

Latent class analysis

R & Latent GOLD
DL Oberski & L Boeschoten

As mentioned on day 1...

... There are multiple software tools available for LCA.

- So far we only worked with R.

Software

Latent GOLD (<https://www.statisticalinnovations.com/>)

- Most advanced features in terms of LCM
- Commercial → free academic licenses per 2025!!!!
- Windows only

Mplus (<https://www.statmodel.com/>)

- Most popular by far
- Also does (mixture) SEM, very good for such models
- Commercial
- Windows+Mac+Linux

LEM (<https://jeroenvermunt.nl/>)

- Very powerful, but limited in model size (and not updated since 1997)
- Free (“as in beer”, *not* open source)
- Windows only

Software: R

- Definitely *not* user-friendly
- Need to use different packages for different things
- Need to understand better what is going on
- A lot more hands-on
- Free (“as in speech”, i.e. open source *and* “as in beer”)

Oh-so-rewarding!

R packages in the course

poLCA

- Probably the most robust and most popular R package for LCA
- Limited to “plain vanilla” LCA, categorical indicators

mclust

- Great for continuous indicators (“latent profile analysis”)
- Nice ecosystem from model-based clustering community
- Functionality and use following book of Bouveyron et al.

R packages in the course (cont.)

flexmix

- Can fit certain extensions, such as random effects (multilevel) models, growth mixture models etc.
- Limited to single categorical latent variable, but flexible (as the name implies) in terms of what differs over classes

Cvam → not updated anymore

- Loglinear approach to latent class and missing data
- Very powerful, can fit almost any LCM involving categorical latent and observed variables (quite similar to LEM)
- Sadly limited to small models due to its approach (like LEM)

R packages for specific models

LMest

- Specific package for latent Markov models
- Functionality following the book of Bartolucci et al.

On the program today:

- Local dependence
- Multiple latent variables
- Ordinal indicators
- Tree step modelling

→ R not always has straightforward options.

→ So, we explore the possibilities with Latent GOLD.

Introduction to Latent GOLD

How to obtain Latent GOLD?

Important note:

Latent GOLD is only available for Windows. If you have a Macbook, install through Wine: <https://www.winehq.org/> (this can be a pain ...)

1. Download the DEMO software here:
<https://www.statisticalinnovations.com/demo-software/>
2. Purchase a **free** LatentGOLD 6.1 Academic New License here:
<https://www.statisticalinnovations.com/product-category/latentgold-6-1-options/>
3. In Latent GOLD, go to help → Serial Number → Fill in your license number.

How to get started?

- Two ways of working with Latent GOLD:
 - GUI
 - Syntax

Latent GOLD GUI

▼ Latent GOLD®

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The Latent GOLD® Syntax manual presents an overview of the most important features included in the Syntax add-on, describes the full syntax language, and provides examples of the features specific to Syntax

[LG-Syntax User's Guide](#)

Download the Latent GOLD® 4.0 User's Guide by Chapter:

[Chapter 1: Overview](#)

[Chapter 2: General Program Structure](#)

[Chapter 3: Data Files and Formats](#)

[Chapter 4: Working with Output](#)

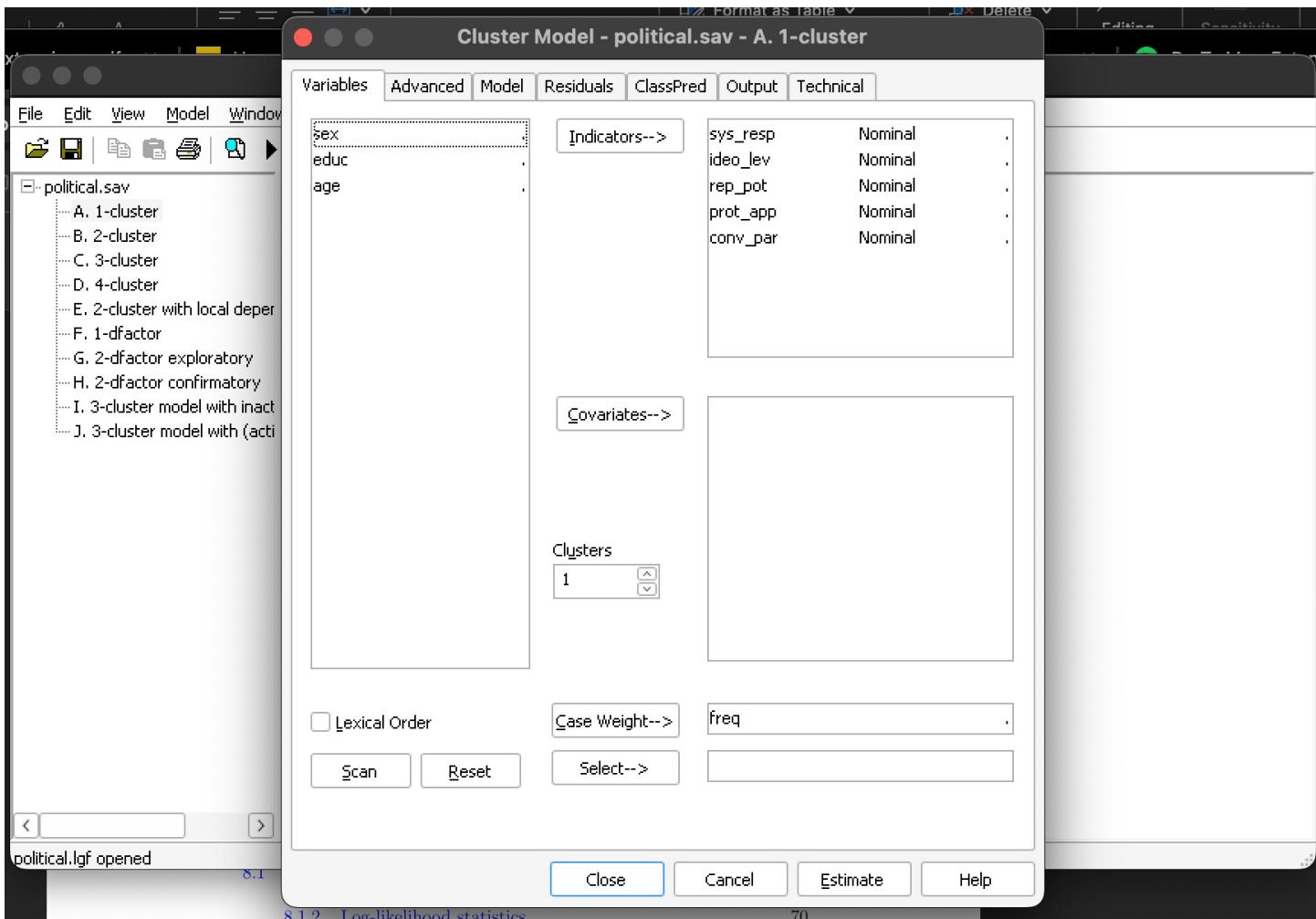
Lots of GUI examples

- Click for example: Help → GUI examples → Dichotomous → Standard LC, Local dependence, Covariates

The screenshot shows a software interface with a menu bar (File, Edit, View, Model, Window, Help) and a toolbar with various icons. On the left is a file browser tree view showing a folder named "political.sav" containing items A through J. To the right is a table with statistical information.

	File name:	political.sav	File size:	3672 bytes 268 records	File date:	2020-Oct-27 2:02:14 AM	Definition:	political.lgf	LL	BIC(LL)	AIC(LL)	AIC3(LL)	Npar	
A. 1-cluster									1-Cluster					
B. 2-cluster									2-Cluster					
C. 3-cluster									3-Cluster					
D. 4-cluster									4-Cluster					
E. 2-cluster with local dependence									2-Cluster					
F. 1-dfactor									1-DFactor					
G. 2-dfactor exploratory									2-DFactor					
H. 2-dfactor confirmatory									2-DFactor					
I. 3-cluster model with inactive covariates									3-Cluster					
J. 3-cluster model with (active) covariates									3-Cluster					

Run a model in GUI



GUI One-class model output

LatentGOLD - Academic use only

File Edit View Model Window Help

litical.sav

A. 1-cluster - $L^2 = 296.5594$

- + Parameters
- + Profile
- + ProbMeans
- Bivariate Residuals
- EstimatedValues-Model
- Iteration Detail
- B. 2-cluster
- C. 3-cluster
- D. 4-cluster
- E. 2-cluster with local dependence
- F. 1-dfactor
- G. 2-dfactor exploratory
- H. 2-dfactor confirmatory
- I. 3-cluster model with inactive cov.
- J. 3-cluster model with (active) cov.

1-Cluster Model

Number of cases	1156
Number of parameters (Npar)	5
Random Seed	98263
Best Start Seed	98263

Chi-squared Statistics

Degrees of freedom (df)	26	p-value
L-squared (L^2)	296.5594	1.0e-47
X-squared	327.5989	6.1e-54
Cressie-Read	312.3193	7.2e-51
BIC (based on L^2)	113.1887	
AIC (based on L^2)	244.5594	
AIC3 (based on L^2)	218.5594	
CAIC (based on L^2)	87.1887	
SABIC (based on L^2)	195.7731	
Dissimilarity Index	0.1867	
Total BVR	302.4427	

Log-likelihood Statistics

Log-likelihood (LL)	-3767.2541
Log-prior	-3.2551

GUI Two-class model output

LatentGOLD - Academic use only

File Edit View Model Window Help

litical.sav

- A. 1-cluster - $L^2 = 296.5594$
- B. 2-cluster - $L^2 = 95.8174$
 - + Parameters
 - + Profile
 - + ProbMeans
 - Bivariate Residuals
 - EstimatedValues-Model
 - Iteration Detail
- C. 3-cluster
- D. 4-cluster
- E. 2-cluster with local dependence
- F. 1-dfactor
- G. 2-dfactor exploratory
- H. 2-dfactor confirmatory
- I. 3-cluster model with inactive co
- J. 3-cluster model with (active) co

2-Cluster Model

Number of cases	1156		
Number of parameters (Npar)	11		
Random Seed	1197953		
Best Start Seed	723268		
Chi-squared Statistics			
Degrees of freedom (df)	20	p-value	
L-squared (L^2)	95.8174	7.0e-12	
X-squared	95.3762	8.4e-12	
Cressie-Read	95.0428	9.6e-12	
BIC (based on L^2)	-45.2371		
AIC (based on L^2)	55.8174		
AIC3 (based on L^2)	35.8174		
CAIC (based on L^2)	-65.2371		
SABIC (based on L^2)	18.2894		
Dissimilarity Index	0.1125		
Total BVR	71.0891		
Log-likelihood Statistics			
Log-likelihood (LL)	-3666.8831		
Log-prior	-4.5029		

GUI Two-class model fit

LatentGOLD - Academic use only

File Edit View Model Window Help

litical.say

- A. 1-cluster - $L^2 = 296.5594$
- B. 2-cluster - $L^2 = 95.8174$
- + Parameters
- + Profile
- + ProbMeans
- Bivariate Residuals
- EstimatedValues-Model
- Iteration Detail
- C. 3-cluster
- D. 4-cluster
- E. 2-cluster with local dependence
- F. 1-dfactor
- G. 2-dfactor exploratory
- H. 2-dfactor confirmatory
- I. 3-cluster model with inactive co
- J. 3-cluster model with (active) co

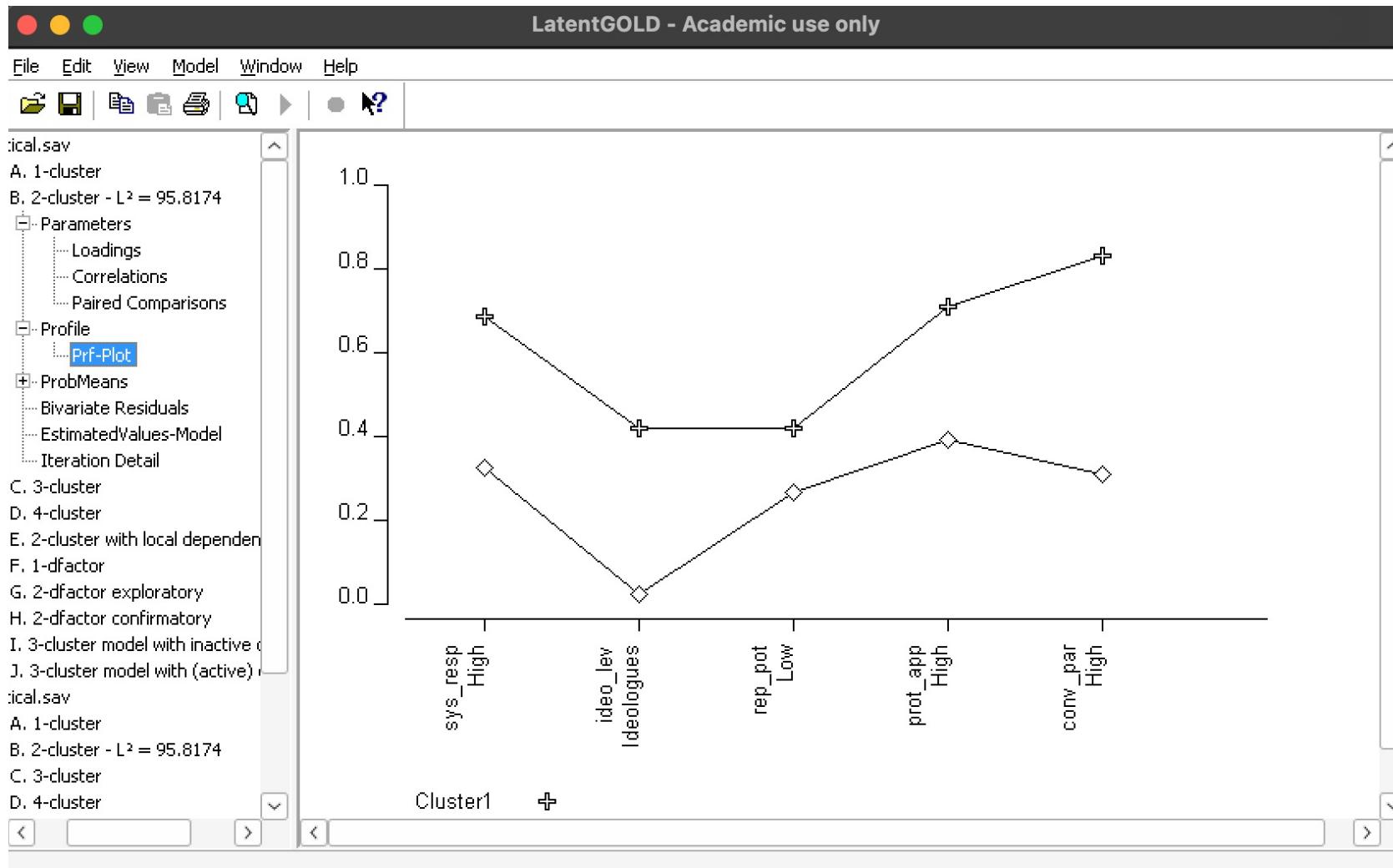
	BIC (based on LL)	7411.3461			
	AIC (based on LL)	7355.7662			
	AIC3 (based on LL)	7366.7662			
	CAIC (based on LL)	7422.3461			
	SABIC (based on LL)	7376.4065			
	Classification Statistics	Clusters			
	Classification errors	0.1642			
	Reduction of errors (Lambda)	0.5957			
	Entropy R-squared	0.4536			
	Standard R-squared	0.5134			
	Classification log-likelihood	-4093.5199			
	Entropy	426.6368			
	CLC	8187.0398			
	AWE	8375.1996			
	ICL-BIC	8264.6197			
	Classification Table	Modal			
	Latent	Cluster1	Cluster2	Total	
	Cluster1	605.9558	80.7477	686.7035	
	Cluster2	109.0442	360.2523	469.2965	
	Total	715.0000	441.0000	1156.0000	

GUI Two-class profile

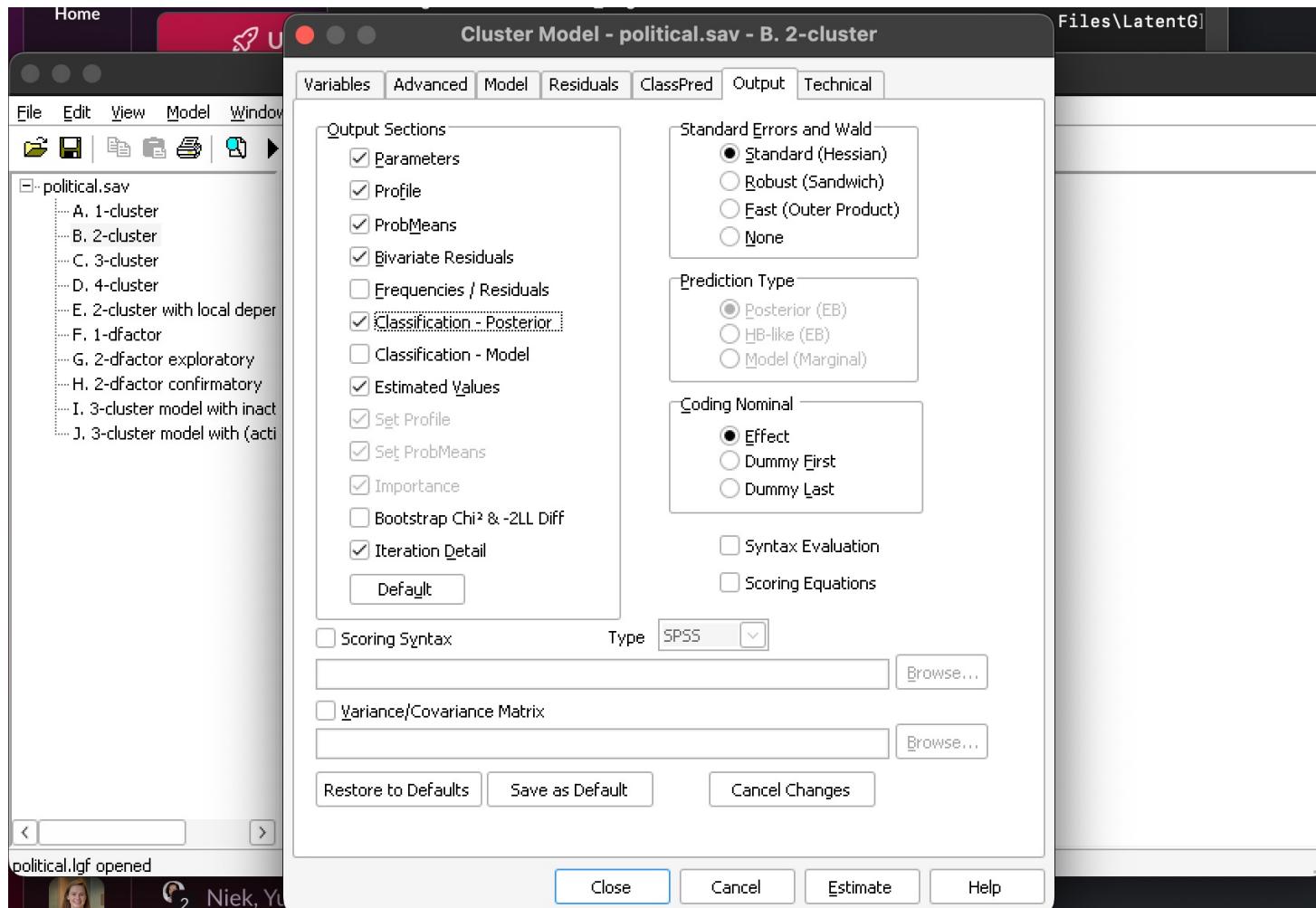
The screenshot shows the LatentGOLD software interface with the title "LatentGOLD - Academic use only". The menu bar includes File, Edit, View, Model, Window, and Help. The toolbar contains icons for opening files, saving, and other functions. The left pane displays a file tree for a project named "political.sav", which includes various model specifications from A to J. The right pane shows a table titled "Profile" with data for "sys_resp", "ideo_lev", "rep_pot", "prot_app", and "conv_par" across "Low" and "High" categories for Cluster1, Cluster2, and Overall.

	Cluster1	Cluster2	Overall
Cluster Size	0.5940	0.4060	
Indicators			
sys_resp			
Low	0.3135	0.6748	0.4602
High	0.6865	0.3252	0.5398
ideo_lev			
Nonideologues	0.5798	0.9756	0.7405
Ideologues	0.4202	0.0244	0.2595
rep_pot			
High	0.5808	0.7334	0.6427
Low	0.4192	0.2666	0.3573
prot_app			
Low	0.2910	0.6076	0.4195
High	0.7090	0.3924	0.5805
conv_par			
Low	0.1688	0.6905	0.3806
High	0.8312	0.3095	0.6194

GUI Two-class profile plot



GUI Options for output



GUI Posterior probabilities

LatentGOLD - Academic use only

File Edit View Model Window Help

political.sav

A. 1-cluster

B. 2-cluster - $L^2 = 95.8174$

Parameters

Profile

ProbMeans

Bivariate Residuals

Classification

EstimatedValues-Model

Iteration Detail

C. 3-cluster

D. 4-cluster

E. 2-cluster with local dependence

F. 1-dfactor

G. 2-dfactor exploratory

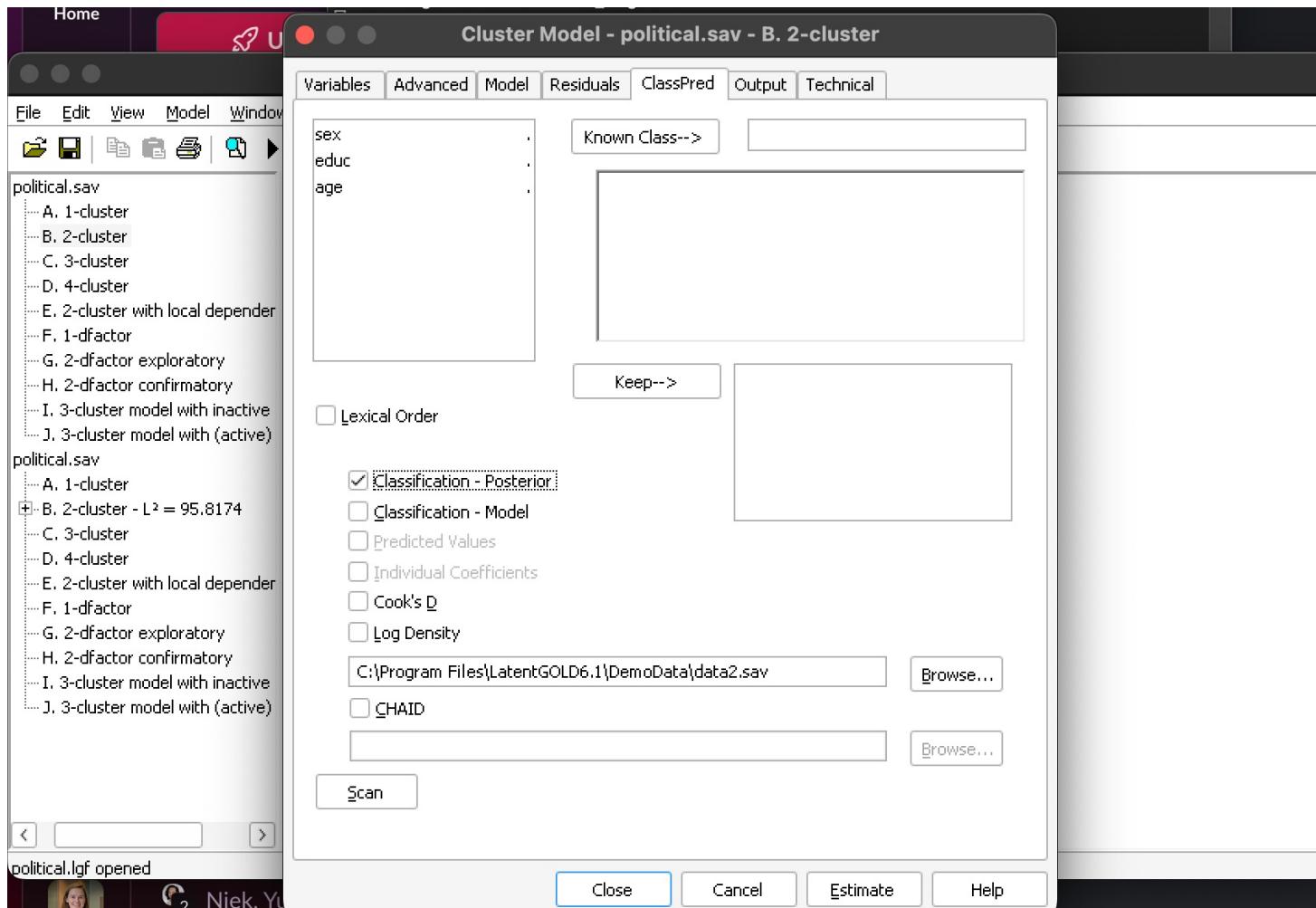
H. 2-dfactor confirmatory

I. 3-cluster model with inactive c

J. 3-cluster model with (active) c

sys_resp	ideo_lev	rep_pot	prot_app	conv_par	ObsFreq	Modal	Cluster1	Cluster2
Low	Nonideologues	High	Low	Low	109.0000	2	0.0361	0.9639
Low	Nonideologues	High	Low	High	68.0000	2	0.2914	0.7086
Low	Nonideologues	High	High	Low	59.0000	2	0.1238	0.8762
Low	Nonideologues	High	High	High	44.0000	1	0.6081	0.3919
Low	Nonideologues	Low	Low	Low	28.0000	2	0.0692	0.9308
Low	Nonideologues	Low	Low	High	18.0000	2	0.4495	0.5505
Low	Nonideologues	Low	High	Low	48.0000	2	0.2191	0.7809
Low	Nonideologues	Low	High	High	54.0000	1	0.7550	0.2450
Low	Ideologues	High	Low	Low	4.0000	1	0.5202	0.4798
Low	Ideologues	High	Low	High	19.0000	1	0.9225	0.0775
Low	Ideologues	High	High	Low	7.0000	1	0.8036	0.1964
Low	Ideologues	High	High	High	32.0000	1	0.9782	0.0218
Low	Ideologues	Low	Low	Low	3.0000	1	0.6829	0.3171
Low	Ideologues	Low	Low	High	3.0000	1	0.9594	0.0406
Low	Ideologues	Low	High	Low	10.0000	1	0.8904	0.1096
Low	Ideologues	Low	High	High	26.0000	1	0.9889	0.0111
High	Nonideologues	High	Low	Low	49.0000	2	0.1454	0.8546
High	Nonideologues	High	Low	High	92.0000	1	0.6514	0.3486
High	Nonideologues	High	High	Low	46.0000	2	0.3910	0.6090
High	Nonideologues	High	High	High	96.0000	1	0.8758	0.1242
High	Nonideologues	Low	Low	Low	16.0000	2	0.2525	0.7475
High	Nonideologues	Low	Low	High	16.0000	1	0.7877	0.2123

GUI Posteriors → save to file



Latent GOLD Syntax

▼ Latent GOLD®

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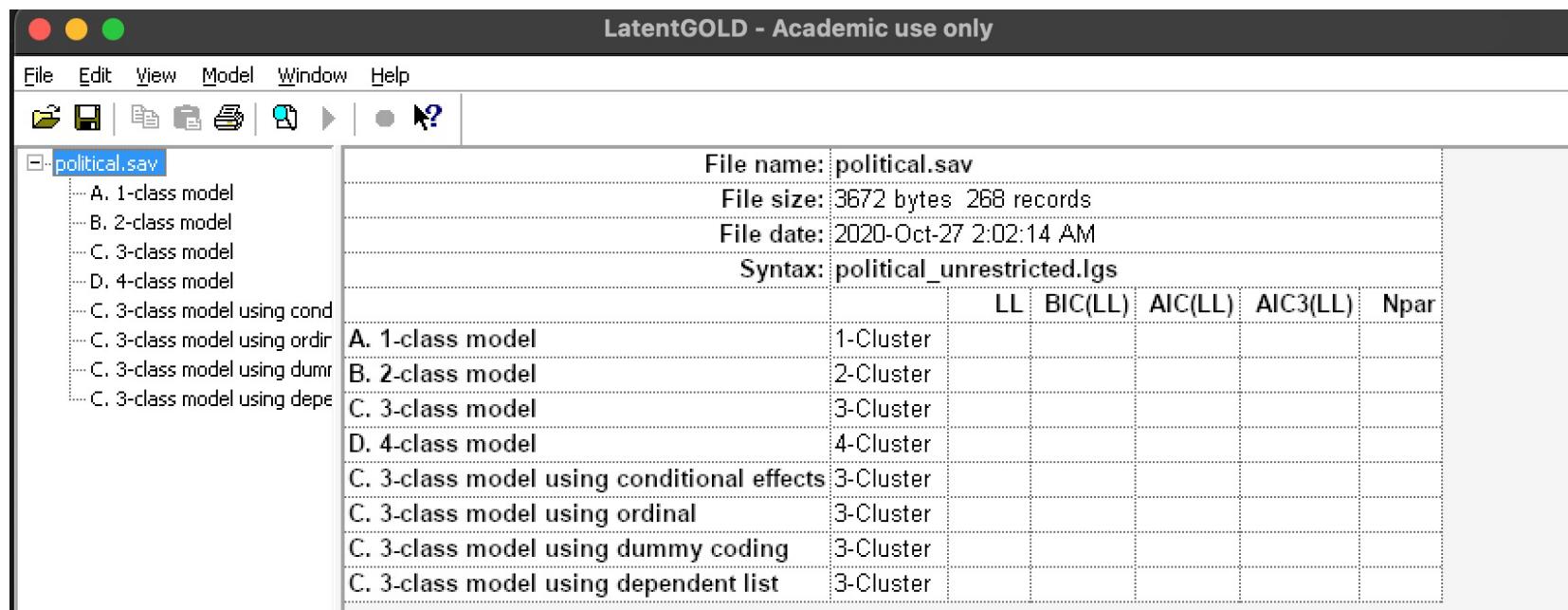
[Chapter 2: General Program Structure](#)

[Chapter 3: Data Files and Formats](#)

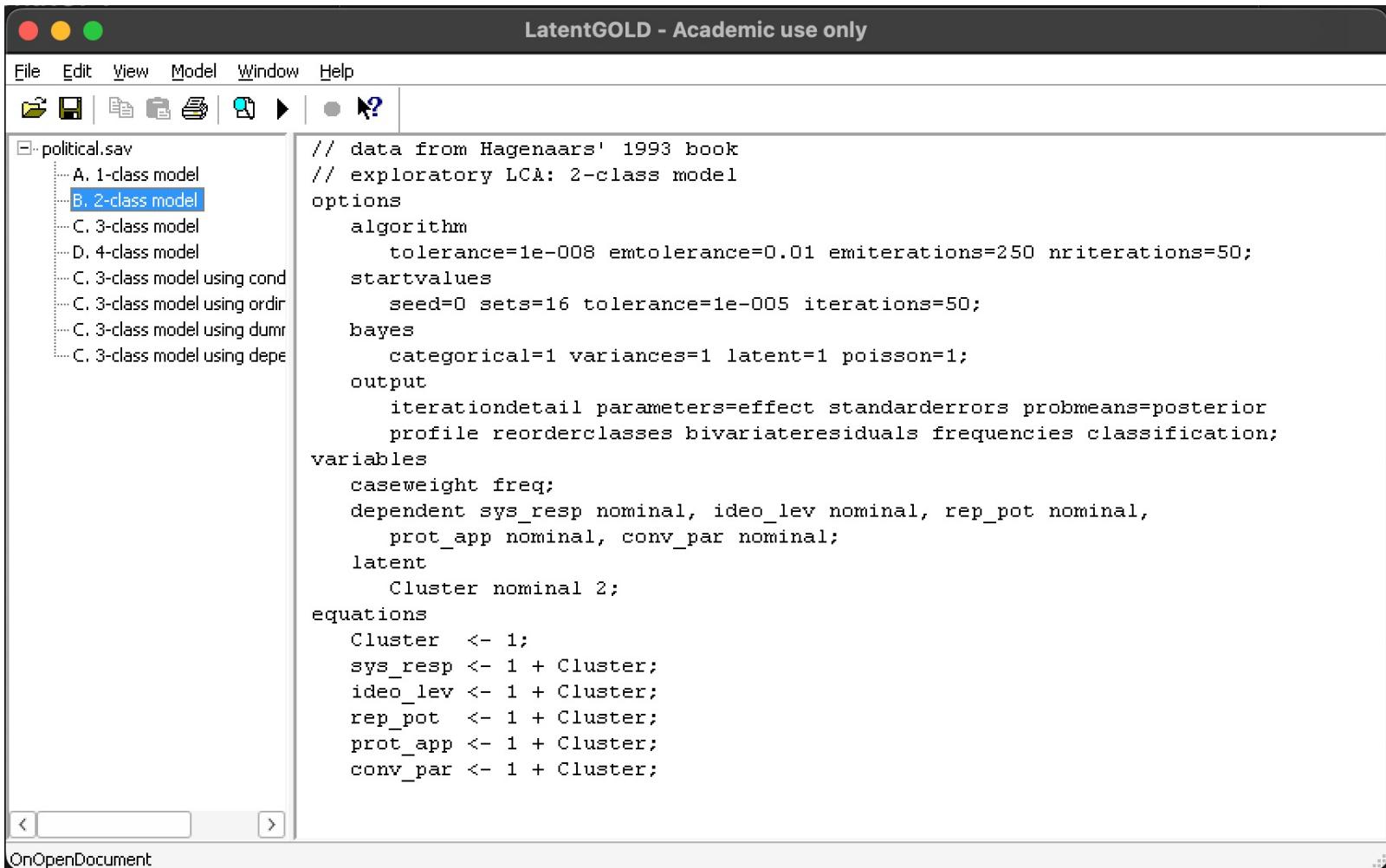
[Chapter 4: Working with Output](#)

Also, lots of Syntax examples

- Click for example: Help → Syntax examples → Latent class analysis → Dichotomous responses → unrestricted (1)



Syntax two-class model



The screenshot shows the LatentGOLD software interface with the title "LatentGOLD - Academic use only". The window has a menu bar with File, Edit, View, Model, Window, and Help. Below the menu is a toolbar with icons for file operations. On the left is a tree view of a project structure under "political.sav": A. 1-class model, B. 2-class model (selected), C. 3-class model, D. 4-class model, C. 3-class model using cond, C. 3-class model using ordir, C. 3-class model using dumr, and C. 3-class model using depo. The main pane displays the following LCA syntax:

```
// data from Hagenaars' 1993 book
// exploratory LCA: 2-class model
options
  algorithm
    tolerance=1e-008 emtolerance=0.01 emititerations=250 nriterations=50;
  startvalues
    seed=0 sets=16 tolerance=1e-005 iterations=50;
  bayes
    categorical=1 variances=1 latent=1 poisson=1;
  output
    iterationdetail parameters=effect standarderrors probmeans=posterior
    profile reorderclasses bivariate residuals frequencies classification;
variables
  caseweight freq;
  dependent sys_resp nominal, ideo_lev nominal, rep_pot nominal,
    prot_app nominal, conv_par nominal;
  latent
    Cluster nominal 2;
equations
  Cluster <- 1;
  sys_resp <- 1 + Cluster;
  ideo_lev <- 1 + Cluster;
  rep_pot <- 1 + Cluster;
  prot_app <- 1 + Cluster;
  conv_par <- 1 + Cluster;
```

At the bottom left, there are navigation buttons (< >) and the text "OnOpenDocument".

Syntax two-class model output

LatentGOLD - Academic use only

File Edit View Model Window Help

2-Cluster Syntax Model

Number of cases	1156
Number of parameters (Npar)	11
Random Seed	441903
Best Start Seed	2094310
Chi-squared Statistics	
Degrees of freedom (df)	20
L-squared (L^2)	95.8174
X-squared	95.3762
Cressie-Read	95.0428
BIC (based on L^2)	-45.2371
AIC (based on L^2)	55.8174
AIC3 (based on L^2)	35.8174
CAIC (based on L^2)	-65.2371
SABIC (based on L^2)	18.2894
Dissimilarity Index	0.1125
Total BVR	71.0891
Log-likelihood Statistics	
Log-likelihood (LL)	-3666.8831
Log-prior	-4.5029

ical.say
A. 1-class model
B. 2-class model - $L^2 = 95.8174$
Syntax
Parameters
Profile
ProbMeans-Posterior
Freqs/Residuals
Bivariate Residuals
Classification-Posterior
Iteration Detail
C. 3-class model
D. 4-class model
C. 3-class model using conditional e
C. 3-class model using ordinal
C. 3-class model using dummy codir
C. 3-class model using dependent li

Syntax model output parameter values

LatentGOLD - Academic use only

File Edit View Model Window Help

ical.sav

A. 1-class model

B. 2-class model - $L^2 = 95.8174$

Syntax

+ Parameters

+ Profile

- ProbMeans-Posterior

- Freqs/Residuals

- Bivariate Residuals

- Classification-Posterior

- Iteration Detail

C. 3-class model

D. 4-class model

C. 3-class model using conditional e

C. 3-class model using ordinal

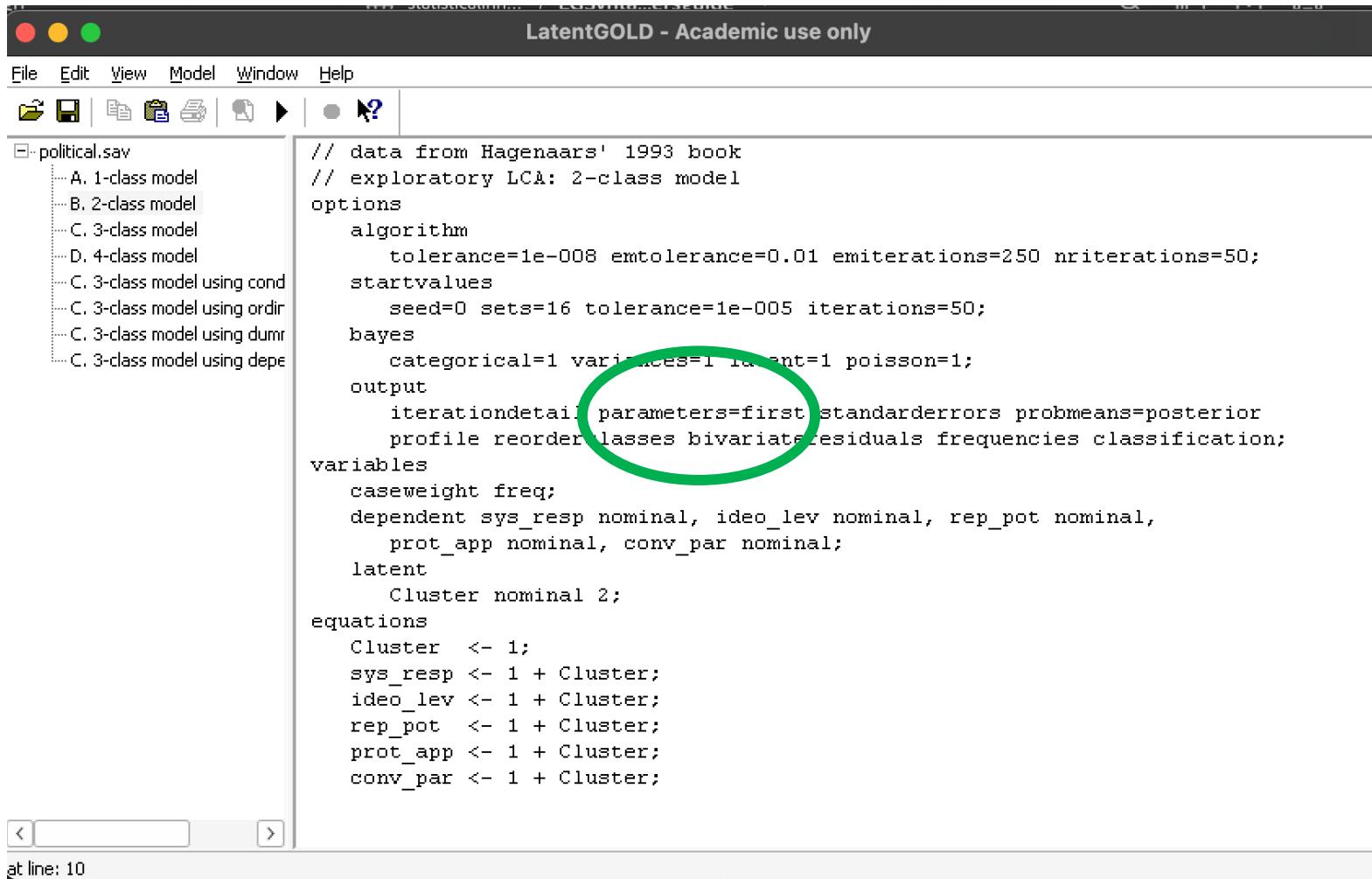
C. 3-class model using dummy codir

C. 3-class model using dependent li

Regression Parameters

	term	coef	s.e.	z-value	p-value	Wald(0)	df	p-value
Cluster(1)	← 1	0.1902	0.1112	1.7108	0.087	2.9269	1	0.087
Cluster(2)	← 1	-0.1902	0.1112	-1.7108	0.087			
sys_resp(Low)	← 1	-0.0134	0.0562	-0.2391	0.81	0.0572	1	0.81
sys_resp(High)	← 1	0.0134	0.0562	0.2391	0.81			
sys_resp(Low)	← Cluster(1)	-0.3785	0.0528	-7.1670	7.7e-13	51.3663	1	7.7e-13
sys_resp(High)	← Cluster(1)	0.3785	0.0528	7.1670	7.7e-13			
sys_resp(Low)	← Cluster(2)	0.3785	0.0528	7.1670	7.7e-13			
sys_resp(High)	← Cluster(2)	-0.3785	0.0528	-7.1670	7.7e-13			
ideo_lev(Nonideologues)	← 1	1.0024	0.2637	3.8014	0.00014	14.4503	1	0.00014
ideo_lev(Ideologues)	← 1	-1.0024	0.2637	-3.8014	0.00014			
ideo_lev(Nonideologues)	← Cluster(1)	-0.8415	0.2486	-3.3843	0.00071	11.4533	1	0.00071
ideo_lev(Ideologues)	← Cluster(1)	0.8415	0.2486	3.3843	0.00071			
ideo_lev(Nonideologues)	← Cluster(2)	0.8415	0.2486	3.3843	0.00071			
ideo_lev(Ideologues)	← Cluster(2)	-0.8415	0.2486	-3.3843	0.00071			
rep_pot(High)	← 1	0.3344	0.0395	8.4743	2.4e-17	71.8134	1	2.4e-17
rep_pot(Low)	← 1	-0.3344	0.0395	-8.4743	2.4e-17			
rep_pot(High)	← Cluster(1)	-0.1715	0.0526	-3.2608	0.0011	10.6330	1	0.0011
rep_pot(Low)	← Cluster(1)	0.1715	0.0526	3.2608	0.0011			

Alternative for parameter settings



The screenshot shows the LatentGOLD software interface. The title bar reads "LatentGOLD - Academic use only". The menu bar includes File, Edit, View, Model, Window, and Help. The toolbar contains icons for opening files, saving, and other functions. A sidebar on the left lists project files: "political.sav" (selected), "A. 1-class model", "B. 2-class model", "C. 3-class model", "D. 4-class model", "C. 3-class model using cond", "C. 3-class model using ordir", "C. 3-class model using dumr", and "C. 3-class model using depo". The main window displays a model specification language (MSL) script. A green circle highlights the "parameters=first" and "standarderrors" lines within the "output" section. The script content is as follows:

```
// data from Hagenaars' 1993 book
// exploratory LCA: 2-class model
options
    algorithm
        tolerance=1e-008 emtolerance=0.01 emiterations=250 nriterations=50;
    startvalues
        seed=0 sets=16 tolerance=1e-005 iterations=50;
    bayes
        categorical=1 variances=1 latent=1 poisson=1;
    output
        iterationdetail parameters=first standarderrors probmeans=posterior
        profile reorder lasses bivariate residuals frequencies classification;
variables
    caseweight freq;
    dependent sys_resp nominal, ideo_lev nominal, rep_pot nominal,
        prot_app nominal, conv_par nominal;
latent
    Cluster nominal 2;
equations
    Cluster <- 1;
    sys_resp <- 1 + Cluster;
    ideo_lev <- 1 + Cluster;
    rep_pot <- 1 + Cluster;
    prot_app <- 1 + Cluster;
    conv_par <- 1 + Cluster;
```

at line: 10

Alternative for parameter settings

The screenshot shows the Mplus software interface with the following details:

- File menu:** File, Edit, View, Model, Window, Help.
- Toolbar:** Includes icons for file operations like Open, Save, and Syntax.
- Model Tree:** Shows the model specification:
 - A. 1-class model
 - B. 2-class model - $L^2 = 95.0174$
 - Syntax
 - Parameters** (selected)
 - Profile
 - ProbMeans-Posterior
 - Freqs/Residuals
 - Bivariate Residuals
 - Classification-Posterior
 - Iteration Detail
 - C. 3-class model
 - D. 4-class model
 - C. 3-class model using conditional e
 - C. 3-class model using ordinal
 - C. 3-class model using dummy codir
 - C. 3-class model using dependent li
- Output View:** Regression Parameters table.

	term	coef	s.e.	z-value	p-value	Wald(0)	df	p-value
Cluster(1)	← 1	0.0000	.	.	.	2.9269	1	0.087
Cluster(2)	← 1	-0.3803	0.2223	-1.7108	0.087			
sys_resp(Low)	← 1	0.0000	.	.	.	41.8027	1	1.0e-10
sys_resp(High)	← 1	0.7839	0.1212	6.4655	1.0e-10			
sys_resp(Low)	← Cluster(1)	0.0000	.	.	.	51.3663	1	7.7e-13
sys_resp(High)	← Cluster(1)	0.0000	.	.	.			
sys_resp(Low)	← Cluster(2)	0.0000	.	.	.			
sys_resp(High)	← Cluster(2)	-1.5139	0.2112	-7.1670	7.7e-13			
ideo_lev(Nonideologues)	← 1	0.0000	.	.	.	5.8911	1	0.015
ideo_lev(Ideologues)	← 1	-0.3218	0.1326	-2.4272	0.015			
ideo_lev(Nonideologues)	← Cluster(1)	0.0000	.	.	.	11.4533	1	0.00071
ideo_lev(Ideologues)	← Cluster(1)	0.0000	.	.	.			
ideo_lev(Nonideologues)	← Cluster(2)	0.0000	.	.	.			
ideo_lev(Ideologues)	← Cluster(2)	-3.3659	0.9946	-3.3843	0.00071			
rep_pot(High)	← 1	0.0000	.	.	.	10.4344	1	0.0012
rep_pot(Low)	← 1	-0.3259	0.1009	-3.2302	0.0012			
rep_pot(High)	← Cluster(1)	0.0000	.	.	.	10.6330	1	0.0011
rep_pot(Low)	← Cluster(1)	0.0000	.	.	.			

Data in Latent GOLD → SPSS data

▷ From the menus choose: File → Open

or select the Open icon  from the toolbar.

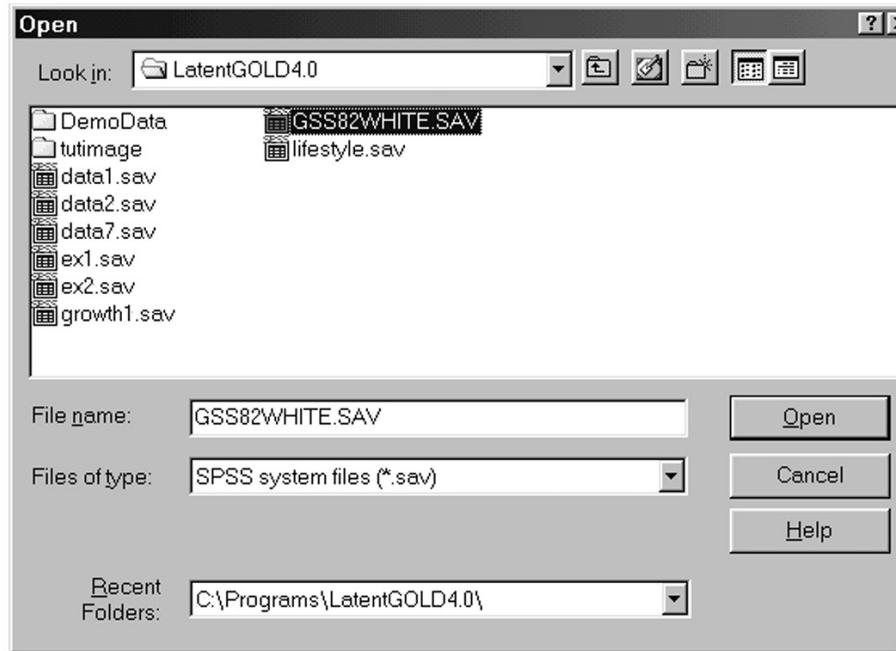


Figure 3-1: File Open Dialog Box

▷ In the Open dialog box, select the type and name of the file you want to open.

Data in Latent GOLD → Other data

TEXT FILES

A text (rectangular) file can be created in any spreadsheet or word processor using the 'Save as..' command to save the data as a text file with either a .dat, .csv or .txt extension.

- The first line of the file needs to contain the variable names separated by blank spaces or a tab. The remainder of the file contains the data.
- For each record, the data for each variable should be separated by either a space or a tab (no other delimiters, such as "," are allowed).
- The data for any variable may be numeric (quantitative values only) or may be a string variable, containing some or all alphabetic characters (such as 'Female', 'Male'). For numeric data, do not use commas (such as 3,634). String variables containing lower and upper case letters, such as 'f' and 'F', are distinguished as separate categories.
- Missing data for a variable may be specified using '..'.
- Each data record should contain exactly the same number of data elements, one for each variable name.

Data examples

IMPROVE	AGE	TREAT	GENDER
0	23	1	F
0	23	0	F
1	27	1	M
0	29	1	M
0	30	1	M
0	30	0	F
0	30	0	F
1	31	0	F
2	32	1	M
0	32	1	F
0	32	0	F
2	33	0	F
1	37	1	F
0	37	0	M

BACK	NECK	JOINT	SWELL	STIFF	FREQ
1	1	1	1	1	3634
1	1	1	1	2	73
1	1	1	2	1	87
1	1	1	2	2	10
1	1	2	1	1	440
1	1	2	1	2	89
1	1	2	2	1	106
1	1	2	2	2	75
1	2	1	1	1	295
2	2	2	1	2	162
2	2	2	2	1	44
2	2	2	2	2	176