

**Obtaining Diagnostic Classification Model Estimates with Mplus**

## Syntax and Output Handout

## NCME Diagnostic Measurement Workshop

To demonstrate how Diagnostic Classification Models (DCMs) can be estimated using Mplus, input syntax and output are included in this document.

**Analysis Data Set – Based on DTMR Data from Session 3 (simulated so it is distributable):**

- 28 items
- Four attributes
- 990 respondents

**Analysis/ECPE Q-matrix:**

Item	Attribute 1	Attribute 2	Attribute 3	Attribute 4
1	1	0	0	0
2	0	0	1	0
3	0	1	0	0
4	1	0	0	0
5	1	0	0	0
6	0	1	0	0
7	1	0	0	0
8a	0	0	1	0
8b	0	0	1	0
8c	0	0	1	0
8d	0	0	1	0
9	1	0	0	0
10a	0	0	0	1
10b	0	0	0	1
10c	0	0	0	1
11	1	0	0	0
12	1	0	0	0
13	0	1	0	1
14	1	1	0	0
15a	1	0	0	1
15b	1	0	0	0
15c	1	0	0	0
16	1	0	0	0
17	1	1	0	0
18	1	1	0	0
19	0	0	1	0
21	1	0	0	0
22	1	1	0	0

To create Mplus syntax, we will follow several steps:

1. 1. Creating a Latent Class-to-Attribute Profile Table
  - Mplus uses generic latent classes in estimation – we must make these into DCM attribute profiles.
2. 2. Creating an Item-to-Profile Table
  - Specifies the form of the LCDM for each combination of item and profile. It will be used to build model syntax.
3. 3. Creating Item Response Function Labels
  - Defines the set of unique item response functions for each item (based on the set of attributes measured by the Q-matrix). Used by Mplus to specify LCDM parameters.

4. 4. Creating the Structural Model
  - For limiting the number of correlational parameters needed; aids in estimation speed and convergence.
5. 5. Specifying Initial Mplus Syntax
  - Commands for input and parsing of data files.
6. 6. Building Mplus MODEL Command Syntax
  - Places labels on all Mplus parameters (thereby enforcing confirmatory model on classes).
7. Building Mplus MODEL CONSTRAINT Command Syntax
  - Specifies LCDM model parameters.

### 1. Creating a Latent Class-to-Attribute Profile Table

Mplus uses latent classes to model categorical data generally. We must represent each possible attribute profiles as a latent class. For DCMs that measure  $A$  attributes, a total of  $2^A$  attribute profiles are possible. It is our job to map each profile onto a latent class. To do so, we use the following process. Recall our example data set specifics:

Number of attributes in example: 4

Number of possible attribute profiles:  $2^4 = 16$

Number of latent classes needed: 8

First, we need a table that has the number of latent classes represented in the rows and the number of attributes represented in the columns.

The following figure shows how to populate the classes with attribute profiles through a sequence of partitions of the table. The table lists the process for three attributes (which map onto eight classes), but a similar method is used for four attributes.

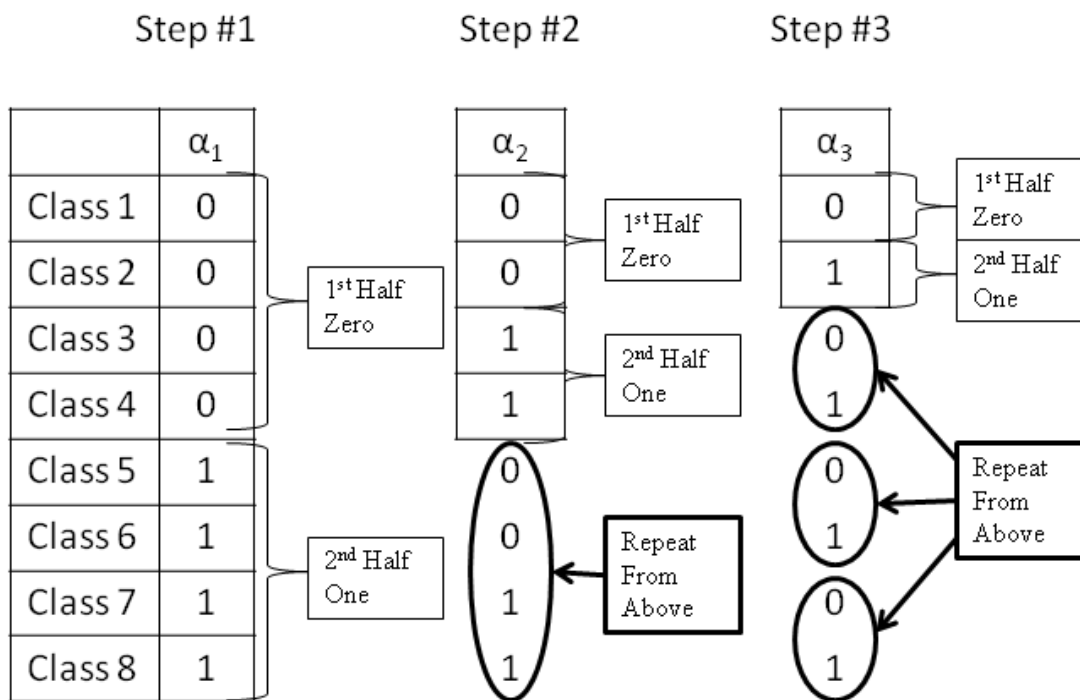


Figure 9.7 from Rupp, Templin, & Henson (2010). Creating a class-to-profile table.

**2. Creating an Item-to-Profile Table**

The next step is to develop the LCDM model specification for each combination of items and attribute profiles, the item response function for respondents with a given attribute profile. In DCMs, not all attributes are measured by each item. Therefore, there will be repeated item response functions. This table will help to denote which are redundant and therefore able to be omitted. We will use the Q-matrix to help form what model parameters should be present for each combination of item and attribute profile.

**Analysis Q-matrix (rearranged to reflect items measuring same set of attributes):**

Items	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Set Number
1, 4, 5, 7, 9, 11, 12, 15b, 15c, 16, 21	1	0	0	0	1
3, 6	0	1	0	0	2
2, 8a, 8b, 8c, 8d, 19	0	0	1	0	3
10a, 10b, 10c	0	0	0	1	4
14, 17, 18, 22	1	1	0	0	5
15a	1	0	0	1	6
13	0	1	0	1	7

**Item-to-Profile Table (first subscript denotes set – change for each item number)**

Class	c <sub>1</sub>	c <sub>2</sub>	c <sub>3</sub>	c <sub>4</sub>	c <sub>5</sub>	c <sub>6</sub>	c <sub>7</sub>	c <sub>8</sub>
$\alpha_c$	[0, 0, 0, 0]	[0, 0, 0, 1]	[0, 0, 1, 0]	[0, 0, 1, 1]	[0, 1, 0, 0]	[0, 1, 0, 1]	[0, 1, 1, 0]	[0, 1, 1, 1]
Set 1	$\lambda_{1,0}$	$\lambda_{1,0}$	$\lambda_{1,0}$	$\lambda_{1,0}$	$\lambda_{1,0}$	$\lambda_{1,0}$	$\lambda_{1,0}$	$\lambda_{1,0}$
Set 2	$\lambda_{2,0}$	$\lambda_{2,0}$	$\lambda_{2,0}$	$\lambda_{2,0}$	$\lambda_{2,0} + \lambda_{2,1,(2)}$	$\lambda_{2,0} + \lambda_{2,1,(2)}$	$\lambda_{2,0} + \lambda_{2,1,(2)}$	$\lambda_{2,0} + \lambda_{2,1,(2)}$
Set 3	$\lambda_{3,0}$	$\lambda_{3,0}$	$\lambda_{3,0} + \lambda_{3,1,(3)}$	$\lambda_{3,0} + \lambda_{3,1,(3)}$	$\lambda_{3,0}$	$\lambda_{3,0}$	$\lambda_{3,0} + \lambda_{3,1,(3)}$	$\lambda_{3,0} + \lambda_{3,1,(3)}$
Set 4	$\lambda_{4,0}$	$\lambda_{4,0} + \lambda_{4,1,(4)}$	$\lambda_{4,0}$	$\lambda_{4,0} + \lambda_{4,1,(4)}$	$\lambda_{4,0}$	$\lambda_{4,0} + \lambda_{4,1,(4)}$	$\lambda_{4,0}$	$\lambda_{4,0} + \lambda_{4,1,(4)}$
Set 5	$\lambda_{5,0}$	$\lambda_{5,0}$	$\lambda_{5,0}$	$\lambda_{5,0}$	$\lambda_{5,0} + \lambda_{5,1,(2)}$	$\lambda_{5,0} + \lambda_{5,1,(2)}$	$\lambda_{5,0} + \lambda_{5,1,(2)}$	$\lambda_{5,0} + \lambda_{5,1,(2)}$
Set 6	$\lambda_{6,0}$	$\lambda_{6,0} + \lambda_{6,1,(4)}$	$\lambda_{6,0}$	$\lambda_{6,0} + \lambda_{6,1,(4)}$	$\lambda_{6,0}$	$\lambda_{6,0} + \lambda_{6,1,(4)}$	$\lambda_{6,0}$	$\lambda_{6,0} + \lambda_{6,1,(4)}$
Set 7	$\lambda_{7,0}$	$\lambda_{7,0} + \lambda_{7,1,(4)}$	$\lambda_{7,0}$	$\lambda_{7,0} + \lambda_{7,1,(4)}$	$\lambda_{7,0} + \lambda_{7,1,(2)}$	$\lambda_{7,0} + \lambda_{7,1,(2)} + \lambda_{7,1,(4)} + \lambda_{7,2,(2,4)}$	$\lambda_{7,0} + \lambda_{7,1,(2)}$	$\lambda_{7,0} + \lambda_{7,1,(2)} + \lambda_{7,1,(4)} + \lambda_{7,2,(2,4)}$

Class	c <sub>9</sub>	c <sub>10</sub>	c <sub>11</sub>	c <sub>12</sub>	c <sub>13</sub>	c <sub>14</sub>	c <sub>15</sub>	c <sub>16</sub>
$\alpha_c$	[1, 0, 0, 0]	[1, 0, 0, 1]	[1, 0, 1, 0]	[1, 0, 1, 1]	[1, 1, 0, 0]	[1, 1, 0, 1]	[1, 1, 1, 0]	[1, 1, 1, 1]
Set 1	$\lambda_{1,0} + \lambda_{1,1,(1)}$	$\lambda_{1,0} + \lambda_{1,1,(1)}$	$\lambda_{1,0} + \lambda_{1,1,(1)}$	$\lambda_{1,0} + \lambda_{1,1,(1)}$	$\lambda_{1,0} + \lambda_{1,1,(1)}$	$\lambda_{1,0} + \lambda_{1,1,(1)}$	$\lambda_{1,0} + \lambda_{1,1,(1)}$	$\lambda_{1,0} + \lambda_{1,1,(1)}$
Set 2	$\lambda_{2,0}$	$\lambda_{2,0}$	$\lambda_{2,0}$	$\lambda_{2,0}$	$\lambda_{2,0} + \lambda_{2,1,(2)}$	$\lambda_{2,0} + \lambda_{2,1,(2)}$	$\lambda_{2,0} + \lambda_{2,1,(2)}$	$\lambda_{2,0} + \lambda_{2,1,(2)}$
Set 3	$\lambda_{3,0}$	$\lambda_{3,0}$	$\lambda_{3,0} + \lambda_{3,1,(3)}$	$\lambda_{3,0} + \lambda_{3,1,(3)}$	$\lambda_{3,0}$	$\lambda_{3,0}$	$\lambda_{3,0} + \lambda_{3,1,(3)}$	$\lambda_{3,0} + \lambda_{3,1,(3)}$
Set 4	$\lambda_{4,0}$	$\lambda_{4,0} + \lambda_{4,1,(4)}$	$\lambda_{4,0}$	$\lambda_{4,0} + \lambda_{4,1,(4)}$	$\lambda_{4,0}$	$\lambda_{4,0} + \lambda_{4,1,(4)}$	$\lambda_{4,0}$	$\lambda_{4,0} + \lambda_{4,1,(4)}$
Set 5	$\lambda_{5,0} + \lambda_{5,1,(1)}$	$\lambda_{5,0} + \lambda_{5,1,(1)}$	$\lambda_{5,0} + \lambda_{5,1,(1)}$	$\lambda_{5,0} + \lambda_{5,1,(1)}$	$\lambda_{5,0} + \lambda_{5,1,(1)} + \lambda_{5,1,(2)} + \lambda_{5,2,(1,2)}$	$\lambda_{5,0} + \lambda_{5,1,(1)} + \lambda_{5,1,(2)} + \lambda_{5,2,(1,2)}$	$\lambda_{5,0} + \lambda_{5,1,(1)} + \lambda_{5,1,(2)} + \lambda_{5,2,(1,2)}$	$\lambda_{5,0} + \lambda_{5,1,(1)} + \lambda_{5,1,(2)} + \lambda_{5,2,(1,2)}$
Set 6	$\lambda_{6,0} + \lambda_{6,1,(1)}$	$\lambda_{6,0} + \lambda_{6,1,(1)} + \lambda_{6,1,(4)} + \lambda_{6,2,(1,4)}$	$\lambda_{6,0} + \lambda_{6,1,(1)}$	$\lambda_{6,0} + \lambda_{6,1,(1)} + \lambda_{6,1,(4)} + \lambda_{6,2,(1,4)}$	$\lambda_{6,0} + \lambda_{6,1,(1)}$	$\lambda_{6,0} + \lambda_{6,1,(1)} + \lambda_{6,1,(4)} + \lambda_{6,2,(1,4)}$	$\lambda_{6,0} + \lambda_{6,1,(1)}$	$\lambda_{6,0} + \lambda_{6,1,(1)} + \lambda_{6,1,(4)} + \lambda_{6,2,(1,4)}$
Set 7	$\lambda_{7,0}$	$\lambda_{7,0} + \lambda_{7,1,(4)}$	$\lambda_{7,0}$	$\lambda_{7,0} + \lambda_{7,1,(4)}$	$\lambda_{7,0} + \lambda_{7,1,(2)}$	$\lambda_{7,0} + \lambda_{7,1,(2)} + \lambda_{7,1,(4)} + \lambda_{7,2,(2,4)}$	$\lambda_{7,0} + \lambda_{7,1,(2)}$	$\lambda_{7,0} + \lambda_{7,1,(2)} + \lambda_{7,1,(4)} + \lambda_{7,2,(2,4)}$

### **3. Creating Item Response Function Labels**

The next step in the process is to label each unique item response function for each *item* in the Item-to-Profile table. *In the table below, we use the first number to represent the set of items from the Item-to-Profile table. In code, this will change to be the item number.* The labeling convention we will use will follow the form of `t[i]_[#]`:

- `t` represents that label is a threshold (Mplus definition for LCDM item response function)
- `[i]` is the item used (omit brackets)
- `[#]` is the index for unique item response function for an item.

The labels are created by reading left-to-right for each row of the Item-to-Profile table. The first entry for the first cell of the first item receives the label `t1_1`, as do all other entries that are the same. The next unique entry receives the label `t1_2`, as do all other entries that look the same. The process continues until all labels have been assigned.

**Item Response Function Labels**

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>
$\alpha_c$	[0,0,0,0]	[0,0,0,1]	[0,0,1,0]	[0,0,1,1]	[0,1,0,0]	[0,1,0,1]	[0,1,1,0]	[0,1,1,1]
set 1	T1_1	T1_1	T1_1	T1_1	T1_1	T1_1	T1_1	T1_1
set 2	T2_1	T2_1	T2_1	T2_1	T2_2	T2_2	T2_2	T2_2
set 3	T3_1	T3_1	T3_2	T3_2	T3_1	T3_2	T3_2	T3_2
set 4	T4_1	T4_2	T4_1	T4_2	T4_1	T4_2	T4_1	T4_2
set 5	T5_1	T5_1	T5_1	T5_1	T5_2	T5_2	T5_2	T5_2
set 6	T6_1	T6_2	T6_1	T6_2	T6_1	T6_2	T6_1	T6_2
set 7	T7_1	T7_2	T7_1	T7_2	T7_3	T7_4	T7_3	T7_4

	C <sub>9</sub>	C <sub>10</sub>	C <sub>11</sub>	C <sub>12</sub>	C <sub>13</sub>	C <sub>14</sub>	C <sub>15</sub>	C <sub>16</sub>
$\alpha_c$	[1,0,0,0]	[1,0,0,1]	[1,0,1,0]	[1,0,1,1]	[1,1,0,0]	[1,1,0,1]	[1,1,1,0]	[1,1,1,1]
set 1	T1_2	T1_2	T1_2	T1_2	T1_2	T1_2	T1_2	T1_2
set 2	T2_1	T2_1	T2_1	T2_1	T2_2	T2_2	T2_2	T2_2
set 3	T3_1	T3_1	T3_2	T3_2	T3_1	T3_2	T3_2	T3_2
set 4	T4_1	T4_2	T4_1	T4_2	T4_1	T4_2	T4_1	T4_2
set 5	T5_3	T5_3	T5_3	T5_3	T5_4	T5_4	T5_4	T5_4
set 6	T6_3	T6_4	T6_3	T6_4	T6_3	T6_4	T6_3	T6_4
set 7	T7_1	T7_2	T7_1	T7_2	T7_3	T7_4	T7_3	T7_4



#### **4. Creating the Structural Model [Optional]**

The next step is to define the structural model – the model that produces estimates of the probability any respondent has a given attribute profile. The structural model is how attribute association (i.e., correlation) is modeled in DCMs.

This step is optional as Mplus will fit a saturated model if none is specified. Specification of the structural model, however, will improve estimation speed and convergence. Mplus uses a log-linear model for the structural component, meaning the model itself will look like a linear model with intercepts, main effects, and interactions. These terms are all specific to attributes and not to the interaction of attributes to produce item responses.

By definition (and for identification), Mplus sets the value of the last class to zero, causing a few inconveniences in syntax building. The table below shows the label for each structural model parameter along with the actual modeling term used. Note that the first row is a new parameter created to be the intercept (defined because the last term is fixed at zero).

Note: a reasonable approach to a structural model would be to have all main effects and two-way interactions, allowing all attributes to be correlated.

**Structural Model Specification Table**

Class	Attribute Profile	Mplus Label	Saturated Log-linear Model
-	-	g0	$\gamma_0 = -(\gamma_{1,(1)} + \gamma_{1,(2)} + \gamma_{1,(3)} + \gamma_{1,(4)} + \gamma_{2,(1,2)} + \gamma_{2,(1,3)} + \gamma_{2,(1,4)} + \gamma_{2,(2,3)} + \gamma_{2,(2,4)} + \gamma_{2,(3,4)} + \gamma_{3,(1,2,3)} + \gamma_{3,(1,2,4)} + \gamma_{3,(2,3,4)} + \gamma_{4,(1,2,3,4)})$
1	$\alpha_1 = [0,0,0,0]$	m1	$\mu_1 = -\gamma_0$
2	$\alpha_2 = [0,0,0,1]$	m2	$\mu_2 = \gamma_{1,(4)} - \gamma_0$
3	$\alpha_3 = [0,0,1,0]$	m3	$\mu_3 = \gamma_{1,(3)} - \gamma_0$
4	$\alpha_4 = [0,0,1,1]$	m4	$\mu_4 = \gamma_{1,(3)} + \gamma_{1,(4)} + \gamma_{2,(3,4)} - \gamma_0$
5	$\alpha_5 = [0,1,0,0]$	m5	$\mu_5 = \gamma_{1,(2)} - \gamma_0$
6	$\alpha_6 = [0,1,0,1]$	m6	$\mu_6 = \gamma_{1,(2)} + \gamma_{1,(4)} + \gamma_{2,(2,4)} - \gamma_0$
7	$\alpha_7 = [0,1,1,0]$	m7	$\mu_7 = \gamma_{1,(2)} + \gamma_{1,(3)} + \gamma_{2,(2,3)} - \gamma_0$
8	$\alpha_8 = [0,1,1,1]$	m8	$\mu_8 = \gamma_{1,(2)} + \gamma_{1,(3)} + \gamma_{1,(4)} + \gamma_{2,(2,3)} + \gamma_{2,(2,4)} + \gamma_{2,(3,4)} + \gamma_{3,(2,3,4)} - \gamma_0$
9	$\alpha_9 = [1,0,0,0]$	m9	$\mu_9 = \gamma_{1,(1)} - \gamma_0$
10	$\alpha_{10} = [1,0,0,1]$	m10	$\mu_{10} = \gamma_{1,(1)} + \gamma_{1,(4)} + \gamma_{2,(1,4)} - \gamma_0$
11	$\alpha_{11} = [1,0,1,0]$	m11	$\mu_{11} = \gamma_{1,(1)} + \gamma_{1,(3)} + \gamma_{2,(1,3)} - \gamma_0$
12	$\alpha_{12} = [1,0,1,1]$	m12	$\mu_{12} = \gamma_{1,(1)} + \gamma_{1,(3)} + \gamma_{1,(4)} + \gamma_{2,(1,3)} + \gamma_{2,(1,4)} + \gamma_{2,(3,4)} + \gamma_{3,(1,3,4)} - \gamma_0$
13	$\alpha_{13} = [1,1,0,0]$	m13	$\mu_{13} = \gamma_{1,(1)} + \gamma_{1,(2)} + \gamma_{2,(1,2)} - \gamma_0$
14	$\alpha_{14} = [1,1,0,1]$	m14	$\mu_{14} = \gamma_{1,(1)} + \gamma_{1,(2)} + \gamma_{1,(4)} + \gamma_{2,(1,2)} + \gamma_{2,(1,4)} + \gamma_{2,(2,4)} + \gamma_{3,(1,2,4)} - \gamma_0$
15	$\alpha_{15} = [1,1,1,0]$	m15	$\mu_{15} = \gamma_{1,(1)} + \gamma_{1,(2)} + \gamma_{1,(3)} + \gamma_{2,(1,2)} + \gamma_{2,(1,3)} + \gamma_{2,(2,3)} + \gamma_{3,(1,2,3)} - \gamma_0$
16	$\alpha_{16} = [1,1,1,1]$	None: FIXED	$\mu_{16} = 0$

## 5. Specifying Initial Mplus Syntax

The initial Mplus syntax contains information about the data set, items, and types of variables.

Note: this comes from file chapter9c.inp

Mplus Syntax	Comments
<b>TITLE:</b> LCDM Estimation simulated DTMR data set.	Provides the title for the analysis that appears in output.
<b>DATA:</b> FILE = data.dat;	Provides location of input data file. Assumes same folder as input file if no path given.
<b>VARIABLE:</b> NAMES = ID I1 I2 ... I22; USEVARIABLE = I1 I2 ... I22; CATEGORICAL = I1 I2 ... I22; CLASSES = c(16); IDVARIABLE = ID;	The variable section lists details about the data – variables and their types. <ul style="list-style-type: none"> <li>• NAMES: labels variables in data file (real data will not have c)</li> <li>• USEVARIABLE: defines which variables are used in the analysis</li> <li>• CATEGORICAL: lists which variables are categorical (default is continuous)</li> <li>• CLASSES: provides number of latent classes to be estimated – <math>2^A</math> for <math>A</math> measured attributes</li> <li>• IDVARIABLE: identification number for each respondent</li> </ul>
<b>ANALYSIS:</b> TYPE=MIXTURE; STARTS=0; PROCESSORS=64;	The analysis section lists details about the estimation procedure. <ul style="list-style-type: none"> <li>• TYPE: Mixture indicates latent classes will be used – mandatory for DCMs</li> <li>• STARTS: Turns off default multiple random starts option</li> <li>• PROCESSORS: Uses multithreaded algorithm, if computer has more than one processor</li> </ul>
<b>OUTPUT:</b> TECH1 TECH5 TECH8 TECH10;	Requests additional output statistics (convergence history; goodness of fit).
<b>SAVEDATA:</b> FORMAT IS f10.5; FILE IS respondent_lcdm.dat; SAVE = CPROBABILITIES;	Instructs Mplus to save respondent estimates to file named respondent_lcdm.dat. File located in same folder as input syntax file.

The remaining two sections provide annotated Mplus syntax for the rest of the analysis.

**6. Building Mplus MODEL Command Syntax**

Mplus Syntax	Comments
<b>MODEL:</b>	<p>The MODEL command lists the specifics for the LCDM. It consists of two portions:</p> <ul style="list-style-type: none"> <li>• Class model labels (offset by %class% statements) <ul style="list-style-type: none"> <li>• Entire item response labels table is entered</li> </ul> </li> <li>• Model constraints (where LCDM parameters are defined) <ul style="list-style-type: none"> <li>• Labels are set equal to item response functions</li> </ul> </li> </ul>
<pre>%OVERALL% [C#1] (M1); !profile [0000] [C#2] (M2); !profile [0001] [C#3] (M3); !profile [0010] [C#4] (M4); !profile [0011] ... [C#14] (M14); !profile [1101] [C#15] (M15); !profile [1110]</pre>	<p>The %OVERALL% section is for the structural model.</p> <ul style="list-style-type: none"> <li>• [C#1] is the Mplus syntax for the value of the first class mean</li> <li>• (m1) is our label (to be used in the model constraints section)</li> <li>• NOTE: [C#16] (m16) is not listed – mean for last class set to zero by Mplus</li> </ul>
<pre>!column #1 of item response function labels table !for profile [0000] %c#1% [I1\$1] (T1_1); !item 1 _ threshold 1 [I2\$1] (T2_1); !item 2 _ threshold 1 [I3\$1] (T3_1); !item 3 _ threshold 1 [I4\$1] (T4_1); !item 4 _ threshold 1 ... [I21\$1] (T21_1); !item 21 _ threshold 1 [I22\$1] (T22_1); !item 22 _ threshold 1</pre>	<p>The %c#1% section specifies the labels for item thresholds for profile [0000] (class #1).</p> <ul style="list-style-type: none"> <li>• Comes from column 1 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_1) is our label for item 1 – threshold 1</li> </ul>
<pre>!column #2 of item respond function labels table !for profile [0001] %c#2% [I1\$1] (T1_1); !item 1 _ threshold 1 [I2\$1] (T2_1); !item 2 _ threshold 1 [I3\$1] (T3_1); !item 3 _ threshold 1 [I4\$1] (T4_1); !item 4 _ threshold 1 ... [I21\$1] (T21_1); !item 21 _ threshold 1 [I22\$1] (T22_1); !item 22 _ threshold 1</pre>	<p>The %c#2% section specifies the labels for item thresholds for profile [0001] (class #2).</p> <ul style="list-style-type: none"> <li>• Comes from column 2 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_1) is our label for item 1 – threshold 1</li> </ul>
<pre>!column #3 of item respond function labels table !for profile [0010] %c#3% [I1\$1] (T1_1); !item 1 _ threshold 1 [I2\$1] (T2_2); !item 2 _ threshold 2 [I3\$1] (T3_1); !item 3 _ threshold 1 [I4\$1] (T4_1); !item 4 _ threshold 1 ... [I21\$1] (T21_1); !item 21 _ threshold 1 [I22\$1] (T22_1); !item 22 _ threshold 1</pre>	<p>The %c#3% section specifies the labels for item thresholds for profile [0010] (class #3).</p> <ul style="list-style-type: none"> <li>• Comes from column 3 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_1) is our label for item 1 – threshold 1</li> </ul>

Mplus Syntax	Comments
<pre>!column #4 of item respond function labels table !for profile [0011] %c#4% [I1\$1] (T1_1); !item 1 _ threshold 1 [I2\$1] (T2_2); !item 2 _ threshold 2 [I3\$1] (T3_1); !item 3 _ threshold 1 [I4\$1] (T4_1); !item 4 _ threshold 1 ... [I21\$1] (T21_1); !item 21 _ threshold 1 [I22\$1] (T22_1); !item 22 _ threshold 1</pre>	<p>The %c#4% section specifies the labels for item thresholds for profile [0011] (class #4).</p> <ul style="list-style-type: none"> <li>• Comes from column 4 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_1) is our label for item 1 – threshold 1</li> </ul>
<pre>!column #5 of item respond function labels table !for profile [0100] %c#5% [I1\$1] (T1_1); !item 1 _ threshold 1 [I2\$1] (T2_1); !item 2 _ threshold 1 [I3\$1] (T3_2); !item 3 _ threshold 2 [I4\$1] (T4_1); !item 4 _ threshold 1 ... [I21\$1] (T21_1); !item 21 _ threshold 1 [I22\$1] (T22_2); !item 22 _ threshold 2</pre>	<p>The %c#5% section specifies the labels for item thresholds for profile [0100] (class #5).</p> <ul style="list-style-type: none"> <li>• Comes from column 5 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_1) is our label for item 1 – threshold 1</li> </ul>
<pre>!column #6 of item respond function labels table !for profile [0101] %c#6% [I1\$1] (T1_1); !item 1 _ threshold 1 [I2\$1] (T2_1); !item 2 _ threshold 1 [I3\$1] (T3_2); !item 3 _ threshold 2 [I4\$1] (T4_1); !item 4 _ threshold 1 ... [I21\$1] (T21_1); !item 21 _ threshold 1 [I22\$1] (T22_2); !item 22 _ threshold 2</pre>	<p>The %c#6% section specifies the labels for item thresholds for profile [0101] (class #6).</p> <ul style="list-style-type: none"> <li>• Comes from column 6 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_1) is our label for item 1 – threshold 1</li> </ul>
<pre>!column #7 of item respond function labels table !for profile [0110] %c#7% [I1\$1] (T1_1); !item 1 _ threshold 1 [I2\$1] (T2_2); !item 2 _ threshold 2 [I3\$1] (T3_2); !item 3 _ threshold 2 [I4\$1] (T4_1); !item 4 _ threshold 1 ... [I21\$1] (T21_1); !item 21 _ threshold 1 [I22\$1] (T22_2); !item 22 _ threshold 2</pre>	<p>The %c#7% section specifies the labels for item thresholds for profile [0110] (class #7).</p> <ul style="list-style-type: none"> <li>• Comes from column 7 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_1) is our label for item 1 – threshold 1</li> </ul>
<pre>!column #8 of item respond function labels table !for profile [0111] %c#8% [I1\$1] (T1_1); !item 1 _ threshold 1 [I2\$1] (T2_2); !item 2 _ threshold 2 [I3\$1] (T3_2); !item 3 _ threshold 2 [I4\$1] (T4_1); !item 4 _ threshold 1 ... [I21\$1] (T21_1); !item 21 _ threshold 1 [I22\$1] (T22_2); !item 22 _ threshold 2</pre>	<p>The %c#8% section specifies the labels for item thresholds for profile [0111] (class #8).</p> <ul style="list-style-type: none"> <li>• Comes from column 8 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_1) is our label for item 1 – threshold 1</li> </ul>

Mplus Syntax	Comments
<pre>!column #9 of item response function labels table !for profile [1000] %c#9% [I1\$1] (T1_2); !item 1 _ threshold 2 [I2\$1] (T2_1); !item 2 _ threshold 1 [I3\$1] (T3_1); !item 3 _ threshold 1 [I4\$1] (T4_2); !item 4 _ threshold 2 ... [I21\$1] (T21_2); !item 21 _ threshold 2 [I22\$1] (T22_3); !item 22 _ threshold 3</pre>	<p>The %c#9% section specifies the labels for item thresholds for profile [1000] (class #9).</p> <ul style="list-style-type: none"> <li>• Comes from column 9 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_2) is our label for item 1 – threshold 2</li> </ul>
<pre>!column #10 of item respond function labels table !for profile [0001] %c#10% [I1\$1] (T1_2); !item 1 _ threshold 2 [I2\$1] (T2_1); !item 2 _ threshold 1 [I3\$1] (T3_1); !item 3 _ threshold 1 [I4\$1] (T4_2); !item 4 _ threshold 2 ... [I21\$1] (T21_2); !item 21 _ threshold 2 [I22\$1] (T22_3); !item 22 _ threshold 3</pre>	<p>The %c#10% section specifies the labels for item thresholds for profile [1001] (class #10).</p> <ul style="list-style-type: none"> <li>• Comes from column 10 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_2) is our label for item 1 – threshold 2</li> </ul>
<pre>!column #11 of item respond function labels table !for profile [1010] %c#11% [I1\$1] (T1_2); !item 1 _ threshold 2 [I2\$1] (T2_2); !item 2 _ threshold 2 [I3\$1] (T3_1); !item 3 _ threshold 1 [I4\$1] (T4_2); !item 4 _ threshold 2 ... [I21\$1] (T21_2); !item 21 _ threshold 2 [I22\$1] (T22_3); !item 22 _ threshold 3</pre>	<p>The %c#11% section specifies the labels for item thresholds for profile [1010] (class #11).</p> <ul style="list-style-type: none"> <li>• Comes from column 1 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_2) is our label for item 1 – threshold 2</li> </ul>
<pre>!column #12 of item respond function labels table !for profile [1011] %c#12% [I1\$1] (T1_2); !item 1 _ threshold 2 [I2\$1] (T2_2); !item 2 _ threshold 2 [I3\$1] (T3_1); !item 3 _ threshold 1 [I4\$1] (T4_2); !item 4 _ threshold 2 ... [I21\$1] (T21_2); !item 21 _ threshold 2 [I22\$1] (T22_3); !item 22 _ threshold 3</pre>	<p>The %c#12% section specifies the labels for item thresholds for profile [1011] (class #12).</p> <ul style="list-style-type: none"> <li>• Comes from column 12 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_2) is our label for item 1 – threshold 2</li> </ul>
<pre>!column #13 of item respond function labels table !for profile [1100] %c#13% [I1\$1] (T1_2); !item 1 _ threshold 2 [I2\$1] (T2_1); !item 2 _ threshold 1 [I3\$1] (T3_2); !item 3 _ threshold 2 [I4\$1] (T4_2); !item 4 _ threshold 2 ... [I21\$1] (T21_2); !item 21 _ threshold 2 [I22\$1] (T22_4); !item 22 _ threshold 4</pre>	<p>The %c#13% section specifies the labels for item thresholds for profile [1100] (class #13).</p> <ul style="list-style-type: none"> <li>• Comes from column 13 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_2) is our label for item 1 – threshold 2</li> </ul>

<pre>!column #14 of item respond function labels table !for profile [1101] %c#14% [I1\$1] (T1_2); !item 1 _ threshold 2 [I2\$1] (T2_1); !item 2 _ threshold 1 [I3\$1] (T3_2); !item 3 _ threshold 2 [I4\$1] (T4_2); !item 4 _ threshold 2 ... [I21\$1] (T21_2); !item 21 _ threshold 2 [I22\$1] (T22_4); !item 22 _ threshold 4</pre>	<p>The %c#14% section specifies the labels for item thresholds for profile [1101] (class #14).</p> <ul style="list-style-type: none"> <li>• Comes from column 14 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_2) is our label for item 1 – threshold 2</li> </ul>
<pre>!column #15 of item respond function labels table !for profile [1110] %c#15% [I1\$1] (T1_2); !item 1 _ threshold 2 [I2\$1] (T2_2); !item 2 _ threshold 2 [I3\$1] (T3_2); !item 3 _ threshold 2 [I4\$1] (T4_2); !item 4 _ threshold 2 ... [I21\$1] (T21_2); !item 21 _ threshold 2 [I22\$1] (T22_4); !item 22 _ threshold 4</pre>	<p>The %c#15% section specifies the labels for item thresholds for profile [1110] (class #15).</p> <ul style="list-style-type: none"> <li>• Comes from column 15 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_2) is our label for item 1 – threshold 2</li> </ul>
<pre>!column #16 of item respond function labels table !for profile [1111] %c#16% [I1\$1] (T1_2); !item 1 _ threshold 2 [I2\$1] (T2_2); !item 2 _ threshold 2 [I3\$1] (T3_2); !item 3 _ threshold 2 [I4\$1] (T4_2); !item 4 _ threshold 2 ... [I21\$1] (T21_2); !item 21 _ threshold 2 [I22\$1] (T22_4); !item 22 _ threshold 4</pre>	<p>The %c#16% section specifies the labels for item thresholds for profile [1111] (class #16).</p> <ul style="list-style-type: none"> <li>• Comes from column 16 of item response function labels table <ul style="list-style-type: none"> <li>• Repeated for all columns of table</li> </ul> </li> <li>• [I1\$1] is the threshold for item I1</li> <li>• (T1_2) is our label for item 1 – threshold 2</li> </ul>

**7. Building Mplus MODEL CONSTRAINT Command Syntax (with representative example items shown)**

Mplus Syntax	Comments
MODEL CONSTRAINT:	<p>The MODEL CONSTRAINT command is where the LCDM parameters are defined and the item response function is given for each label.</p> <ul style="list-style-type: none"> <li>• Structural model given [optional]</li> <li>• Syntax needed for all items</li> </ul>
<pre>!STRUCTURAL MODEL PORTION; !define structural model parameters: !NOTE: ANALYSIS USES UP 2-WAY INTERACTION PARAMETERS ONLY NEW(G_0 G_11 G_12 G_13 G_14     G_212 G_213 G_214 G_223 G_224 G_234);  m1= - (G_11+G_12+G_13+G_14+       G_212+G_213+G_214+G_223+G_224+G_234); m2= G_14 - (G_11+G_12+G_13+G_14+            G_212+G_213+G_214+G_223+G_224+G_234); m3= G_13 - (G_11+G_12+G_13+G_14+            G_212+G_213+G_214+G_223+G_224+G_234); m4= G_13+G_14+G_234-(G_11+G_12+G_13+G_14+                     G_212+G_213+G_214+G_223+G_224+G_234); m5= G_12 - (G_11+G_12+G_13+G_14+            G_212+G_213+G_214+G_223+G_224+G_234); m6= G_12+G_14+G_224-(G_11+G_12+G_13+G_14+                     G_212+G_213+G_214+G_223+G_224+G_234); m7= G_12+G_13+G_223-(G_11+G_12+G_13+G_14+                     G_212+G_213+G_214+G_223+G_224+G_234); m8= G_12+G_13+G_14+G_223+G_224+G_234 -     (G_11+G_12+G_13+G_14+      G_212+G_213+G_214+G_223+G_224+G_234); m9= G_11 - (G_11+G_12+G_13+G_14+            G_212+G_213+G_214+G_223+G_224+G_234); m10= G_11+G_14+G_214-(G_11+G_12+G_13+G_14+                     G_212+G_213+G_214+G_223+G_224+G_234); m11= G_11+G_13+G_213-(G_11+G_12+G_13+G_14+                     G_212+G_213+G_214+G_223+G_224+G_234); m12= G_11+G_13+G_14+G_213+G_214+G_234 -     (G_11+G_12+G_13+G_14+      G_212+G_213+G_214+G_223+G_224+G_234); m13= G_11+G_12+G_212 -     (G_11+G_12+G_13+G_14+G_212+G_213+G_214+      G_223+G_224+G_234); m14= G_11+G_12+G_14+G_212+G_214+G_224 -     (G_11+G_12+G_13+G_14+      G_212+G_213+G_214+G_223+G_224+G_234); m15= G_11+G_12+G_13+G_212+G_213+G_223 -     (G_11+G_12+G_13+G_14+      G_212+G_213+G_214+G_223+G_224+G_234);</pre>	<p>The structural model section.</p> <ul style="list-style-type: none"> <li>• Taken from structural model specification table</li> <li>• NEW: creates new parameters for Mplus to use in estimation</li> <li>• G_[ea1...]: label for gamma parameter; structural model effect parameter             <ul style="list-style-type: none"> <li>• e: effect level (0- intercept; 1- main effect; 2 – two way interaction...)</li> <li>• a1...: attribute(s) to which effect applies; number of attributes is equal to effect level e</li> </ul> </li> </ul>



<pre>! Item 1 [1000] NEW(L1_0 L1_11); !link labels with LCDM item response function: T1_1=-(L1_0); T1_2=-(L1_0+L1_11); !main effect order constraint: L1_11&gt;0;</pre>	<p>The LCDM item parameter section for item 1.</p> <ul style="list-style-type: none"> <li>• Links label with item response function</li> <li>• NEW: creates new parameters for Mplus to use in estimation</li> <li>• L1_[ea1...]: label for lambda parameter; LCDM item parameter <ul style="list-style-type: none"> <li>• 1: parameter for item 1</li> <li>• e: effect level (0- intercept; 1- main effect; 2 – two way interaction...)</li> <li>• a1...: attribute(s) to which effect applies; number of attributes is equal to effect level e</li> </ul> </li> <li>• LCDM item response function multiplied by -1 (Mplus modeling difference)</li> </ul>
<pre>! Item 3 [0100] NEW(L3_0 L3_12); !link labels with LCDM item response function: T3_1=-(L3_0); T3_2=-(L3_0+L3_12); !main effect order constraint: L3_12&gt;0;</pre>	<p>The LCDM item parameter section for item 3.</p> <ul style="list-style-type: none"> <li>• Links label with item response function</li> <li>• NEW: creates new parameters for Mplus to use in estimation</li> <li>• L3_[ea1...]: label for lambda parameter; LCDM item parameter <ul style="list-style-type: none"> <li>• 3: parameter for item 3</li> <li>• e: effect level (0- intercept; 1- main effect; 2 – two way interaction...)</li> <li>• a1...: attribute(s) to which effect applies; number of attributes is equal to effect level e</li> </ul> </li> <li>• LCDM item response function multiplied by -1 (Mplus modeling difference)</li> </ul>
<pre>! Item 8a [0010] NEW(L8a_0 L8a_13); !link labels with LCDM item response function: T8a_1=-(L8a_0); T8a_2=-(L8a_0+L8a_13); !main effect order constraint: L8a_13&gt;0;</pre>	<p>The LCDM item parameter section for item 8a.</p> <ul style="list-style-type: none"> <li>• Links label with item response function</li> <li>• NEW: creates new parameters for Mplus to use in estimation</li> <li>• L8a_[ea1...]: label for lambda parameter; LCDM item parameter <ul style="list-style-type: none"> <li>• 8a: parameter for item 8a</li> <li>• e: effect level (0- intercept; 1- main effect; 2 – two way interaction...)</li> <li>• a1...: attribute(s) to which effect applies; number of attributes is equal to effect level e</li> </ul> </li> <li>• LCDM item response function multiplied by -1 (Mplus modeling difference)</li> </ul>

<pre>! Item 10a [0001] NEW(L10a_0 L10a_13); !link labels with LCDM item response function: T10a_1=-(L10a_0); T10a_2=-(L10a_0+L10a_14); !main effect order constraint: L10a_14&gt;0;</pre>	<p>The LCDM item parameter section for item 10a.</p> <ul style="list-style-type: none"> <li>• Links label with item response function</li> <li>• NEW: creates new parameters for Mplus to use in estimation</li> <li>• L10a_[ea1...]: label for lambda parameter; LCDM item parameter <ul style="list-style-type: none"> <li>• 10a: parameter for item 10a</li> <li>• e: effect level (0- intercept; 1- main effect; 2 – two way interaction...)</li> <li>• a1...: attribute(s) to which effect applies; number of attributes is equal to effect level e</li> </ul> </li> <li>• LCDM item response function multiplied by -1 (Mplus modeling difference)</li> </ul>
<pre>! Item 14 [1100] NEW(L14_0 L4_11 L4_12 L4_212); !link labels with LCDM item response function: T14_1=-(L14_0); T14_2=-(L14_0+L14_12); T14_3=-(L14_0+L14_11); T14_4=-(L14_0+L14_11+L14_12+L14_212); !main effect order constraints: L14_11&gt;0; L14_12&gt;0; !two-way interaction constraints: L14_212&gt;-L14_11; L14_212&gt;-L14_12;</pre>	<p>The LCDM item parameter section for item 14.</p> <ul style="list-style-type: none"> <li>• Links label with item response function</li> <li>• NEW: creates new parameters for Mplus to use in estimation</li> <li>• L14_[ea1...]: label for lambda parameter; LCDM item parameter <ul style="list-style-type: none"> <li>• 14: parameter for item 14</li> <li>• e: effect level (0- intercept; 1- main effect; 2 – two way interaction...)</li> <li>• a1...: attribute(s) to which effect applies; number of attributes is equal to effect level e</li> </ul> </li> </ul> <p>LCDM item response function multiplied by -1 (Mplus modeling difference)</p>
<pre>! Item 15a [1001] NEW(L15a_0 L15a_11 L15a_14 L15a_214); !link labels with LCDM item response function: T15a_1=-(L15a_0); T15a_2=-(L15a_0+L15a_14); T15a_3=-(L15a_0+L15a_11); T15a_4=-(L15a_0+L15a_11+L15a_14+L15a_214); !main effect order constraints: L15a_11&gt;0; L15a_14&gt;0; !two-way interaction constraints: L15a_214&gt;-L15a_11; L15a_214&gt;-L15a_14;</pre>	<p>The LCDM item parameter section for item 15a.</p> <ul style="list-style-type: none"> <li>• Links label with item response function</li> <li>• NEW: creates new parameters for Mplus to use in estimation</li> <li>• L15a_[ea1...]: label for lambda parameter; LCDM item parameter <ul style="list-style-type: none"> <li>• 15a: parameter for item 15a</li> <li>• e: effect level (0- intercept; 1- main effect; 2 – two way interaction...)</li> <li>• a1...: attribute(s) to which effect applies; number of attributes is equal to effect level e</li> </ul> </li> </ul> <p>LCDM item response function multiplied by -1 (Mplus modeling difference)</p>

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! Item 13 [0101]
NEW(L13_0 L13_12 L13_14 L13_224);
!link labels with LCDM item response function:
T13_1=-(L13_0);
T13_2=-(L13_0+L13_14);
T13_3=-(L13_0+L13_12);
T13_4=-(L13_0+L13_12+L13_14+L13_224);
!main effect order constraints:
L13_12>0; L13_14>0;
!two-way interaction constraints:
L13_224>-L13_12; L13_224>-L13_14;

```

The LCDM item parameter section for item 13.

- Links label with item response function
- NEW: creates new parameters for Mplus to use in estimation
- L13\_[ea1...]: label for lambda parameter; LCDM item parameter
  - 13: parameter for item 3
  - e: effect level (0- intercept; 1- main effect; 2 – two way interaction...)
  - a1...: attribute(s) to which effect applies; number of attributes is equal to effect level e

LCDM item response function multiplied by -1 (Mplus modeling difference)

**Understanding Mplus Output**

Once the syntax has been built and Mplus finishes estimating the model, the Mplus output contains all the information needed to evaluate the model run. Mplus syntax is voluminous in its size, with only a few sections of interest (and many that are redundant). Each section is discussed in the following pages, in order of appearance in the output file.

1. Tests of Model Fit Output Section
2. Final class counts and proportions
3. New/Additional parameters
4. Technical 10

**Tests of Model Fit Output Section**

## MODEL FIT INFORMATION

Number of Free Parameters	71
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## Loglikelihood

H0 Value	-14257.169
H0 Scaling Correction Factor for MLR	1.063

## Information Criteria

Akaike (AIC)	28656.338
Bayesian (BIC)	29004.075
Sample-Size Adjusted BIC	28778.576
(n* = (n + 2) / 24)	

- Provides basic model fit information
- Information Criteria: Used to compare model fit for non-nested models (smaller is better)

**Final Class Counts and Estimated Proportions Output Section**

FINAL CLASS COUNTS AND PROPORTIONS FOR THE LATENT CLASSES  
 BASED ON THE ESTIMATED MODEL

Latent  
Classes

1	210.34540	0.21247
2	69.20994	0.06991
3	55.19197	0.05575
4	82.74175	0.08358
5	37.63398	0.03801
6	25.56661	0.02582
7	49.04489	0.04954
8	151.80987	0.15334
9	2.24094	0.00226
10	3.50645	0.00354
11	2.32019	0.00234
12	16.54147	0.01671
13	3.33667	0.00337
14	10.77973	0.01089
15	17.15841	0.01733
16	252.57174	0.25512

Provides the probability a random respondent has a given attribute profile

- 21.23% of sample has profile [0,0,0,0]
- 6.99% of sample has profile [0,0,0,1]

**New/Additional Parameters Output Section**

New/Additional Parameters					Two-Tailed P-Value
	Estimate	S.E.	Est./S.E.		
G_0	-0.183	0.142	-1.288	0.198	Structural Model Parameters
G_11	-4.542	0.758	-5.989	0.000	
G_12	-1.721	0.319	-5.390	0.000	
G_13	-1.338	0.358	-3.742	0.000	
G_14	-1.112	0.241	-4.618	0.000	
G_212	2.119	0.515	4.117	0.000	
G_213	1.373	0.557	2.465	0.014	
G_214	1.559	0.488	3.196	0.001	
G_223	1.603	0.374	4.285	0.000	
G_224	0.725	0.362	2.005	0.045	
G_234	1.517	0.348	4.354	0.000	
L1_0	-1.118	0.123	-9.106	0.000	LCDM Item Parameters
L1_11	2.239	0.201	11.120	0.000	
L2_0	0.585	0.130	4.492	0.000	
L2_13	1.271	0.215	5.924	0.000	
L3_0	-2.069	0.218	-9.497	0.000	
L3_12	1.695	0.239	7.084	0.000	
L4_0	-1.191	0.109	-10.906	0.000	
L4_11	0.648	0.188	3.448	0.001	
L5_0	-1.668	0.138	-12.047	0.000	
L5_11	1.517	0.196	7.726	0.000	
L6_0	-3.806	0.473	-8.043	0.000	
L6_12	2.075	0.503	4.128	0.000	
L7_0	-0.726	0.089	-8.143	0.000	
L7_11	1.204	0.221	5.441	0.000	
L8A_0	-0.615	0.249	-2.468	0.014	
L8A_13	4.245	0.637	6.667	0.000	
L8B_0	-0.091	0.172	-0.529	0.596	
L8B_13	2.159	0.237	9.118	0.000	
L8C_0	0.283	0.128	2.215	0.027	
L8C_13	0.869	0.178	4.874	0.000	
L8D_0	-1.032	0.166	-6.214	0.000	
L8D_13	1.805	0.213	8.471	0.000	
L9_0	-1.224	0.100	-12.246	0.000	
L9_11	0.764	0.186	4.106	0.000	

- Provides each parameter estimate and standard error
- Hypothesis test provides way of testing whether each parameter is equal to zero
  - Works for all structural model parameters
  - Works for LCDM intercept item parameters (although test isn't informative)
  - Will not work for LCDM main effect parameters
  - Is only approximate for interaction parameters

**Technical 10 Output Section**

BIVARIATE MODEL FIT INFORMATION				
		Estimated Probabilities		
Variable	Variable	H1	H0	Standardized Residual (z-score)
I1	I2			
Category 1	Category 1	0.148	0.140	0.744
Category 1	Category 2	0.446	0.456	-0.629
Category 2	Category 1	0.069	0.077	-0.986
Category 2	Category 2	0.338	0.328	0.678
Bivariate Pearson Chi-Square				1.898
Bivariate Log-Likelihood Chi-Square				1.922

- Provides quick goodness of fit check for pairs of items – similar to raw residuals in SEM