    1    1
 ACTIVE     1    1

12 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 1 AND 2
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3
                  |  N |  A |
                  |  O |  C |
                  |  T |  T |
                  |    |  I |
                  |  A |  V |
                  |  C |  E |
                  |  T |    |
                  |    |    |
 NOT ACT  NOT ACT
 NOT ACT  ACTIVE
 ACTIVE   NOT ACT
 ACTIVE   ACTIVE

13 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 2 AND 3
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 4
                  |  N |  A |
                  |  O |  C |
                  |  T |  T |
                  |    |  I |
                  |  A |  V |
                  |  C |  E |
                  |  T |    |
                  |    |    |
 NOT ACT  NOT ACT
 NOT ACT  ACTIVE
 ACTIVE   NOT ACT
 ACTIVE   ACTIVE

14 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 3 AND 4
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 5
                  |  N |  A |
                  |  O |  C |
                  |  T |  T |
                  |    |  I |
                  |  A |  V |
                  |  C |  E |
                  |  T |    |
                  |    |    |
 NOT ACT  NOT ACT
 NOT ACT  ACTIVE
 ACTIVE   NOT ACT
 ACTIVE   ACTIVE

 ***********************************************

       15 START VALUES

 ***********************************************

16 BIG RHO PARAMETERS
 BIG RHOS ARE PROBABILITIES OF RESPONSES
 TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
 CONDITIONAL ON LATENT STATUS AND TIME

          RHO PARAMETERS FOR TIME  1

          RESPONSE CATEGORY  1

         | H N | P N | D N |
         | A O | A O | E O |
         | L   | R   | L   |
         | L   | A   | U   |
         | U   | N   | S   |
         | C   | O   | I   |
         |     | I   | O   |
         |     |     | N   |
 NOT ACT  0.600 0.600 0.600
 ACTIVE   0.400 0.400 0.400

          RESPONSE CATEGORY  2

         | H Y | P Y | D Y |
         | A E | A E | E E |
         | L S | R S | L S |
         | L   | A   | U   |
         | U   | N   | S   |
         | C   | O   | I   |
         |     | I   | O   |
         |     |     | N   |
```

```
NOT ACT  0.400 0.400 0.400
ACTIVE   0.600 0.600 0.600
```

**17** RHO PARAMETERS FOR TIME 2

RESPONSE CATEGORY 1

| H N A O L L U C | P N A O R A N O I | D N E O L U S I O N |
|---|---|---|
| 0.600 | 0.600 | 0.600 |
| 0.400 | 0.400 | 0.400 |

RESPONSE CATEGORY 2

| H Y A E L S L U C | P Y A E R S A N O I | D Y E E L S U S I O N |
|---|---|---|
| 0.400 | 0.400 | 0.400 |
| 0.600 | 0.600 | 0.600 |

**18** RHO PARAMETERS FOR TIME 3

RESPONSE CATEGORY 1

| H N A O L L U C | P N A O R A N O I | D N E O L U S I O N |
|---|---|---|
| 0.600 | 0.600 | 0.600 |
| 0.400 | 0.400 | 0.400 |

RESPONSE CATEGORY 2

| H Y A E L S L U | P Y A E R S A N | D Y E E L S U S |
|---|---|---|

| C | O I | I O N |
|---|---|---|
| 0.400 | 0.400 | 0.400 |
| 0.600 | 0.600 | 0.600 |

**19** RHO PARAMETERS FOR TIME 4

RESPONSE CATEGORY 1

| H N A O L L U C | P N A O R A N O I | D N E O L U S I O N |
|---|---|---|
| 0.600 | 0.600 | 0.600 |
| 0.400 | 0.400 | 0.400 |

RESPONSE CATEGORY 2

| H Y A E L S L U C | P Y A E R S A N O I | D Y E E L S U S I O N |
|---|---|---|
| 0.400 | 0.400 | 0.400 |
| 0.600 | 0.600 | 0.600 |

**20** RHO PARAMETERS FOR TIME 5

RESPONSE CATEGORY 1

| H N A O L L U C | P N A O R A N O I | D N E O L U S I O N |
|---|---|---|
| 0.600 | 0.600 | 0.600 |
| 0.400 | 0.400 | 0.400 |

RESPONSE CATEGORY 2

| H Y A E | P Y A E | D Y E E |
|---|---|---|

```
        | L S | R S | L S |
        | L   | A   | U   |
        | U   | N   | S   |
        | C   | O   | I   |
        |     | I   | O   |
        |     |     | N   |
 NOT ACT  0.400 0.400 0.400
 ACTIVE   0.600 0.600 0.600

 ************************************************
```

**21** DELTA PARAMETERS

```
 DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP

          TIME 1
 NOT ACT   0.800
 ACTIVE    0.200

 ************************************************
```

**22** TAU PARAMETERS

```
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1
(COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIMES T-1 AND T
(ROWS)

  TRANSITION PROBABILITIES
```

**23** ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

```
        |  N  |  A  |
        |  O  |  C  |
        |  T  |  T  |
        |     |  I  |
        |  A  |  V  |
        |  C  |  E  |
        |  T  |     |
        |     |     |
 NOT ACT  0.900 0.100
 ACTIVE   0.900 0.100
```

**24** ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 1 AND 2
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

```
                |  N  |  A  |
                |  O  |  C  |
                |  T  |  T  |
                |     |  I  |
                |  A  |  V  |
                |  C  |  E  |
                |  T  |     |
                |     |     |
 NOT ACT  0.600 0.400
 NOT ACT  0.100 0.900
 ACTIVE   0.100 0.900
 ACTIVE   0.100 0.900
```

**25** ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 2 AND 3
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 4

```
                |  N  |  A  |
                |  O  |  C  |
                |  T  |  T  |
                |     |  I  |
                |  A  |  V  |
                |  C  |  E  |
                |  T  |     |
                |     |     |
 NOT ACT  0.100 0.900
 NOT ACT  0.100 0.900
 ACTIVE   0.900 0.100
 ACTIVE   0.900 0.100
```

**26** ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 3 AND 4
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 5

```
                |  N  |  A  |
                |  O  |  C  |
                |  T  |  T  |
                |     |  I  |
                |  A  |  V  |
                |  C  |  E  |
                |  T  |     |
                |     |     |
 NOT ACT  0.100 0.900
 NOT ACT  0.100 0.900
 ACTIVE   0.900 0.100
 ACTIVE   0.600 0.400

 ************************************************
```

**27** ITERATION HISTORY

```
 ************************************************

 STARTING G-SQUARED= 11230.128

ITER-   MAD         ITER-   MAD         ITER-   MAD
ATION               ATION               ATION

   1  .0200734366      2  .0321996307      3  .0383432507
   4  .0343456271      5  .0264377935      6  .0198358966
   7  .0149939883      8  .0110002293      9  .0077226812
  10  .0052312414     11  .0034650345     12  .0023857200
  13  .0016533418     14  .0011461542     15  .0007950016
  16  .0005538694     17  .0003873785     18  .0002721369
```

```
   19  .0001921346     20  .0001363707     21  .0000973162
   22  .0000698214     23  .0000503592     24  .0000365086
   25  .0000266113     26  .0000195304     27  .0000144812
   28  .0000107752     29  .0000081325

 ************************************************

28
  MODEL FIT

 G-Squared Test of Model Fit:              8015.219
 Degrees of Freedom:                          32751


 ************************************************

  **WARNING**: BE SURE TO INTERPRET THE LATENT STATUSES
CAREFULLY
               BASED ON THE ESTIMATED RHO PARAMETERS REPORTED
BELOW.
               YOU MAY WISH TO CHANGE THE LABELS YOU PREVIOUSLY
ASSIGNED
               TO THE LATENT STATUSES IN ORDER TO MAKE THEM
               CONSISTENT WITH YOUR INTERPRETATION.

 ************************************************

29
  BIG RHO PARAMETERS
 BIG RHOS ARE PROBABILITIES OF RESPONSES
 TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
 CONDITIONAL ON LATENT STATUS AND TIME

          RHO PARAMETERS FOR TIME  1

          RESPONSE CATEGORY  1

         | H N | P N | D N |
         | A O | A O | E O |
         | L   | R   | L   |
         | L   | A   | U   |
         | U   | N   | S   |
         | C   | O   | I   |
         |     | I   | O   |
         |     |     | N   |
 NOT ACT  0.800 0.800 0.800
 ACTIVE   0.200 0.200 0.200

          RESPONSE CATEGORY  2

         | H Y | P Y | D Y |
         | A E | A E | E E |
         | L S | R S | L S |
         | L   | A   | U   |
         | U   | N   | S   |
         | C   | O   | I   |
         |     | I   | O   |
         |     |     | N   |
 NOT ACT  0.200 0.200 0.200
 ACTIVE   0.800 0.800 0.800

30
  RHO PARAMETERS FOR TIME  2

          RESPONSE CATEGORY  1

         | H N | P N | D N |
         | A O | A O | E O |
         | L   | R   | L   |
         | L   | A   | U   |
         | U   | N   | S   |
         | C   | O   | I   |
         |     | I   | O   |
         |     |     | N   |
 NOT ACT  0.800 0.800 0.800
 ACTIVE   0.200 0.200 0.200

          RESPONSE CATEGORY  2

         | H Y | P Y | D Y |
         | A E | A E | E E |
         | L S | R S | L S |
         | L   | A   | U   |
         | U   | N   | S   |
         | C   | O   | I   |
         |     | I   | O   |
         |     |     | N   |
 NOT ACT  0.200 0.200 0.200
 ACTIVE   0.800 0.800 0.800

31
  RHO PARAMETERS FOR TIME  3

          RESPONSE CATEGORY  1

         | H N | P N | D N |
         | A O | A O | E O |
         | L   | R   | L   |
         | L   | A   | U   |
         | U   | N   | S   |
         | C   | O   | I   |
         |     | I   | O   |
         |     |     | N   |
 NOT ACT  0.800 0.800 0.800
 ACTIVE   0.200 0.200 0.200

          RESPONSE CATEGORY  2

         | H Y | P Y | D Y |
         | A E | A E | E E |
```

| | L S | R S | L S |
|---|---|---|---|
| | L | A | U |
| | U | N | S |
| | C | O | I |
| | | I | O |
| | | | N |
| NOT ACT | 0.200 | 0.200 | 0.200 |
| ACTIVE | 0.800 | 0.800 | 0.800 |

32 RHO PARAMETERS FOR TIME 4

RESPONSE CATEGORY 1

| | H N | P N | D N |
|---|---|---|---|
| | A O | A O | E O |
| | L | R | L |
| | L | A | U |
| | U | N | S |
| | C | O | I |
| | | I | O |
| | | | N |
| NOT ACT | 0.800 | 0.800 | 0.800 |
| ACTIVE | 0.200 | 0.200 | 0.200 |

RESPONSE CATEGORY 2

| | H Y | P Y | D Y |
|---|---|---|---|
| | A E | A E | E E |
| | L S | R S | L S |
| | L | A | U |
| | U | N | S |
| | C | O | I |
| | | I | O |
| | | | N |
| NOT ACT | 0.200 | 0.200 | 0.200 |
| ACTIVE | 0.800 | 0.800 | 0.800 |

33 RHO PARAMETERS FOR TIME 5

RESPONSE CATEGORY 1

| | H N | P N | D N |
|---|---|---|---|
| | A O | A O | E O |
| | L | R | L |
| | L | A | U |
| | U | N | S |
| | C | O | I |
| | | I | O |
| | | | N |
| NOT ACT | 0.800 | 0.800 | 0.800 |
| ACTIVE | 0.200 | 0.200 | 0.200 |

RESPONSE CATEGORY 2

| | H Y | P Y | D Y |
|---|---|---|---|
| | A E | A E | E E |
| | L S | R S | L S |
| | L | A | U |
| | U | N | S |
| | C | O | I |
| | | I | O |
| | | | N |
| NOT ACT | 0.200 | 0.200 | 0.200 |
| ACTIVE | 0.800 | 0.800 | 0.800 |

**********

34 DELTA PARAMETERS
DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP

| | TIME 1 | TIME 2 | TIME 3 | TIME 4 | TIME 5 |
|---|---|---|---|---|---|
| NOT ACT | 0.604 | 0.635 | 0.491 | 0.455 | 0.507 |
| ACTIVE | 0.396 | 0.365 | 0.509 | 0.545 | 0.493 |

**********

35 TAU PARAMETERS
TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1 (COLUMNS)
CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIMES T-1 AND T (ROWS)

TRANSITION PROBABILITIES

36 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

| | N | A |
|---|---|---|
| | O | C |
| | T | T |
| | | I |
| | A | V |
| | C | E |
| | T | |
| NOT ACT | 0.668 | 0.332 |
| ACTIVE | 0.584 | 0.416 |

37 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 1 AND 2
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 3

| | N | A |
|---|---|---|
| | O | C |
| | T | T |
| | | I |
| | A | V |

```
                  |  C  |  E  |
                  |  T  |     |
                  |     |     |
 NOT ACT  0.793 0.207
 NOT ACT  0.313 0.687
 ACTIVE   0.223 0.777
 ACTIVE   0.344 0.656

38 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 2 AND 3
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 4
                  |  N  |  A  |
                  |  O  |  C  |
                  |  T  |  T  |
                  |     |  I  |
                  |  A  |  V  |
                  |  C  |  E  |
                  |  T  |     |
                  |     |     |
 NOT ACT  0.287 0.713
 NOT ACT  0.203 0.797
 ACTIVE   0.683 0.317
 ACTIVE   0.869 0.131

39 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIMES 3 AND 4
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 5
                  |  N  |  A  |
                  |  O  |  C  |
                  |  T  |  T  |
                  |     |  I  |
                  |  A  |  V  |
                  |  C  |  E  |
                  |  T  |     |
                  |     |     |
 NOT ACT  0.299 0.701
 NOT ACT  0.242 0.758
 ACTIVE   0.606 0.394
 ACTIVE   0.892 0.108

 PROGRAM FINISHED: Fri Mar 29 16:12:30 2002
 ELAPSED TIME:    0 HOURS,    0 MINUTES,    0 SECONDS.
```

# Explanation of the WinLTA Output File for Example 4

The following sections refer to the example 4 output. The first sections of the output contain a listing of the parameter restrictions, starting values, and other information entered in the program control file. The next section is the iteration history, followed by the parameter estimates. In this example, residuals were not requested, so the parameter estimates are the final section of the output.

**Program Control File Information**

**1** The title lines and comments entered in the General tab will be printed first.

**2** Basic information from the Model and Data tab and the Estimation tab is echoed back in the first section of the output file. The filenames for the control file, the data, and the output are shown first. The next lines include the number of latent statuses, number of items (for statuses), number of participants, number of observed response patterns, maximum number of iterations allowed, convergence criterion, and whether there is missing data in the response patterns. Finally, there is line stating whether or not residuals will be printed.

**Parameter Restrictions**

**3** This section contains a listing of the user-specified parameter restrictions.

**4** In this section, parameter restrictions for the big rho parameters (for items measuring the dynamic latent variable) are printed. These big rho parameters are conditional on latent status and time. The big rho parameter restrictions are sectioned by response categories and by time. These are the big rho parameters for Time 1; the first set is for the first response category, and the second set is for the second response category.

**5** Next is the set of user-specified big rho parameter restrictions for both response categories at Time 2.

**6** Next is the set of user-specified big rho parameter restrictions for both response categories at Time 3.

**7** Next is the set of user-specified big rho parameter restrictions for both response categories at Time 4.

**8** Next is the set of user-specified big rho parameter restrictions for both response categories at Time 5.

**9** In this section, the user-specified parameter restrictions for the delta parameters are printed.

**10** In this section, the user-specified parameter restrictions for the tau parameters are printed.

**11** In this section, the user-specified tau restrictions for the first-order tau parameters are printed. The 1's indicate that they will all be estimated freely.

**12** These are the user-specified parameter restrictions for the second-order tau parameters representing movement from Time 1 and Time 2 to Time 3.

**13** These are the user-specified parameter restrictions for the second-order tau parameters representing movement from Time 2 and Time 3 to Time 4.

**14** These are the user-specified parameter restrictions for the second-order tau parameters representing movement from Time 3 and Time 4 to Time 5.

**Starting Values**

**15** This section contains a listing of user-specified starting values for the parameters.

**16** These are the starting values for the big rho parameters, the response probabilities for items measuring the dynamic latent variable conditional on latent status and time. Starting values for the big rhos were only entered for Time 1; the program assumes that the big rho parameters will be started equal across times.

**17** These are the user-specified starting values for the big rho parameters for Time 2.

**18** These are the user-specified starting values for the big rho parameters for Time 3.

**19** These are the user-specified starting values for the big rho parameters for Time 4.

**20** These are the user-specified starting values for the big rho parameters for Time 5.

**21** In this section, user-specified starting values for the delta parameters are printed.

**22** In this section, user-specified starting values for the tau parameters are printed.

**23** In this section, user-specified starting values for the first-order tau parameters are printed.

**24** In this section, user-specified starting values for the second-order tau parameters are printed. These parameters represent movement from Time 1 and Time 2 to Time 3.

**25** In this section, user-specified starting values for the second-order tau parameters are printed. These parameters represent movement from Time 2 and Time 3 to Time 4.

**26** In this section, user-specified starting values for the second-order tau parameters are printed. These parameters represent movement from Time 3 and Time 4 to Time 5.

**Iteration History**

**27** This section contains the iteration history of the EM run.

**28** This is the final $G^2$.

**Parameter Estimates**

The estimates for the parameters are printed in the next sections of output.

Big Rho Parameters

**29-33** The big rho parameters are the probabilities of a particular item response conditional on latent status and time. The probabilities are grouped by response category for each time. The big rho parameters for Time 1 are in section **29**, the big rho parameter estimates for Time 2 are in section **30**, and so on. The rho parameters were constrained to be equal across times, so they will all be the same for every occasion of measurement.

Delta Parameters

**34** The estimates for the delta parameters are the probabilities of latent status membership. For example, the probability of a participant's being not actively psychotic at Time 1 was estimated at 0.604, and the probability of a participant's being actively psychotic at the fourth year was estimated at 0.545.

Tau Parameters

**35** For second-order models, the tau parameters between Time 1 and 2 are the probabilities of being in a latent status at Time 2 conditional on being in a particular latent status at Time 1. For later times, the tau parameters are the probabilities of being in a particular latent status at Time T+2, given latent status membership at Time T and Time T +1.

**36** These are the Time 1 to Time 2 (first-order) transition probability estimates. For instance, given membership in latent status 1 (not actively psychotic) at Time 1, the probability of being in latent status 2 (actively psychotic) at Time 2 was estimated at 0.332.

**37** These are the first set of second-order transition probability estimates. Latent status membership at Time 3 is conditional on latent status memberships at both Times 1 and 2. For example, the probability of being in latent status 1 (not actively psychotic) at Time 3 given membership in latent status 2 (actively psychotic) at Time 1 and the not actively psychotic latent status at Time 2 is 0.223.

**38** These are the Time 2 and Time 3 to Time 4 (second-order) transition probability estimates. For example, the probability of being in latent status 2 (actively psychotic) at Time 4 given membership in latent status 2 at Time 2 and latent status 2 at Time 3 is 0.131.

**39** These are the second-order transition probability estimates for movement from Time 3 and Time 4 to Time 5. For example, the probability of being in latent status 1 at Time 5 given membership in latent status 1 at Time 3 and latent status 1 at Time 4 is 0.299.

**Response Patterns and Statistics**

If requested by the option in the General tab, response patterns and residuals are printed. These were not requested in this example. For an example in which residuals are printed, see Example 2.

# Example 5

## A Latent Transition Example

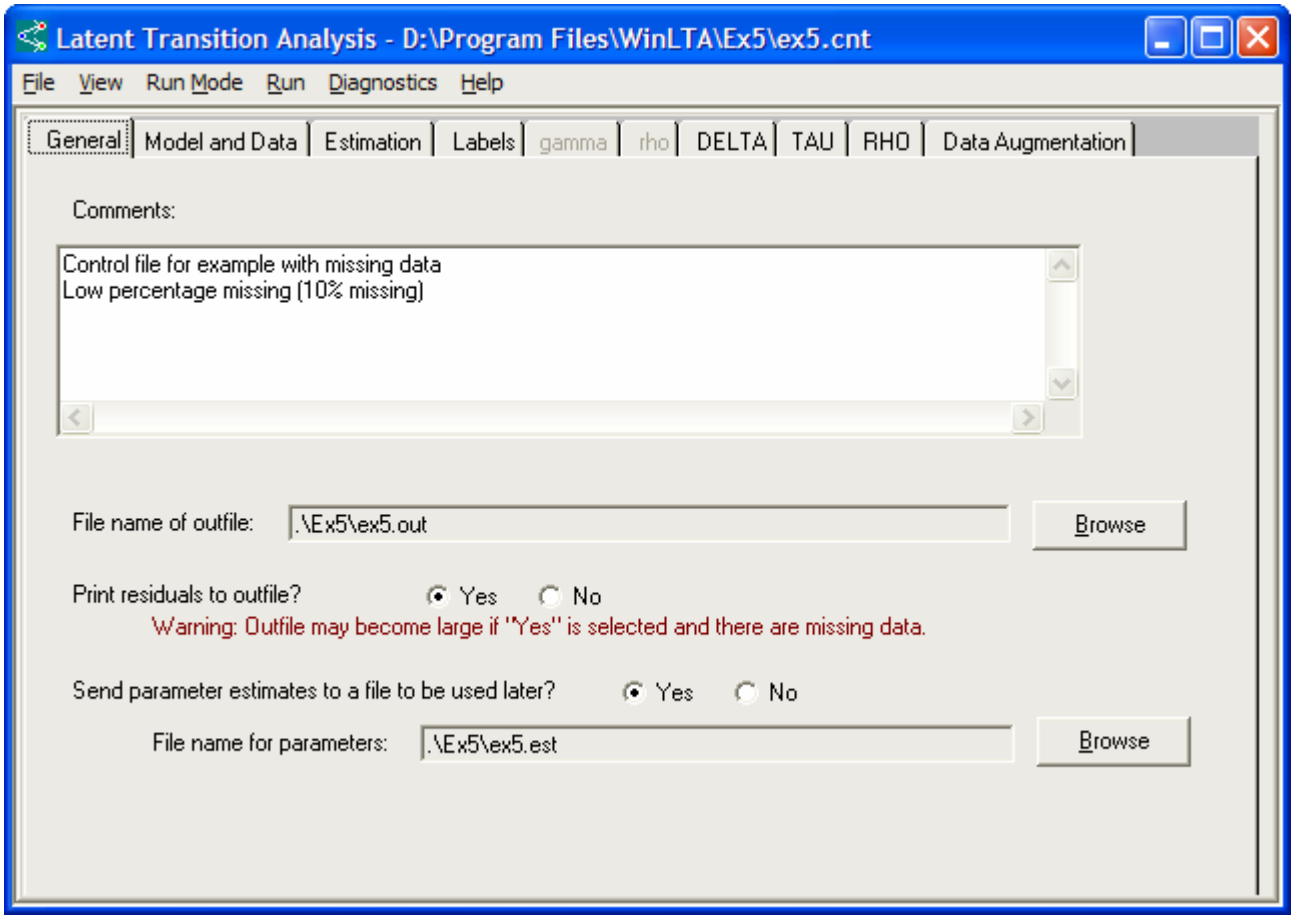
## with Missing Data

# Example 5

Below is an example of a program control file that is used with the WinLTA program. This example is a latent transition problem with approximately 10% missing data. The data are artificial, but for ease of exposition let us assume that the participants are 200 high school students who were surveyed about substance use in their junior and senior year. The students have been asked at both occasions of measurement about whether or not they have recently engaged in the following behaviors: alcohol or tobacco use, drunkenness, marijuana use, and cocaine use. The answers to those questions will be used to determine the students' membership in one of five latent statuses regarding substance use. Because substance use behavior may advance over time, this is the dynamic latent variable.

Quantities such as starting values, which parameters to estimate, parameter restrictions, and number of latent statuses will need to be entered into WinLTA depending upon the model chosen. To begin entering information into WinLTA, first click on File, and choose New Control File. A series of tabs will appear. Select the General tab, as shown below. If you would like to follow along with these examples instead of entering your own information, click on File, Open Control File, and choose the folder for Example 5. Then open the file called ex5.cnt.

*General tab window*




Listed below are the field descriptions for the General tab:

- **Comments:** Enter titles or comments in this space. These will be the first lines in the output.

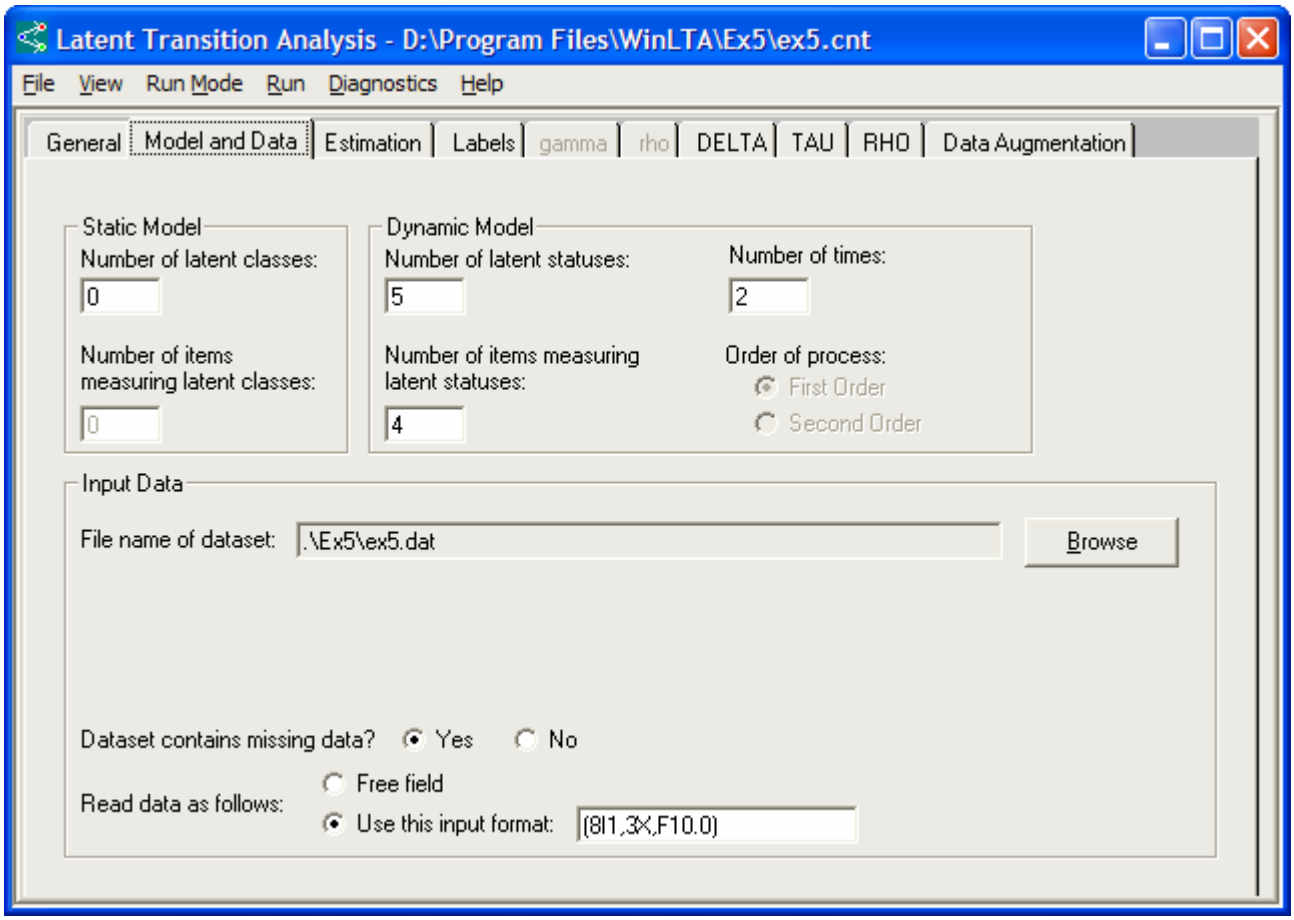
- **File name of outfile:** Specify the file in which the output will be saved by pressing the browse button.

- **Print residuals to outfile?:** Allows you to choose whether the residuals will be included in the output file. Note that when the data set includes missing data, traditional residuals will not be printed. Instead, fit indicators will be printed which can be used to assess model fit. See the main WinLTA manual for more information on fit indicators.

- **Send parameter estimates to a file to be used later?:** If you choose yes for this option, the parameter estimates will be saved in a separate file, which will allow you to use crossvalidation or to continue the run if it fails to converge. Select this filename by pressing the browse button to call up a Save As dialog box.

Next, click on the Model and Data tab, as shown below.

*Model and Data tab window*




Listed below are the field descriptions for the Model and Data tab:

- **Static Model:** This section contains information about the static latent variable.
- **Number of latent classes:** 0
- **Number of items measuring latent classes:** 0

- **Dynamic Model:** This section contains information about the dynamic latent variable.
- **Number of latent statuses:** 5
- **Number of items measuring latent statuses:** 4
- **Number of times:** 2
- **Order of process:** First order.

- **Input Data:**
- **File name of dataset:** Select the file by pressing the browse button. A dialog box will appear in which you can search for a file to open (not shown). This dialog box automatically lists files that are in .dat format, but you can change this to view all files (*.*) if necessary.
- **Dataset contains missing data?:** If the dataset contains missing data, select yes; otherwise, select no. In this example, yes is selected. Remember that missing data must always be coded as 0 in the dataset.
- **Read data as follows:** This option allows you to specify free field or an input format. If each field is separated by one or more spaces, it is not necessary to specify an input format. In this case, choose the free field option. If each variable is not separated by a space, you will need to specify an input format. Use a Fortran-type input format for this purpose.

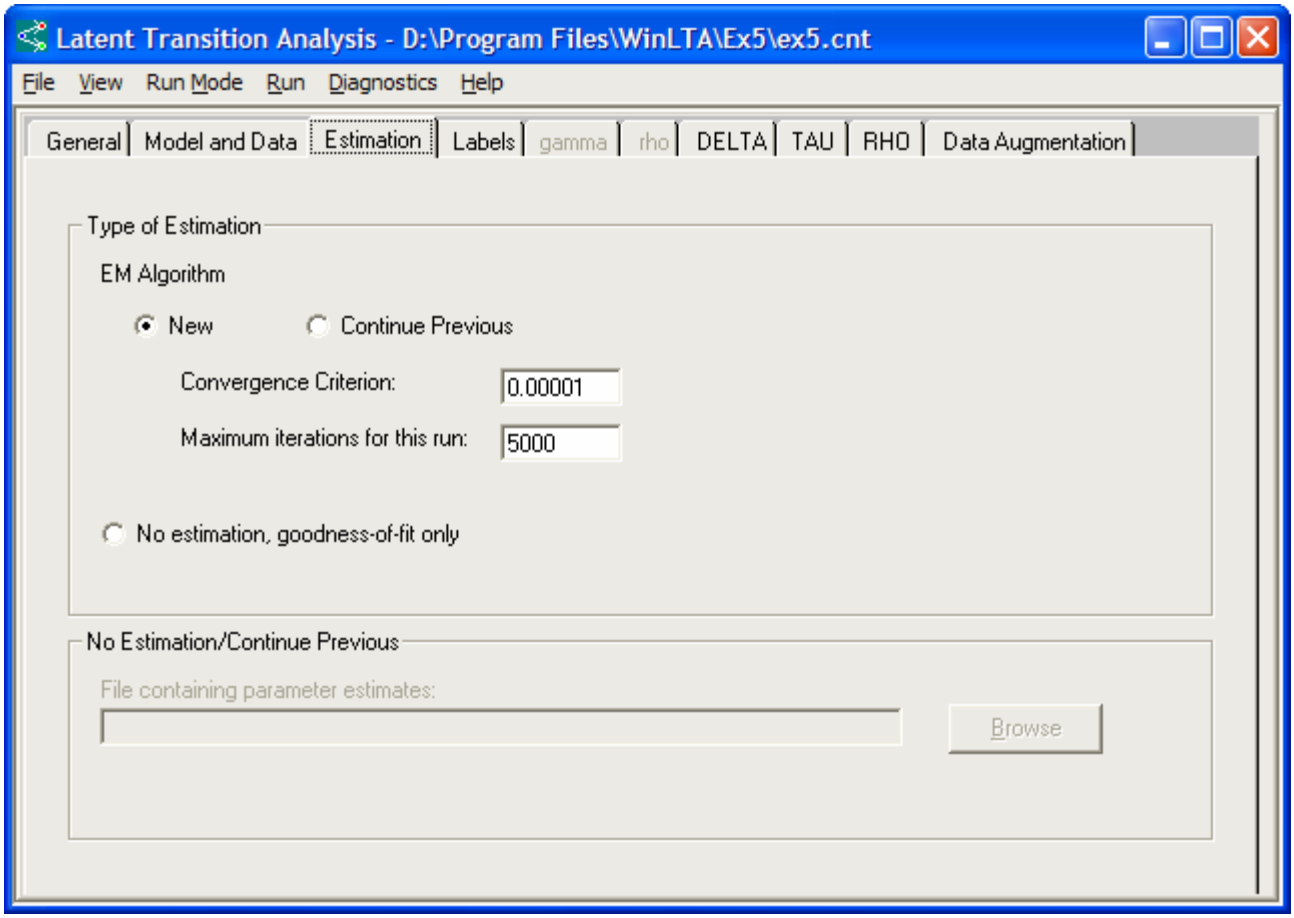
  In this example, the dataset is in the following format:

```
21100000   1
21200000   1
11110000   8
21110000   1…
```

  The Fortran input format for this data is (8I1, 3X, F10.0). 8I1 indicates that there are eight columns with one integer in each column. 3X indicates three columns that are blank, or that act as a space. F10.0 provides information about the column that contains the number of subjects having each response pattern. This is a real number that is 10 digits long and has 0 digits after the decimal place. This allows for the possibility that there are 1,000,000,000 or more subjects in a particular response pattern, although this is not the case in this dataset. More information about input formats as well as another example can be found in the Help file in WinLTA.

Next, choose the Estimation tab, as shown below.

*Estimation tab window*



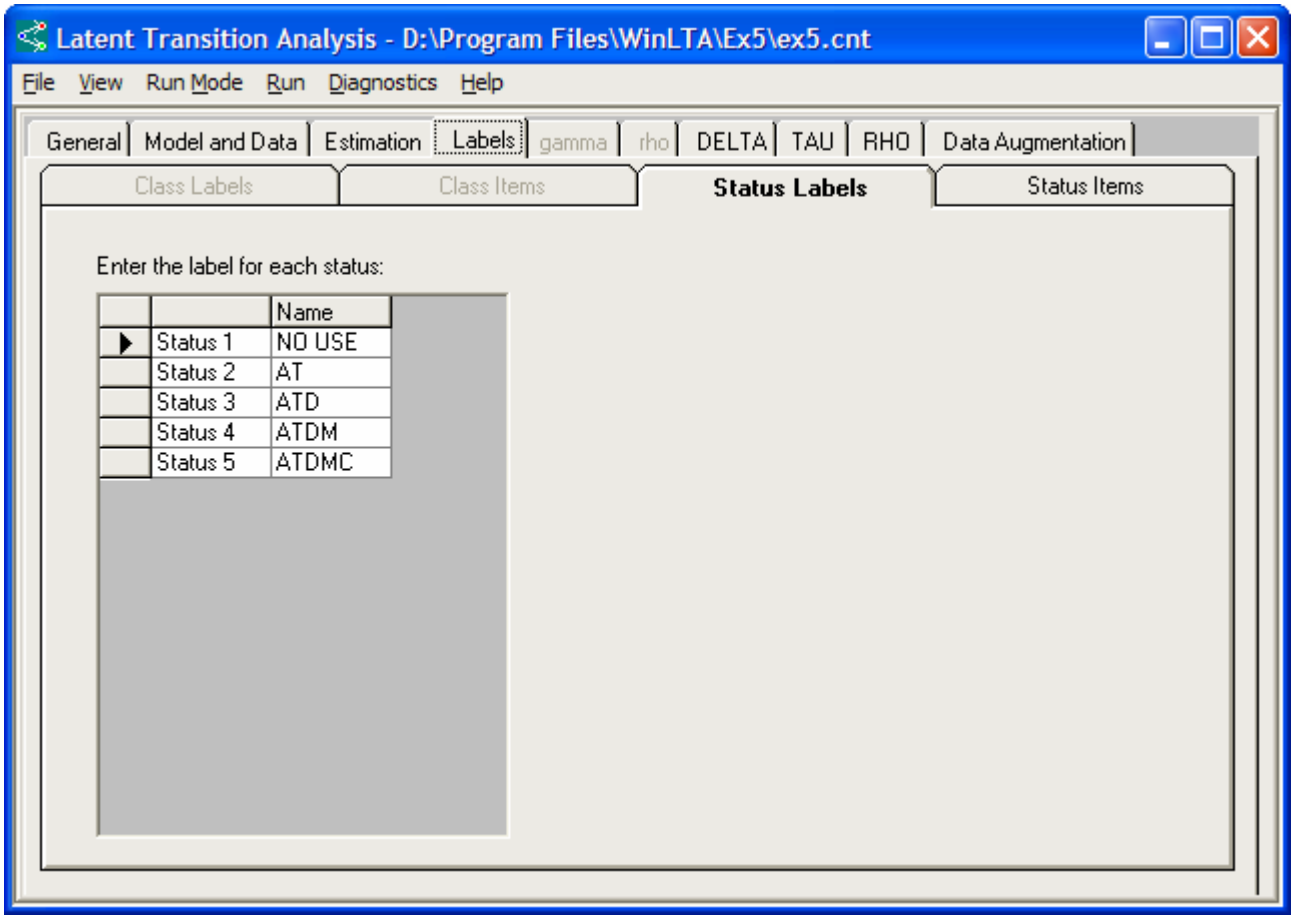

Listed below are the field descriptions for the Estimation tab:

- **Type of estimation:**
- **EM Algorithm:**
  - **New/Continue Previous:** For new runs, select New. Select Continue Previous only when you want to continue a run that previously failed to converge. (See "How to Continue a Run That Did Not Converge" in the manual.)
  - **Convergence Criterion:** When the Mean Absolute Deviation (MAD) reaches or falls below this number, the program has converged and will stop the estimation. In this example, it is set to $10^{-5}$.
  - **Maximum iterations for this run:** In this example, if 5000 iterations are reached, the program will stop whether or not convergence has been reached.
- **No estimation, goodness-of-fit only:** If this option is selected, the parameters will not be estimated. Only a goodness-of-fit statistic for the entire model will be produced. (See "How to Crossvalidate" in the manual.)

- **File containing parameter estimates:** If you choose to continue a previous run or if you select no estimation, a filename containing parameter estimates will need to be entered. Select this file by pressing the browse button.

Then move on to the Labels tab. There are two tabs nested within the Labels tab. For a latent transition model such as this one (which involves only a dynamic latent variable) the two tabs that require information to be entered are the Status Labels tab and the Status Items tab. The Status Labels tab is shown below.

*Labels—Status Labels tab window*

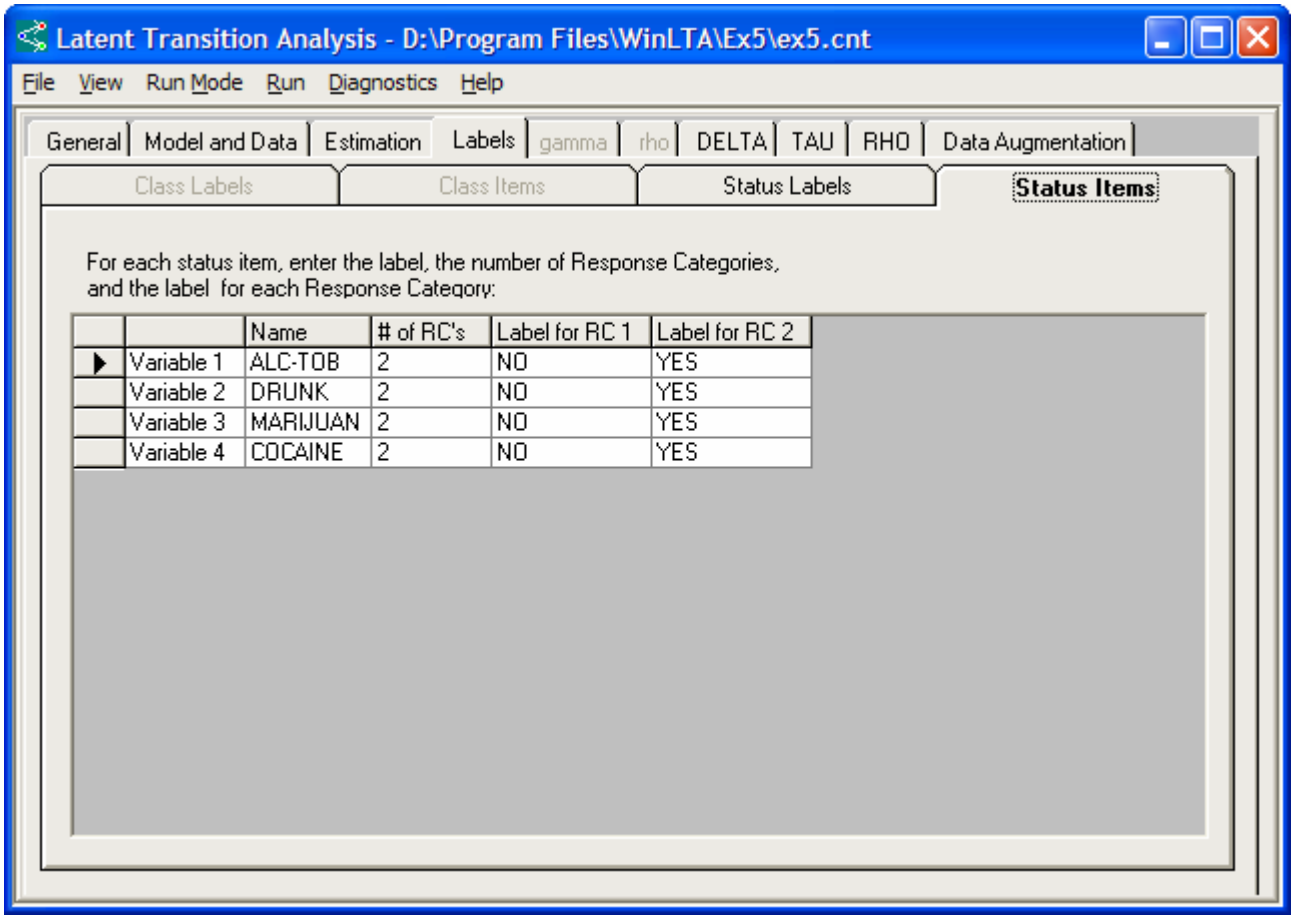



Listed below are the field descriptions for the Labels—Status Labels tab:

- This tab asks you to enter a label for each status. There is a limit of 8 characters per label.

The other tab that is found within the Labels tab is the Status Items tab.

*Labels—Status Items tab window*

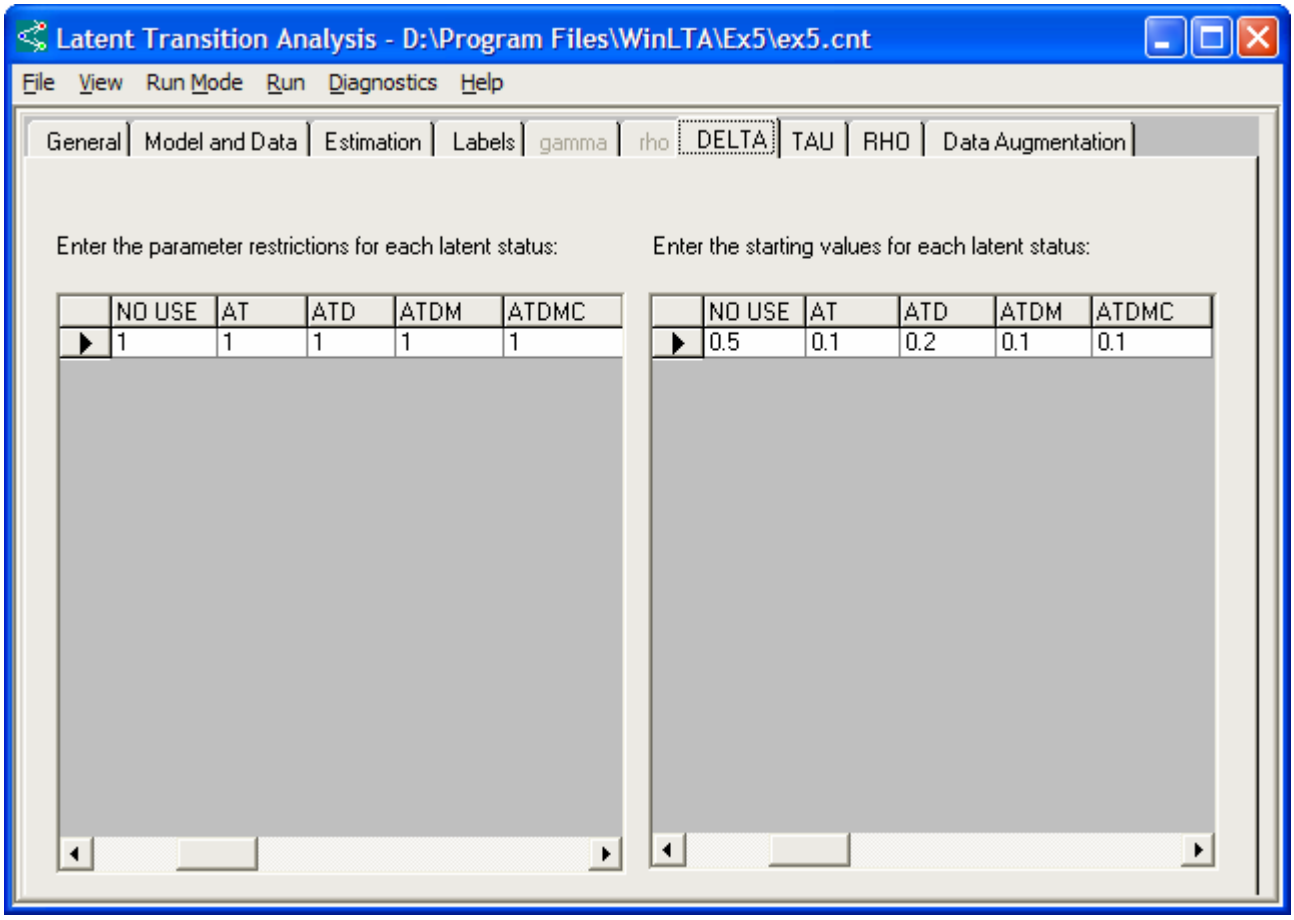



Listed below are the field descriptions for the Labels—Status Items tab:

- **Status items:** In the Model and Data tab, you entered the number of items measuring the latent statuses. In this example, there are 4 items. Accordingly, these items are listed as 4 **variables** in the Status Items tab. For each of these items, enter a **label**, the **number of response categories**, and a **label for each of the response categories**. In this example, the first variable is named "ALC-TOB" and it has 2 response categories. Response category #1 is named "NO" and response category #2 is named "YES." Note that you do not need to label the response category 0 for missing data.

The first parameter that you will enter information about is the delta parameter.

*DELTA tab window*




Listed below are the field descriptions for the DELTA tab:

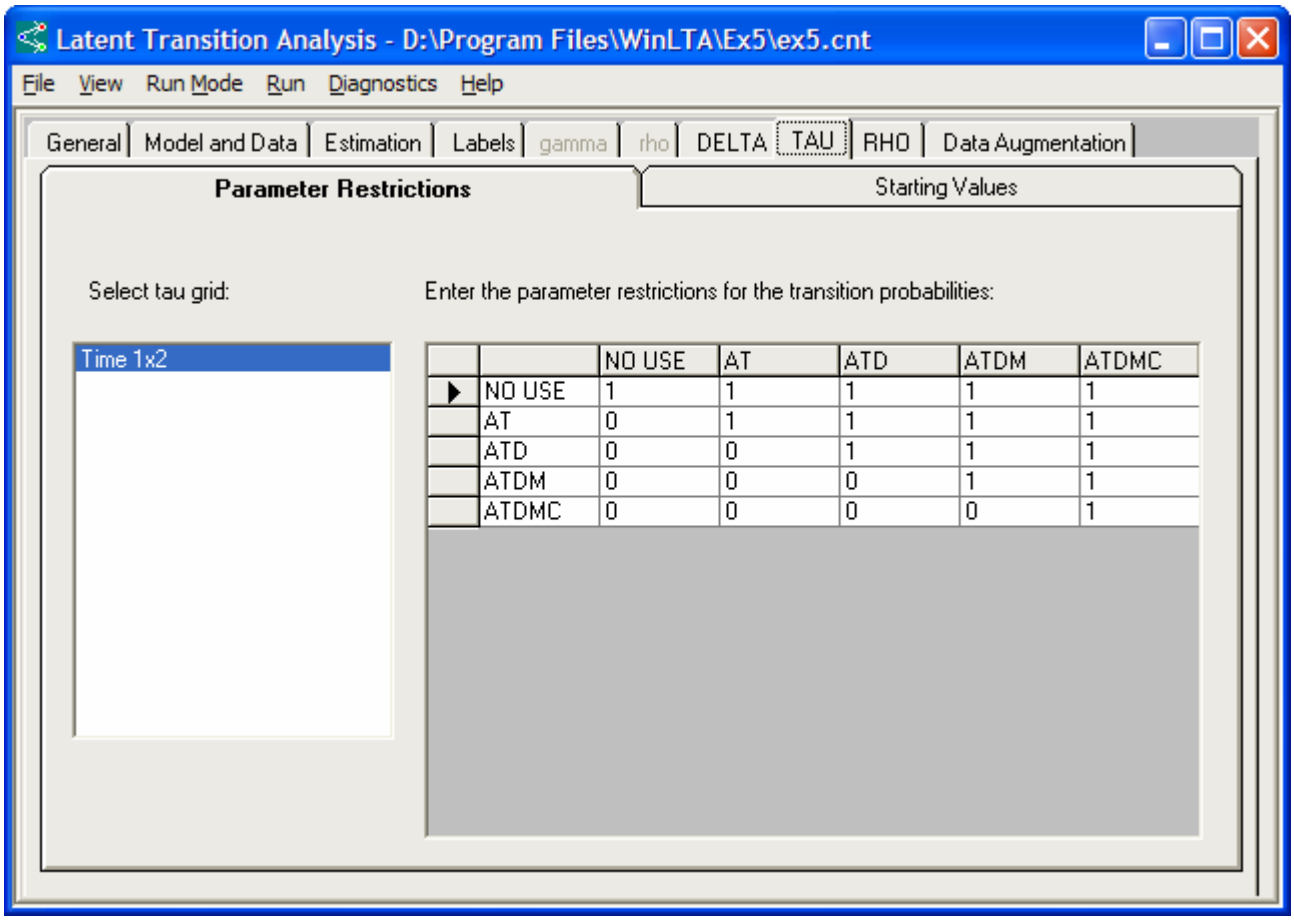
- **Enter the parameter restrictions for each latent status:** The delta parameters represent the unconditional probability of being in a latent status at a given occasion of measurement. They can be constrained, estimated freely, or not estimated at all. Enter a "1" if you want the parameter to be estimated freely. Enter a "0" if the parameter will not be estimated at all (i.e., it will be fixed at the starting value). Enter a "2" or greater to indicate that the parameter is constrained. In this example, all deltas are estimated freely.

- **Enter the starting values for each status:** These are the starting values for the delta parameters; note that they must sum to one.

- The horizontal scroll bar at the bottom of each column will allow you to view all of the statuses.

Next, move on to the TAU tab. Two tabs are nested within this tab. First, click on the Parameter Restrictions tab.

*TAU—Parameter Restrictions tab window*

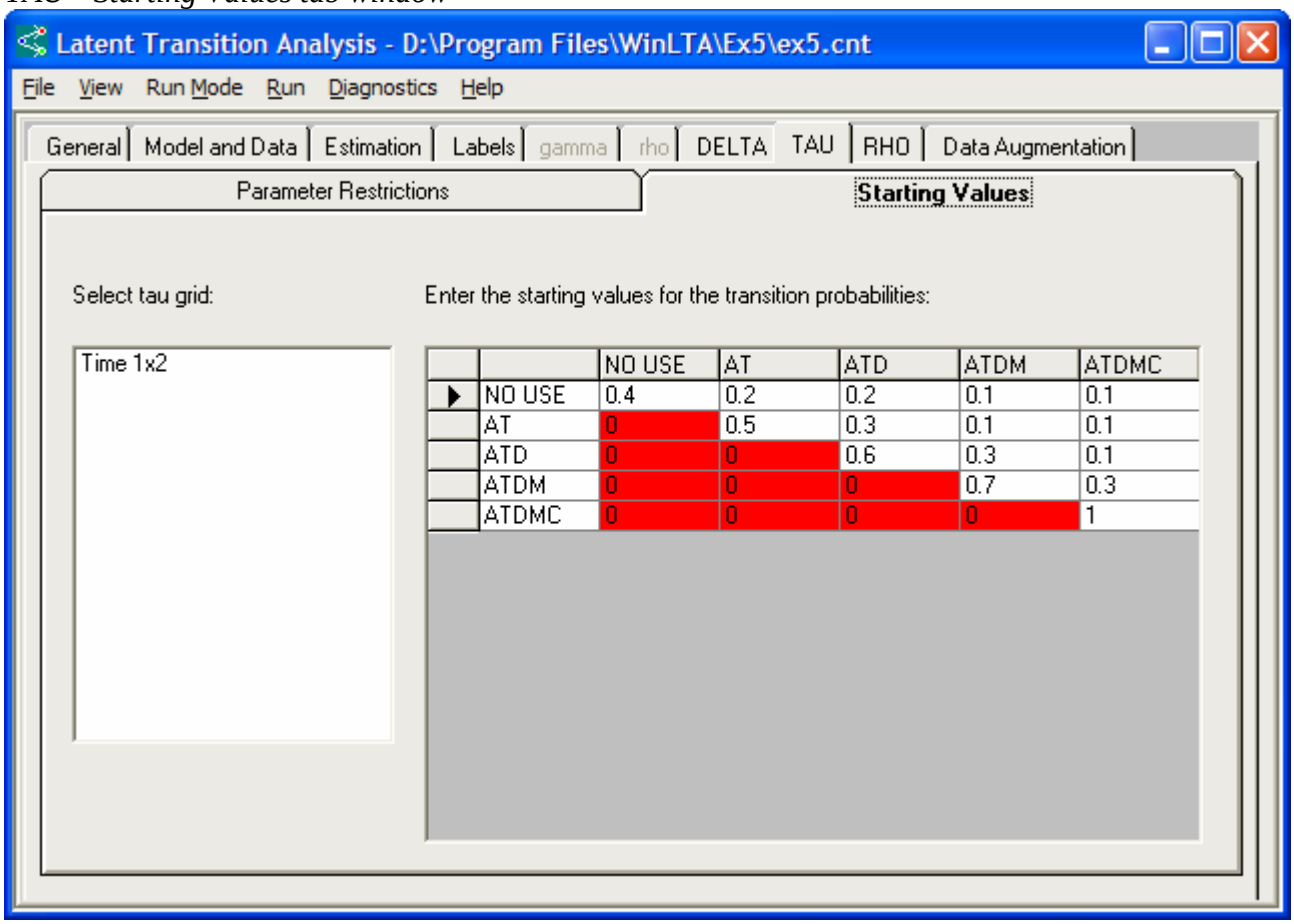



Listed below are the field descriptions for the TAU—Parameter Restrictions tab:

- In the grid, enter the restrictions for the tau parameters. There is a row and a column for each latent status, so this matrix is 5 x 5. In this example, only the upper triangle of the tau matrix will be freely estimated. It is our intention to test a model that does not allow backward movement. We will fix the lower triangle of the tau matrix here, and on the TAU—Starting Values tab we will indicate the value to which we want the taus fixed.

The other tab found within the TAU tab is the TAU—Starting Values tab, shown below.

*TAU—Starting Values tab window*

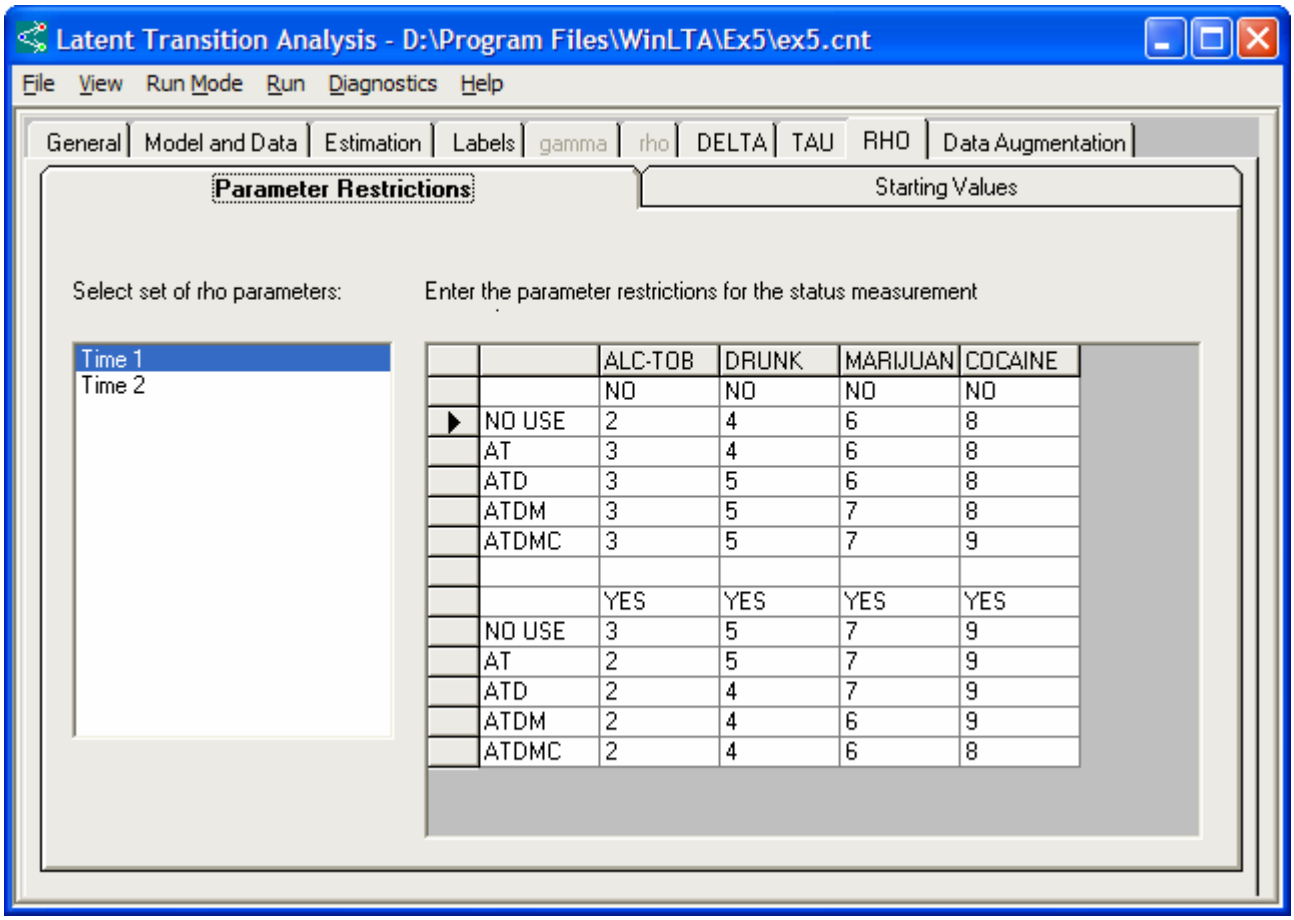



Listed below are the field descriptions for the TAU—Starting Values tab:

- In this grid, enter the starting values for the tau parameters. The probabilities along the main diagonal are usually started higher than the off-diagonal probabilities, since they represent the probability of being in the original latent status at the second occasion of measurement.
- Note that the lower triangle of the matrix appears in red. These starting values must all be "0" because we are interested in testing a model where backward movement is not allowed.

Finally, select the RHO tab. Two tabs are nested within this tab: the Parameter Restrictions tab, shown below, and the Starting Values tab.

*RHO—Parameter Restrictions tab window*




| | | ALC-TOB | DRUNK | MARIJUAN | COCAINE |
|---|---|---|---|---|---|
| | | NO | NO | NO | NO |
| ▶ | NO USE | 2 | 4 | 6 | 8 |
| | AT | 3 | 4 | 6 | 8 |
| | ATD | 3 | 5 | 6 | 8 |
| | ATDM | 3 | 5 | 7 | 8 |
| | ATDMC | 3 | 5 | 7 | 9 |
| | | | | | |
| | | YES | YES | YES | YES |
| | NO USE | 3 | 5 | 7 | 9 |
| | AT | 2 | 5 | 7 | 9 |
| | ATD | 2 | 4 | 7 | 9 |
| | ATDM | 2 | 4 | 6 | 9 |
| | ATDMC | 2 | 4 | 6 | 8 |

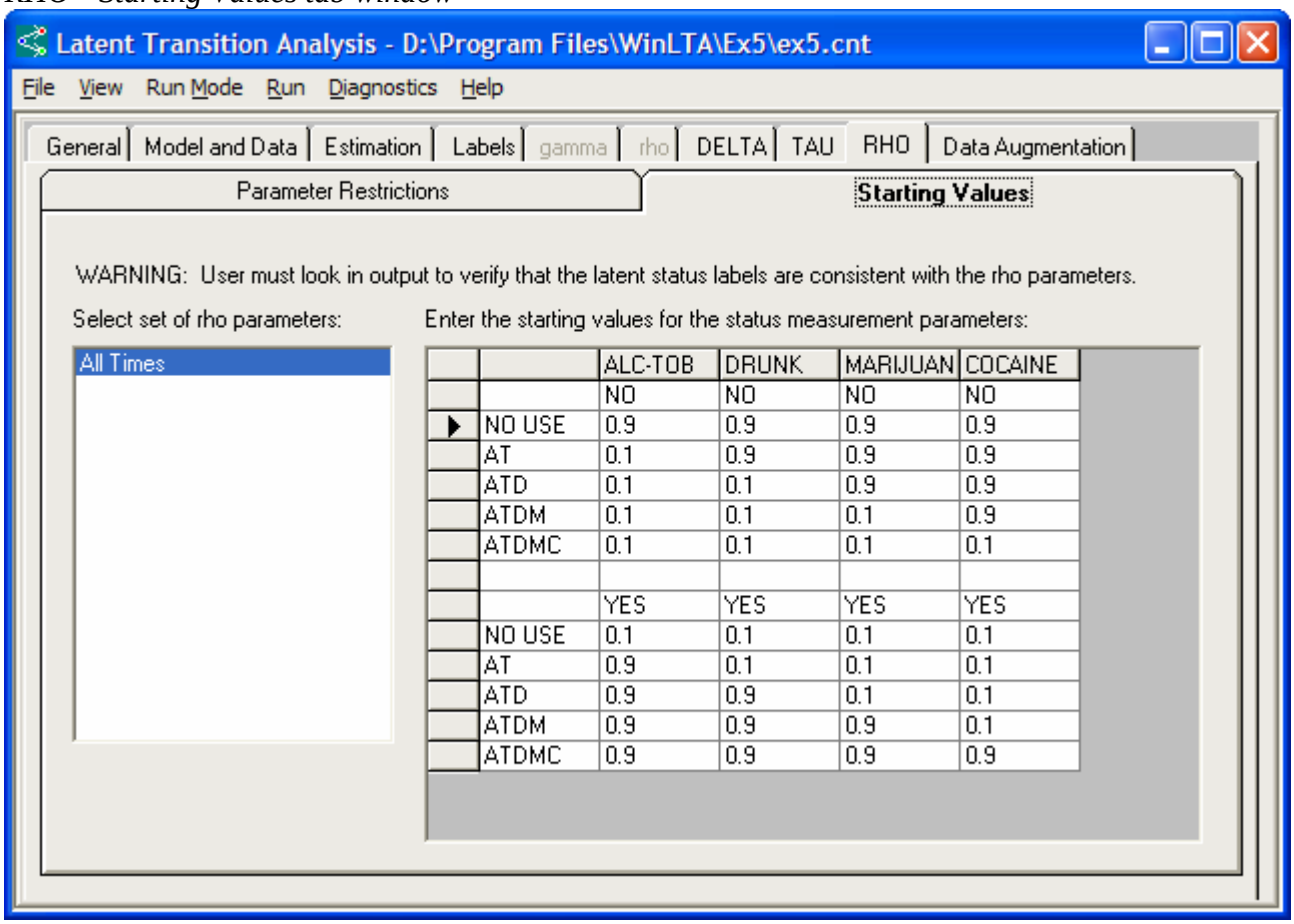
It is important to note that there is a rho parameter for each combination of latent status (rows), substance use item (columns), response category, and time. In this example, the rho parameters have been constrained to be equal across times.

Listed below are the field descriptions for the RHO—Parameter Restrictions tab:

- The upper matrix contains the parameter restrictions for the first response category (1 = no) for Time 1.
- The lower matrix contains the parameter restrictions for the second response category (2 = yes) for Time 1. If the rho parameters for the first response category have been constrained, then those for the second response category must also be constrained. Keep in mind that each corresponding rho parameter for the two response categories should sum to one.
- To enter the parameter restrictions for the second occasion of measurement, select Time 2 on the left of the window. Enter these restrictions just as you did for Time 1. Because the measurement parameters are constrained to be equal across times in this example, the two sets of constraints (Time 1 and Time 2) are identical.

The final tab is the RHO—Starting Values tab.

*RHO—Starting Values tab window*




Listed below are the field descriptions for the RHO—Starting Values tab:

- The upper matrix contains the starting values for the measurement parameters in the first response category. The probabilities in this matrix must sum to one with the probabilities in the corresponding lower matrix (for the second response category), or the program will be terminated and an error message will pop up.
- The lower matrix contains the starting values for the rho parameters in the second response category. The program assumes that the measurement parameters will have the same starting values for all occasions of measurement, so no additional input is necessary.

# Saving Your Work and Running WinLTA

- **Saving the control file:** In WinLTA, click on File, and then Save. If this is the first time you have saved this file, a Save As dialog box will appear. In this box you can choose the location of the file and you will be required to enter a filename. By default, the file will be saved with the file extension .cnt.

- **To run WinLTA:** Once the information is completely entered into the control file, click on Run, and then Run EM. EM will begin running automatically. If you have not saved the current version of the control file, you will see a dialog box that asks you if you would like to save before proceeding. Choosing Yes will save the file and run EM automatically. Choosing No will run EM without saving the file. Choosing Cancel will allow you to return to the control file without running EM.

    - Once EM begins running, a separate dialog box entitled "LTA EM Run" will appear on your screen and WinLTA will automatically be minimized. This dialog box tells you the status of the EM run as well as the date and time the run began and finished. The box also has two buttons: Abort and Get Info. Pressing the Abort button during the run will cancel the run. Pressing Get Info gives you the iteration number and the MAD at the time shown, although the information is automatically updated every 5 seconds. Once the run is finished (because the run has converged, you pressed Abort, or the maximum number of iterations has been reached), the Abort button changes to Close. When you press the Close button, WinLTA will automatically be restored as the active window. You can still access WinLTA on your taskbar without pressing the Close button, but Close must be pressed before another EM run can be started.

- **Viewing the WinLTA outfile:** Once the EM run is completed, you can view the output file by clicking on View, and Current LTA Outfile (if you would like to view an older saved outfile, click on Choose LTA Outfile). This will bring up the output file that corresponds with the last EM run.

# The WinLTA Output File

The following is an example of an output file from the WinLTA program. The endnote reference numbers that have been added to the output correspond to the endnotes that follow.

```
1PROGRAM STARTED:       Fri Mar 29 16:45:21 2002

* Control file for example with missing data
* Low percentage missing (10% missing)

 ************************************************

2INFORMATION ABOUT THIS JOB:

 RUN TYPE: PARAMETER ESTIMATION BY EM

 CONTROL DATA READ FROM FILE:
D:\WinLTA\Ex5\ex5.cnt

 DATA ANALYZED IN THIS RUN READ FROM FILE:
.\Ex5\ex5.dat

 OUTPUT SAVED IN FILE:
.\Ex5\ex5.out

 PARAMETER ESTIMATES SAVED IN FILE:
.\Ex5\ex5.est


 STATIC LATENT VARIABLE                      NO

 DYNAMIC LATENT VARIABLE                    YES
 NUMBER OF LATENT STATUSES                    5
 NUMBER OF OCCASIONS OF MEASUREMENT           2
 NUMBER OF MANIFEST ITEMS PER OCCASION        4
 TYPE OF PROCESS                    FIRST-ORDER

 NUMBER OF SUBJECTS                         200
 NUMBER OF UNIQUE RESPONSE PATTERNS         122
 MAXIMUM NUBMER OF ITERATIONS              5000
 CONVERGENCE CRITERION          .00001000000000
 MISSING DATA IN RESPONSE PATTERNS          YES
 PRINT RESIDUALS                            YES

 ************************************************


3THE FOLLOWING PARAMETER RESTRICTIONS HAVE BEEN SPECIFIED
 WHERE 0=FIXED TO START VALUE
       1=FREE
       2 OR GREATER MEANS CONSTRAINED EQUAL TO ANY OTHER
         PARAMETER WITH THE SAME DESIGNATION

 ************************************************

4BIG RHO PARAMETER RESTRICTIONS
 BIG RHOS ARE PROBABILITIES OF RESPONSE
 TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
 CONDITIONAL ON LATENT STATUS AND TIME

          BIG RHO PARAMETER RESTRICTIONS FOR TIME  1

          RESPONSE CATEGORY  1

          | A N | D N | M N | C N |
          | L O | R O | A O | O O |
          | C   | U   | R   | C   |
          | -   | N   | I   | A   |
          | T   | K   | J   | I   |
          | O   |     | U   | N   |
          | B   |     | A   | E   |
          |     |     | N   |     |
NO USE      2     4     6     8
AT          3     4     6     8
ATD         3     5     6     8
ATDM        3     5     7     8
ATDMC       3     5     7     9

          RESPONSE CATEGORY  2

          | A Y | D Y | M Y | C Y |
          | L E | R E | A E | O E |
          | C S | U S | R S | C S |
          | -   | N   | I   | A   |
          | T   | K   | J   | I   |
          | O   |     | U   | N   |
          | B   |     | A   | E   |
          |     |     | N   |     |
NO USE      3     5     7     9
AT          2     5     7     9
ATD         2     4     7     9
ATDM        2     4     6     9
ATDMC       2     4     6     8

          BIG RHO PARAMETER RESTRICTIONS FOR TIME  2

          RESPONSE CATEGORY  1

          | A N | D N | M N | C N |
          | L O | R O | A O | O O |
          | C   | U   | R   | C   |
          | -   | N   | I   | A   |
          | T   | K   | J   | I   |
          | O   |     | U   | N   |
          | B   |     | A   | E   |
          |     |     | N   |     |
NO USE      2     4     6     8
AT          3     4     6     8
ATD         3     5     6     8
ATDM        3     5     7     8
ATDMC       3     5     7     9
```

```
          RESPONSE CATEGORY  2

         | A Y | D Y | M Y | C Y |
         | L E | R E | A E | O E |
         | C S | U S | R S | C S |
         | -   | N   | I   | A   |
         | T   | K   | J   | I   |
         | O   |     | U   | N   |
         | B   |     | A   | E   |
         |     |     | N   |     |
 NO USE      3     5     7     9
 AT          2     5     7     9
 ATD         2     4     7     9
 ATDM        2     4     6     9
 ATDMC       2     4     6     8

 ************************************************
```

5 DELTA PARAMETER RESTRICTIONS
DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP

```
          TIME 1
 NO USE      1
 AT          1
 ATD         1
 ATDM        1
 ATDMC       1

 ************************************************
```

6 TAU PARAMETER RESTRICTIONS
TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1 (COLUMNS)
CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)

TRANSITION PROBABILITIES

ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

```
         |  N |  A |  A |  A |  A |
         |  O |  T |  T |  T |  T |
         |    |    |  D |  D |  D |
         |  U |    |    |  M |  M |
         |  S |    |    |    |  C |
         |  E |    |    |    |    |
         |    |    |    |    |    |
         |    |    |    |    |    |
 NO USE     1    1    1    1    1
 AT         0    1    1    1    1
 ATD        0    0    1    1    1
 ATDM       0    0    0    1    1
 ATDMC      0    0    0    0    1

 ************************************************
```

7 START VALUES

```
 ************************************************
```

BIG RHO PARAMETERS
BIG RHOS ARE PROBABILITIES OF RESPONSES
TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
CONDITIONAL ON LATENT STATUS AND TIME

8 RHO PARAMETERS FOR TIME  1

```
          RESPONSE CATEGORY  1

         | A N | D N | M N | C N |
         | L O | R O | A O | O O |
         | C   | U   | R   | C   |
         | -   | N   | I   | A   |
         | T   | K   | J   | I   |
         | O   |     | U   | N   |
         | B   |     | A   | E   |
         |     |     | N   |     |
 NO USE   0.900 0.900 0.900 0.900
 AT       0.100 0.900 0.900 0.900
 ATD      0.100 0.100 0.900 0.900
 ATDM     0.100 0.100 0.100 0.900
 ATDMC    0.100 0.100 0.100 0.100

          RESPONSE CATEGORY  2

         | A Y | D Y | M Y | C Y |
         | L E | R E | A E | O E |
         | C S | U S | R S | C S |
         | -   | N   | I   | A   |
         | T   | K   | J   | I   |
         | O   |     | U   | N   |
         | B   |     | A   | E   |
         |     |     | N   |     |
 NO USE   0.100 0.100 0.100 0.100
 AT       0.900 0.100 0.100 0.100
 ATD      0.900 0.900 0.100 0.100
 ATDM     0.900 0.900 0.900 0.100
 ATDMC    0.900 0.900 0.900 0.900
```

RHO PARAMETERS FOR TIME  2

RESPONSE CATEGORY  1

| | A N L O C - T O B | D N R O U N K | M N A O R I J U A N | C N O O C A I N E |
|---|---|---|---|---|
| NO USE | 0.900 | 0.900 | 0.900 | 0.900 |
| AT | 0.100 | 0.900 | 0.900 | 0.900 |
| ATD | 0.100 | 0.100 | 0.900 | 0.900 |
| ATDM | 0.100 | 0.100 | 0.100 | 0.900 |
| ATDMC | 0.100 | 0.100 | 0.100 | 0.100 |

RESPONSE CATEGORY 2

| | A Y L E C S - T O B | D Y R E U S N K | M Y A E R S I J U A N | C Y O E C S A I N E |
|---|---|---|---|---|
| NO USE | 0.100 | 0.100 | 0.100 | 0.100 |
| AT | 0.900 | 0.100 | 0.100 | 0.100 |
| ATD | 0.900 | 0.900 | 0.100 | 0.100 |
| ATDM | 0.900 | 0.900 | 0.900 | 0.100 |
| ATDMC | 0.900 | 0.900 | 0.900 | 0.900 |

**********

**9** DELTA PARAMETERS
DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP

| | TIME 1 |
|---|---|
| NO USE | 0.500 |
| AT | 0.100 |
| ATD | 0.200 |
| ATDM | 0.100 |
| ATDMC | 0.100 |

**********

**10** TAU PARAMETERS
TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1 (COLUMNS)
CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)

TRANSITION PROBABILITIES

ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

| | N O U S E | A T | A T D | A T D M | A T D M C |
|---|---|---|---|---|---|
| NO USE | 0.400 | 0.200 | 0.200 | 0.100 | 0.100 |
| AT | 0.000 | 0.500 | 0.300 | 0.100 | 0.100 |
| ATD | 0.000 | 0.000 | 0.600 | 0.300 | 0.100 |
| ATDM | 0.000 | 0.000 | 0.000 | 0.700 | 0.300 |
| ATDMC | 0.000 | 0.000 | 0.000 | 0.000 | 1.000 |

**********

**11** ITERATION HISTORY

**********

STARTING G-SQUARED= 436.446

| ITERATION | MAD | ITERATION | MAD | ITERATION | MAD |
|---|---|---|---|---|---|
| 1 | .0130763992 | 2 | .0077898742 | 3 | .0048851999 |
| 4 | .0036511828 | 5 | .0028022235 | 6 | .0021847718 |
| 7 | .0017269112 | 8 | .0013890233 | 9 | .0011328384 |
| 10 | .0009358235 | 11 | .0007812873 | 12 | .0006586742 |
| 13 | .0005603412 | 14 | .0004806826 | 15 | .0004155394 |
| 16 | .0003617927 | 17 | .0003222516 | 18 | .0002891574 |
| 19 | .0002604474 | 20 | .0002354328 | 21 | .0002135465 |
| 22 | .0001943188 | 23 | .0001773590 | 24 | .0001623406 |
| 25 | .0001494657 | 26 | .0001387463 | 27 | .0001290481 |
| 28 | .0001202404 | 29 | .0001124374 | 30 | .0001052406 |
| 31 | .0000985714 | 32 | .0000923839 | 33 | .0000866370 |
| 34 | .0000812939 | 35 | .0000763214 | 36 | .0000716896 |
| 37 | .0000673714 | 38 | .0000633547 | 39 | .0000596810 |
| 40 | .0000562483 | 41 | .0000530368 | 42 | .0000500289 |
| 43 | .0000472089 | 44 | .0000445625 | 45 | .0000420771 |
| 46 | .0000397411 | 47 | .0000375441 | 48 | .0000354765 |
| 49 | .0000335296 | 50 | .0000316955 | 51 | .0000299668 |
| 52 | .0000283369 | 53 | .0000267994 | 54 | .0000253487 |
| 55 | .0000239795 | 56 | .0000226867 | 57 | .0000214659 |
| 58 | .0000203127 | 59 | .0000192232 | 60 | .0000181936 |
| 61 | .0000172205 | 62 | .0000163006 | 63 | .0000154309 |
| 64 | .0000146084 | 65 | .0000138306 | 66 | .0000130950 |
| 67 | .0000123991 | 68 | .0000117407 | 69 | .0000111178 |
| 70 | .0000105284 | 71 | .0000099706 | | |

**********

12 MODEL FIT

G-Squared Test of Model Fit: 101.628
Degrees of Freedom: 237

G-Squared Test for MCAR = 321.717
Degrees of Freedom: 1602

**********

**WARNING**: BE SURE TO INTERPRET THE LATENT STATUSES CAREFULLY
BASED ON THE ESTIMATED RHO PARAMETERS REPORTED BELOW.
YOU MAY WISH TO CHANGE THE LABELS YOU PREVIOUSLY ASSIGNED
TO THE LATENT STATUSES IN ORDER TO MAKE THEM
CONSISTENT WITH YOUR INTERPRETATION.

**********

BIG RHO PARAMETERS
BIG RHOS ARE PROBABILITIES OF RESPONSES
TO ITEMS MEASURING THE DYNAMIC LATENT VARIABLE
CONDITIONAL ON LATENT STATUS AND TIME

RHO PARAMETERS FOR TIME 1

13 RESPONSE CATEGORY 1

| | A N L O C - T O B | D N R O U N K | M N A O R I J U A N | C N O O C A I N E |
|---|---|---|---|---|
| NO USE | 0.930 | 0.900 | 0.897 | 0.893 |
| AT | 0.070 | 0.900 | 0.897 | 0.893 |
| ATD | 0.070 | 0.100 | 0.897 | 0.893 |
| ATDM | 0.070 | 0.100 | 0.103 | 0.893 |
| ATDMC | 0.070 | 0.100 | 0.103 | 0.107 |

14 RESPONSE CATEGORY 2

| | A Y L E C S - | D Y R E U S N | M Y A E R S I | C Y O E C S A |
|---|---|---|---|---|
| NO USE | 0.070 | 0.100 | 0.103 | 0.107 |
| AT | 0.930 | 0.100 | 0.103 | 0.107 |
| ATD | 0.930 | 0.900 | 0.103 | 0.107 |
| ATDM | 0.930 | 0.900 | 0.897 | 0.107 |
| ATDMC | 0.930 | 0.900 | 0.897 | 0.893 |

15 RHO PARAMETERS FOR TIME 2

RESPONSE CATEGORY 1

| | A N L O C - T O B | D N R O U N K | M N A O R I J U A N | C N O O C A I N E |
|---|---|---|---|---|
| NO USE | 0.930 | 0.900 | 0.897 | 0.893 |
| AT | 0.070 | 0.900 | 0.897 | 0.893 |
| ATD | 0.070 | 0.100 | 0.897 | 0.893 |
| ATDM | 0.070 | 0.100 | 0.103 | 0.893 |
| ATDMC | 0.070 | 0.100 | 0.103 | 0.107 |

RESPONSE CATEGORY 2

| | A Y L E C S - | D Y R E U S N | M Y A E R S I | C Y O E C S A |
|---|---|---|---|---|
| NO USE | 0.070 | 0.100 | 0.103 | 0.107 |
| AT | 0.930 | 0.100 | 0.103 | 0.107 |
| ATD | 0.930 | 0.900 | 0.103 | 0.107 |
| ATDM | 0.930 | 0.900 | 0.897 | 0.107 |
| ATDMC | 0.930 | 0.900 | 0.897 | 0.893 |

**********

16 DELTA PARAMETERS
DELTAS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP

| | TIME 1 | TIME 2 |
|---|---|---|
| NO USE | 0.526 | 0.230 |
| AT | 0.089 | 0.091 |
| ATD | 0.234 | 0.327 |

```
 ATDM      0.063  0.158
 ATDMC     0.089  0.194

 ************************************************

17 TAU PARAMETERS
 TAUS ARE PROBABILITIES OF LATENT STATUS MEMBERSHIP AT TIME T+1
(COLUMNS)
 CONDITIONAL ON LATENT STATUS MEMBERSHIP AT TIME T (ROWS)

  TRANSITION PROBABILITIES

 ROWS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 1
 COLUMNS REPRESENT LATENT STATUS MEMBERSHIP AT TIME 2

         |  N  |  A  |  A  |  A  |  A  |
         |  O  |  T  |  T  |  T  |  T  |
         |     |     |  D  |  D  |  D  |
         |  U  |     |     |  M  |  M  |
         |  S  |     |     |     |  C  |
         |  E  |     |     |     |     |
         |     |     |     |     |     |
         |     |     |     |     |     |
 NO USE   0.437 0.076 0.341 0.031 0.114
 AT       0.000 0.573 0.306 0.075 0.045
 ATD      0.000 0.000 0.516 0.355 0.129
 ATDM     0.000 0.000 0.000 0.820 0.180
 ATDMC    0.000 0.000 0.000 0.000 1.000

 ************************************************

                18 CELL FREQUENCIES AND FIT INDICATORS
                   ADJUSTED FOR MISSINGNESS

             Sat Model   LTA Model      Fit     Scaled Fit
              Expected    Expected   Indicator   Indicator

 11111111       9.1288     10.3316     -1.2028     -0.3742
 21111111       3.1752      0.9598      2.2154      2.2613*
 12111111       1.5306      1.1550      0.3756      0.3495
 22111111       0.0000      0.1548     -0.1548     -0.3934
 11211111       1.9034      1.1913      0.7121      0.6525
 21211111       0.0000      0.1109     -0.1109     -0.3330
 12211111       0.0000      0.1333     -0.1333     -0.3652
 22211111       0.0000      0.0201     -0.0201     -0.1416
 11121111       1.4700      1.2362      0.2338      0.2102
 21121111       0.0000      0.1149     -0.1149     -0.3389
 12121111       0.0000      0.1382     -0.1382     -0.3718
 22121111       0.0000      0.0186     -0.0186     -0.1363
 11221111       0.0000      0.1425     -0.1425     -0.3776
 21221111       0.1148      0.0133      0.1015      0.8796
 12221111       0.0000      0.0160     -0.0160     -0.1264
 22221111       0.0000      0.0029     -0.0029     -0.0534
 11112111       2.8205      3.5939     -0.7733     -0.4079
 21112111       1.7513      2.7008     -0.9495     -0.5778
 12112111       1.5842      0.4483      1.1359      1.6965
 22112111       0.7440      0.9367     -0.1926     -0.1991
 11212111       1.2706      0.4146      0.8559      1.3293
 21212111       0.6125      0.3148      0.2977      0.5306
 12212111       0.0000      0.0540     -0.0540     -0.2323
 22212111       0.0000      0.1383     -0.1382     -0.3717
 11122111       0.6748      0.4300      0.2448      0.3732
 21122111       0.0000      0.3232     -0.3232     -0.5685
 12122111       0.0000      0.0537     -0.0537     -0.2317
 22122111       0.0000      0.1128     -0.1128     -0.3358
 11222111       0.0000      0.0497     -0.0497     -0.2229
 21222111       0.1148      0.0383      0.0765      0.3909
 12222111       0.0000      0.0069     -0.0069     -0.0831
 22222111       0.0000      0.0225     -0.0225     -0.1499
 11111211       0.6310      1.7577     -1.1267     -0.8498
 21111211       0.2646      0.2909     -0.0263     -0.0488
 12111211       0.0677      0.2282     -0.1605     -0.3360
 22111211       0.3302      0.4614     -0.1313     -0.1932
 11211211       0.0018      0.2028     -0.2010     -0.4463
 21211211       0.0000      0.0358     -0.0358     -0.1893
 12211211       0.0000      0.0278     -0.0278     -0.1669
 22211211       0.0000      0.0736     -0.0736     -0.2712
 11121211       0.0000      0.2103     -0.2103     -0.4586
 21121211       0.0000      0.0349     -0.0349     -0.1867
 12121211       0.0000      0.0273     -0.0273     -0.1653
 22121211       0.0000      0.0557     -0.0557     -0.2359
 11221211       0.0000      0.0243     -0.0243     -0.1559
 21221211       0.1148      0.0047      0.1101      1.6007
 12221211       0.0000      0.0036     -0.0036     -0.0603
 22221211       0.0000      0.0128     -0.0128     -0.1132
 11112211       7.0891      8.4623     -1.3732     -0.4720
 21112211       3.9118      2.7469      1.1649      0.7028
 12112211       2.9918      1.3721      1.6198      1.3828
 22112211       4.2236      6.0101     -1.7865     -0.7287
 11212211       1.0889      0.9780      0.1109      0.1121
 21212211       0.0000      0.3470     -0.3470     -0.5891
 12212211       0.4855      0.1786      0.3069      0.7260
 22212211       1.3591      0.9647      0.3944      0.4016
 11122211       0.5237      1.0126     -0.4889     -0.4859
 21122211       0.0000      0.3294     -0.3294     -0.5739
 12122211       0.0000      0.1646     -0.1646     -0.4058
 22122211       1.0580      0.7253      0.3327      0.3907
 11222211       0.0000      0.1175     -0.1175     -0.3427
 21222211       0.1148      0.0474      0.0674      0.3094
 12222211       0.0239      0.0254     -0.0015     -0.0095
 22222211       0.0000      0.1686     -0.1686     -0.4106
 11111121       0.5928      1.2003     -0.6075     -0.5545
 21111121       0.0000      0.1177     -0.1177     -0.3430
 12111121       0.0000      0.1367     -0.1367     -0.3697
 22111121       0.0000      0.0520     -0.0520     -0.2280
 11211121       0.6353      0.1386      0.4967      1.3344
 21211121       0.0000      0.0158     -0.0158     -0.1256
```

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 12211121 | 0.0000 | 0.0172 | -0.0172 | -0.1313 | 11222221 | 0.0000 | 0.0346 | -0.0346 | -0.1861 |
| 22211121 | 0.0000 | 0.0257 | -0.0257 | -0.1602 | 21222221 | 0.1148 | 0.0987 | 0.0161 | 0.0513 |
| 11121121 | 0.0000 | 0.1436 | -0.1436 | -0.3790 | 12222221 | 0.0000 | 0.0639 | -0.0639 | -0.2527 |
| 21121121 | 0.0000 | 0.0141 | -0.0141 | -0.1189 | 22222221 | 0.0630 | 0.8089 | -0.7459 | -0.8293 |
| 12121121 | 0.0000 | 0.0164 | -0.0164 | -0.1280 | 11111112 | 1.2765 | 1.2388 | 0.0377 | 0.0339 |
| 22121121 | 0.0000 | 0.0067 | -0.0067 | -0.0816 | 21111112 | 0.0000 | 0.1154 | -0.1154 | -0.3396 |
| 11221121 | 0.0000 | 0.0166 | -0.0166 | -0.1289 | 12111112 | 0.0000 | 0.1386 | -0.1386 | -0.3723 |
| 21221121 | 0.1148 | 0.0023 | 0.1125 | 2.3373* | 22111112 | 0.0000 | 0.0199 | -0.0199 | -0.1412 |
| 12221121 | 0.0000 | 0.0024 | -0.0024 | -0.0485 | 11211112 | 0.0000 | 0.1428 | -0.1428 | -0.3779 |
| 22221121 | 0.0000 | 0.0069 | -0.0069 | -0.0833 | 21211112 | 0.0000 | 0.0134 | -0.0134 | -0.1159 |
| 11112121 | 0.0000 | 0.5350 | -0.5350 | -0.7314 | 12211112 | 0.0000 | 0.0161 | -0.0161 | -0.1268 |
| 21112121 | 0.7056 | 0.4047 | 0.3009 | 0.4731 | 22211112 | 0.0000 | 0.0035 | -0.0034 | -0.0583 |
| 12112121 | 0.0000 | 0.0985 | -0.0985 | -0.3138 | 11121112 | 0.6564 | 0.1482 | 0.5082 | 1.3199 |
| 22112121 | 0.0759 | 0.5619 | -0.4860 | -0.6483 | 21121112 | 0.0000 | 0.0139 | -0.0139 | -0.1177 |
| 11212121 | 0.0000 | 0.0639 | -0.0639 | -0.2528 | 12121112 | 0.0000 | 0.0166 | -0.0166 | -0.1289 |
| 21212121 | 0.0000 | 0.0759 | -0.0759 | -0.2755 | 22121112 | 0.0000 | 0.0028 | -0.0028 | -0.0531 |
| 12212121 | 0.0000 | 0.0311 | -0.0311 | -0.1764 | 11221112 | 0.0000 | 0.0171 | -0.0171 | -0.1309 |
| 22212121 | 0.9382 | 0.3274 | 0.6108 | 1.0676 | 21221112 | 0.1148 | 0.0020 | 0.1128 | 2.5087* |
| 11122121 | 0.1655 | 0.0641 | 0.1015 | 0.4009 | 12221112 | 0.0000 | 0.0022 | -0.0022 | -0.0469 |
| 21122121 | 0.0000 | 0.0491 | -0.0491 | -0.2215 | 22221112 | 0.0000 | 0.0041 | -0.0041 | -0.0644 |
| 12122121 | 0.0000 | 0.0122 | -0.0122 | -0.1106 | 11112112 | 0.0000 | 0.4638 | -0.4638 | -0.6811 |
| 22122121 | 0.0000 | 0.0732 | -0.0732 | -0.2705 | 21112112 | 0.0000 | 0.3299 | -0.3299 | -0.5744 |
| 11222121 | 0.0000 | 0.0081 | -0.0081 | -0.0899 | 12112112 | 0.0000 | 0.0588 | -0.0588 | -0.2424 |
| 21222121 | 0.1148 | 0.0148 | 0.1000 | 0.8219 | 22112112 | 1.0634 | 0.1308 | 0.9326 | 2.5781* |
| 12222121 | 0.0000 | 0.0076 | -0.0076 | -0.0871 | 11212112 | 0.0000 | 0.0536 | -0.0536 | -0.2315 |
| 22222121 | 0.0000 | 0.0906 | -0.0906 | -0.3010 | 21212112 | 0.0000 | 0.0398 | -0.0398 | -0.1995 |
| 11111221 | 0.5588 | 0.2841 | 0.2747 | 0.5153 | 12212112 | 0.0000 | 0.0080 | -0.0080 | -0.0892 |
| 21111221 | 0.5292 | 0.0965 | 0.4327 | 1.3930 | 22212112 | 0.0000 | 0.0308 | -0.0307 | -0.1752 |
| 12111221 | 0.0000 | 0.0579 | -0.0579 | -0.2406 | 11122112 | 0.0000 | 0.0555 | -0.0555 | -0.2357 |
| 22111221 | 0.2769 | 0.3595 | -0.0826 | -0.1377 | 21122112 | 0.0000 | 0.0401 | -0.0401 | -0.2003 |
| 11211221 | 0.0000 | 0.0342 | -0.0342 | -0.1850 | 12122112 | 0.0000 | 0.0075 | -0.0075 | -0.0864 |
| 21211221 | 0.0000 | 0.0309 | -0.0309 | -0.1757 | 22122112 | 0.0000 | 0.0214 | -0.0214 | -0.1462 |
| 12211221 | 0.0000 | 0.0200 | -0.0200 | -0.1414 | 11222112 | 0.0000 | 0.0068 | -0.0068 | -0.0826 |
| 22211221 | 0.0000 | 0.2187 | -0.2186 | -0.4675 | 21222112 | 0.1148 | 0.0103 | 0.1046 | 1.0312 |
| 11121221 | 0.0000 | 0.0340 | -0.0340 | -0.1845 | 12222112 | 0.0000 | 0.0047 | -0.0047 | -0.0684 |
| 21121221 | 0.0000 | 0.0120 | -0.0120 | -0.1095 | 22222112 | 0.0000 | 0.0532 | -0.0532 | -0.2307 |
| 12121221 | 0.0000 | 0.0072 | -0.0072 | -0.0850 | 11111212 | 0.0000 | 0.2331 | -0.2331 | -0.4828 |
| 22121221 | 0.0000 | 0.0470 | -0.0470 | -0.2168 | 21111212 | 0.2646 | 0.0394 | 0.2252 | 1.1348 |
| 11221221 | 0.0000 | 0.0044 | -0.0044 | -0.0662 | 12111212 | 0.0000 | 0.0308 | -0.0308 | -0.1754 |
| 21221221 | 0.1148 | 0.0076 | 0.1073 | 1.2339 | 22111212 | 0.0000 | 0.0679 | -0.0679 | -0.2605 |
| 12221221 | 0.0000 | 0.0050 | -0.0050 | -0.0707 | 11211212 | 0.0000 | 0.0270 | -0.0270 | -0.1642 |
| 22221221 | 0.0000 | 0.0609 | -0.0609 | -0.2467 | 21211212 | 0.0000 | 0.0057 | -0.0057 | -0.0756 |
| 11112221 | 2.2853 | 2.0583 | 0.2270 | 0.1582 | 12211212 | 0.0000 | 0.0043 | -0.0043 | -0.0659 |
| 21112221 | 0.6874 | 1.1537 | -0.4663 | -0.4341 | 22211212 | 0.0000 | 0.0184 | -0.0184 | -0.1354 |
| 12112221 | 0.6186 | 0.5781 | 0.0405 | 0.0532 | 11121212 | 0.0000 | 0.0279 | -0.0279 | -0.1671 |
| 22112221 | 5.3888 | 4.7657 | 0.6232 | 0.2855 | 21121212 | 0.0000 | 0.0051 | -0.0051 | -0.0717 |
| 11212221 | 0.0000 | 0.2571 | -0.2571 | -0.5070 | 12121212 | 0.0000 | 0.0040 | -0.0040 | -0.0630 |
| 21212221 | 0.0000 | 0.3956 | -0.3956 | -0.6290 | 22121212 | 0.0000 | 0.0120 | -0.0120 | -0.1094 |
| 12212221 | 0.0000 | 0.2439 | -0.2439 | -0.4938 | 11221212 | 0.0000 | 0.0035 | -0.0035 | -0.0592 |
| 22212221 | 3.0613 | 2.9056 | 0.1556 | 0.0913 | 21221212 | 0.1148 | 0.0044 | 0.1104 | 1.6630 |
| 11122221 | 0.4229 | 0.2467 | 0.1762 | 0.3547 | 12221212 | 0.0000 | 0.0030 | -0.0030 | -0.0551 |
| 21122221 | 0.0000 | 0.1440 | -0.1440 | -0.3794 | 22221212 | 0.0000 | 0.0356 | -0.0356 | -0.1888 |
| 12122221 | 0.0000 | 0.0732 | -0.0732 | -0.2705 | 11112212 | 2.7938 | 1.3160 | 1.4778 | 1.2882 |
| 22122221 | 1.5478 | 0.6234 | 0.9244 | 1.1708 | 21112212 | 0.0000 | 0.3895 | -0.3895 | -0.6241 |

| | | | | |
|---|---|---|---|---|
| 12112212 | 0.0000 | 0.2101 | -0.2101 | -0.4584 |
| 22112212 | 2.4511 | 0.8876 | 1.5635 | 1.6596 |
| 11212212 | 0.0000 | 0.1529 | -0.1529 | -0.3910 |
| 21212212 | 0.0000 | 0.0606 | -0.0606 | -0.2462 |
| 12212212 | 0.0239 | 0.0348 | -0.0110 | -0.0587 |
| 22212212 | 0.0000 | 0.2431 | -0.2431 | -0.4930 |
| 11122212 | 0.4900 | 0.1579 | 0.3321 | 0.8358 |
| 21122212 | 0.0000 | 0.0523 | -0.0523 | -0.2287 |
| 12122212 | 0.4900 | 0.0290 | 0.4610 | 2.7071* |
| 22122212 | 0.4097 | 0.1574 | 0.2522 | 0.6357 |
| 11222212 | 0.0000 | 0.0220 | -0.0220 | -0.1484 |
| 21222212 | 0.1148 | 0.0568 | 0.0581 | 0.2436 |
| 12222212 | 0.0239 | 0.0376 | -0.0137 | -0.0708 |
| 22222212 | 0.1527 | 0.4735 | -0.3208 | -0.4662 |
| 11111122 | 0.7688 | 0.1657 | 0.6031 | 1.4817 |
| 21111122 | 0.0000 | 0.0185 | -0.0185 | -0.1359 |
| 12111122 | 0.0000 | 0.0197 | -0.0197 | -0.1404 |
| 22111122 | 0.0000 | 0.0185 | -0.0185 | -0.1359 |
| 11211122 | 0.0000 | 0.0192 | -0.0192 | -0.1385 |
| 21211122 | 0.0000 | 0.0033 | -0.0033 | -0.0572 |
| 12211122 | 0.0000 | 0.0030 | -0.0030 | -0.0551 |
| 22211122 | 0.0000 | 0.0124 | -0.0123 | -0.1108 |
| 11121122 | 0.0000 | 0.0199 | -0.0199 | -0.1409 |
| 21121122 | 0.0000 | 0.0026 | -0.0026 | -0.0513 |
| 12121122 | 0.0000 | 0.0026 | -0.0026 | -0.0514 |
| 22121122 | 0.0000 | 0.0059 | -0.0059 | -0.0770 |
| 11221122 | 0.0000 | 0.0026 | -0.0026 | -0.0507 |
| 21221122 | 0.1148 | 0.0040 | 0.1109 | 1.7544 |
| 12221122 | 0.0000 | 0.0028 | -0.0028 | -0.0529 |
| 22221122 | 0.0000 | 0.0338 | -0.0338 | -0.1838 |
| 11112122 | 0.0000 | 0.3573 | -0.3573 | -0.5977 |
| 21112122 | 1.4111 | 0.1073 | 1.3039 | 3.9814* |
| 12112122 | 0.0000 | 0.0562 | -0.0562 | -0.2371 |
| 22112122 | 0.0033 | 0.2300 | -0.2267 | -0.4726 |
| 11212122 | 0.0000 | 0.0423 | -0.0423 | -0.2058 |
| 21212122 | 0.0000 | 0.0275 | -0.0275 | -0.1659 |
| 12212122 | 0.0000 | 0.0167 | -0.0167 | -0.1293 |
| 22212122 | 0.0000 | 0.1626 | -0.1626 | -0.4032 |
| 11122122 | 0.0000 | 0.0432 | -0.0432 | -0.2078 |
| 21122122 | 0.0000 | 0.0184 | -0.0184 | -0.1355 |
| 12122122 | 0.0000 | 0.0105 | -0.0105 | -0.1022 |
| 22122122 | 0.0000 | 0.0771 | -0.0771 | -0.2776 |
| 11222122 | 0.0000 | 0.0087 | -0.0087 | -0.0931 |
| 21222122 | 0.1148 | 0.0512 | 0.0637 | 0.2815 |
| 12222122 | 0.0000 | 0.0343 | -0.0343 | -0.1852 |
| 22222122 | 0.8386 | 0.4490 | 0.3896 | 0.5814 |
| 11111222 | 0.0000 | 0.2319 | -0.2319 | -0.4816 |
| 21111222 | 0.0000 | 0.0512 | -0.0512 | -0.2264 |
| 12111222 | 0.0000 | 0.0369 | -0.0369 | -0.1921 |
| 22111222 | 0.5476 | 0.1529 | 0.3947 | 1.0095 |
| 11211222 | 0.0000 | 0.0275 | -0.0275 | -0.1659 |
| 21211222 | 0.0000 | 0.0161 | -0.0161 | -0.1271 |
| 12211222 | 0.0000 | 0.0112 | -0.0112 | -0.1057 |
| 22211222 | 0.0000 | 0.1095 | -0.1094 | -0.3307 |
| 11121222 | 0.0000 | 0.0280 | -0.0280 | -0.1674 |
| 21121222 | 0.0000 | 0.0099 | -0.0099 | -0.0993 |
| 12121222 | 0.0000 | 0.0069 | -0.0069 | -0.0833 |
| 22121222 | 0.0000 | 0.0517 | -0.0517 | -0.2274 |
| 11221222 | 0.0000 | 0.0057 | -0.0057 | -0.0756 |
| 21221222 | 0.1148 | 0.0342 | 0.0806 | 0.4356 |
| 12221222 | 0.0000 | 0.0231 | -0.0231 | -0.1521 |
| 22221222 | 0.0000 | 0.3030 | -0.3030 | -0.5505 |
| 11112222 | 3.9113 | 2.8777 | 1.0335 | 0.6093 |
| 21112222 | 0.5292 | 0.6659 | -0.1367 | -0.1675 |
| 12112222 | 0.0000 | 0.4679 | -0.4679 | -0.6840 |
| 22112222 | 0.4286 | 2.0309 | -1.6023 | -1.1244 |
| 11212222 | 0.0000 | 0.3420 | -0.3420 | -0.5848 |
| 21212222 | 0.0000 | 0.2129 | -0.2129 | -0.4614 |
| 12212222 | 0.0000 | 0.1458 | -0.1458 | -0.3818 |
| 22212222 | 2.8668 | 1.4553 | 1.4115 | 1.1700 |
| 11122222 | 0.4900 | 0.3481 | 0.1419 | 0.2406 |
| 21122222 | 0.0000 | 0.1292 | -0.1292 | -0.3595 |
| 12122222 | 0.0000 | 0.0894 | -0.0894 | -0.2990 |
| 22122222 | 0.0000 | 0.6875 | -0.6875 | -0.8291 |
| 11222222 | 0.0000 | 0.0732 | -0.0732 | -0.2706 |
| 21222222 | 0.1148 | 0.4551 | -0.3402 | -0.5043 |
| 12222222 | 0.0000 | 0.3073 | -0.3073 | -0.5544 |
| 22222222 | 5.0009 | 4.0288 | 0.9721 | 0.4843 |

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PROGRAM FINISHED: Fri Mar 29 16:45:21 2002
ELAPSED TIME: 0 HOURS, 0 MINUTES, 0 SECONDS.

# Explanation of the WinLTA Output File for Example 5

The following sections refer to output given by the program using the example latent status control file. The first sections of the output contain a listing of the parameter restrictions, starting values, and other information entered in the program control file. The next section is the iteration history, which is followed by the parameter estimates. The final section of the output contains fit indicators (analogous to residuals).

**Program Control File Information**

**1** The title lines and comments entered in the General tab will be printed first.

**2** Basic information from the Model and Data tab and the Estimation tab is echoed back in the first section of the output file. The filenames for the control file, the data, the output, and the parameter estimates are shown first. The next lines display whether or not there is a static latent variable and a dynamic latent variable in the current model. Next the number of latent classes, number of latent statuses, number of occasions of measurement, number of items (for classes and statuses), and order of the process are shown. The following lines display the number of participants, number of observed response patterns, maximum number of iterations allowed, convergence criterion, and whether there is missing data in the response patterns. Finally, there is a line stating whether or not residuals will be printed.

**Parameter Restrictions**

**3** This section contains a listing of the user-specified parameter restrictions.

**4** The big rho parameter restrictions are printed in this section.

**5** In this section, the user-specified parameter restrictions for the delta parameters are printed.

**6** In this section, the user-specified parameter restrictions for the tau parameters are printed.

**Starting Values**

**7** This section contains a listing of the user-specified starting values.

**8** In this section, the user-specified starting values for the big rho parameters in response category 1 and response category 2 are printed.

**9** In this section, the user-specified starting values for the delta parameters are printed.

**10** In this section, the user-specified starting values for the tau parameters are printed.

**Iteration History**

**11** After each iteration, the iteration number and the Mean Absolute Deviation (MAD) are printed. The maximum iterations for the run as specified in the Estimation tab determine the maximum number of iterations allowed. MAD is the mean absolute deviation; i.e. the absolute value of the difference between parameter estimates from the last iteration and the corresponding parameters from the present iteration, averaged across parameters. The user-specified convergence criterion set in the Estimation tab determines at what value of MAD the program will stop.

**12** The model fit section displays two statistical tests. First, the final $G^2$ for the **test of model fit** is shown. This statistic reflects the fit of the model, with degrees of freedom equal to the number of response patterns minus the number of parameters estimated in the LTA model minus one. The null hypothesis for this test is that the current LTA model fits the data sufficiently well. The obtained value of the goodness-of-fit statistic is compared to a chi-squared distribution. In this case, the observed test statistic, $G^2 = 101.628$, is smaller than the number of degrees of freedom (237), indicating that we should accept the current model as providing sufficient fit. The second statistical test is a $G^2$ for the **test of MCAR**. The null hypothesis for this test is that the missing data are MCAR (missing completely at random). Our $G^2 = 321.717$ with 1602 degrees of freedom, providing strong evidence that we should accept the null hypothesis that the data are MCAR.

**Parameter Estimates**

The estimates for the parameters are printed in the next sections of output.

Big Rho Parameters

**13** The big rho parameters are the probabilities of a particular item response conditional on latent status and time. The probabilities are grouped by response category and time. This section is for the first response category "1" for Time 1. In this example, a "1" designates the response "no" to the items. For example, the probability of answering no to the first item (alcohol) given membership in the alcohol and tobacco latent status is 0.070. Participants in the alcohol and tobacco latent status would not be expected to answer no to an item about having tried alcohol or tobacco. This is reflected in the low conditional probability.

**14** The estimates for the big rho parameters for the second response category are given in this section. In this example, a "2" indicates the response "yes." For example, the probability of answering yes to the item about marijuana use given membership in the alcohol and tobacco use latent status is 0.103, and the probability of answering yes to the drunkenness item given membership in the alcohol and tobacco use latent status is 0.100.

**15** The next section contains the big rho parameters for Time 2. Because the rhos were constrained to be equal across times, this section is identical to **13** and **14**.

In factor analysis, the patterns of factor loadings characterize the factors. In latent transition analysis, the conditional probabilities characterize the latent statuses. The big rhos have been constrained to be equal across time, so that discussion of the patterns of these conditional probabilities applies to both Times 1 and 2. For the first latent status, the probability of answering no to the four substance use items is fairly high. Therefore, this latent status is characterized as the "no use" latent status. Latent statuses 2 through 5 are characterized similarly by the patterns of the big rho parameter estimates.

Delta Parameters

**16** The estimates for the delta parameters are the probabilities of latent status membership. For example, the probability of being in latent status 1 at Time 1 was estimated at 0.526, and the probability of being in latent status 5 at Time 2 was 0.194. That means that according to this model, 52.6% of the participants had not tried any substances at the first occasion of measurement, and 19.4% had used all four of the substances and been drunk at the second occasion of measurement.

Tau Parameters

**17** The tau parameters are the probabilities of being in a particular latent status at Time 2 given membership in another latent status at Time 1. The transition probability matrix indicates the probability of movement of the subjects between the latent statuses from Time 1 to Time 2. The diagonal of this matrix indicates the probability that the participants remain in a particular latent status across time. For example, the first diagonal element, $\tau_{1|1} = 0.437$, indicates that participants who were in the "no use" latent status at Time 1 had a fairly low probability of being in the "no use" latent status at Time 2. That is, there was a fairly high chance that these participants would try a substance by the second occasion of measurement. These same participants had a 34.1% chance of progressing to the alcohol + tobacco + drunk latent status by Time 2 ($\tau_{3|1} = 0.341$). Participants in the alcohol + tobacco latent status at Time 1 were somewhat more likely to be in that latent status at Time 2 ($\tau_{2|2} = 0.573$). Those in the alcohol + tobacco + drunk latent status at Time 1 had a moderate probability of remaining in that status at Time 2 ($\tau_{3|3} = 0.516$). Similarly, those in latent status 4 at Time 1 were highly likely to remain in that latent status at Time 2 ($\tau_{4|4} = 0.820$). The last element of the diagonal indicates that the participants in latent status 5 at Time 1 were certain to be in latent status 5 at Time 2 ($\tau_{5|5} = 1.000$). This probability of 1.000 represents the fact that backward movement was not possible in this model.

**Response Patterns and Statistics**

**18** The residuals were requested in this example. In models fit to completely-observed data, the residuals table includes the response patterns, the observed cell counts, the cell counts expected under the LTA model, the residuals, and the Pearson residuals. See Example 2 for an example of a residuals output in the case of no missing data. In the present example there are missing data, and thus fit indicators are shown instead of traditional residuals. The following columns appear in the output: all possible response patterns for completely-observed data, expected cell counts under the saturated model, expected cell counts under the current LTA model, the fit indicator (analogous to a residual), and the scaled fit indicator (analogous to a Pearson residual). The fit indicators can be used to diagnose model misspecification. Large indicators suggest response patterns that are not sufficiently accounted for under the current LTA model. For more on the fit indicators output for models based on missing data, see the section entitled "Missing Data in LTA" in the main LTA manual.