

# SEM with Formative Indicators

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2019



# Outline

- 1 Formative Conceptualization
- 2 Formative Operationalization
  - Formative indicators in lavaan
  - Formative indicators in Mplus
- 3 An Example with the Political Democracy Data Set
  - The reflective operationalization
  - The formative operationalization
- 4 Another Example - Being Bullied Predicting Depression
- 5 References
- 6 Supplemental - Formative indicators and canonical correlations

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## Causality and model specification - Bollen's differentiation

## DIRECTION OF CAUSATION

65

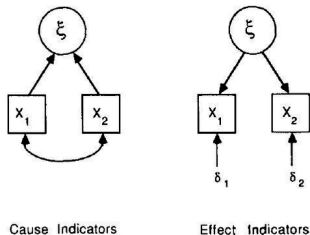


Figure 3.8 Simple Example of Cause and Effect Indicators

cause (“formative” or “induced”) indicators from effect (“reflective”) indicators (see Figure 3.8). Cause indicators are observed variables that are assumed to cause a latent variable. For effect indicators the latent variable causes the observed variable. Most researchers in the social sciences assume that indicators are effect indicators. Cause indicators are neglected despite their appropriateness in many instances.

1

<sup>1</sup>Bollen (1989, p. 65) Structural Equations with Latent Variables

# Causality and model specification - Reflective indicators

Responses to this set of questions (indicators) reflect someone's unobserved level of depression (a latent state). The causal paths go from the factor to its indicators.

45. Think about how you have been feeling over the last 30 days. Mark the number that goes with how often you have felt or done each of these. (Please mark one circle for each line)

	Always	Often	Sometimes	Seldom	Never
a. Were you very sad?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Were you grouchy or irritable, or in a bad mood?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Did you feel hopeless about the future?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Did you feel like not eating or eating more than usual?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Did you sleep a lot more or a lot less than usual?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
f. Did you have difficulty concentrating on your school work?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

2

<sup>2</sup>Iannotti (2005-2006) Health Behavior in School-Aged Children (HBSC), 2005-2006

# Causality and model specification - Formative indicators

The level/existence of someone's alcohol consumption (a factor) is caused by the types of alcohol beverages consumed (indicators). The causal paths go from the indicators to the factor.

65. At present, how often do you drink anything alcoholic, such as beer, wine or hard liquor like, Vodka or rum? Try to include even those times when you only drink a small amount (e.g. one or two sips). (Please mark one circle for each line)

	Never	Rarely	Every month	Every week	Every day
a. Beer	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b. Wine	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c. Liquor/Spirits	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d. Pre-mixed drinks (for example, Smirnoff Ice, Bacardi Breezer, Mike's Hard Lemonade)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
e. Any other drink that contains alcohol	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3

<sup>3</sup>Iannotti (2005-2006) Health Behavior in School-Aged Children (HBSC), 2005-2006

# Practical issues - Formative indicators

In addition to the causality considerations, there are practical reasons for using formative indicators. For example:

- 1 An effective way to summarize observed information (e.g., education level, income, and occupational prestige as formative indicators for socioeconomic status)
- 2 Create more parsimonious model structure (e.g., fewer number of parameters are estimated at construct level)

# Formative indicators - Causal or composite

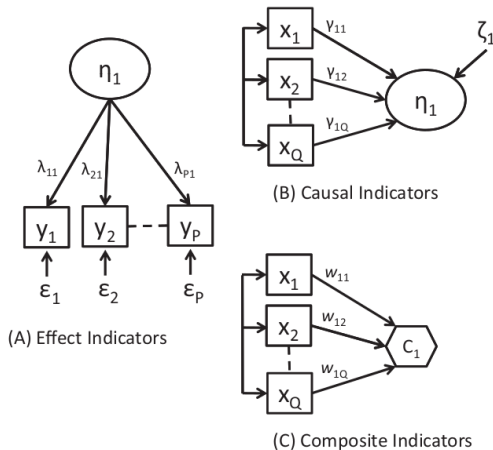


Figure 2. Types of measurement models.

4

<sup>4</sup>Bollen and Bauldry (2011, p. 268) Three Cs in Measurement Models



# Formative indicators - Causal or composite

where  $C_{1i}$  is a composite variable for the  $i$ th case. Formative indicators as originally defined by Fornell and Bookstein (1982) are the same as composite indicators: “When constructs are conceived as explanatory combinations of indicators (such as ‘population change’ or “marketing mix”) which are determined by a combination of variables, their indicators should be formative” (p. 442). Current usage of formative indicators is ambiguous in that sometimes it refers to causal indicators as defined above and other times as its original meaning of composite indicators as defined in this subsection. We stay with the terms of causal indicators and composite indicators to avoid this confusion.

5 6

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<sup>5</sup>Bollen and Bauldry (2011, p. 268) Three Cs in Measurement Models

<sup>6</sup>Fornell and Bookstein (1982) LISREL and PLS applied to consumer exit-voice theory

# Formative indicators - Causal or composite

Distinctions between causal indicators and composite indicators are very subtle. Most times, When the term “formative indicators” is being used in SEM analysis, the model specifications correspond to the composite-indicator specification.

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# Formative operationalization in lavaan

```
## Setting working environment
ddir <- "../data"
odir <- "output"
list.files(ddir)
```

```
[1] "OOREADME.txt"           "affect-2.csv"
[3] "affect-2.rds"           "anxiety.dat"
[5] "anxiety.dta"            "cils-subset_integer.rds"
[7] "hbsc-subset2.dat"       "hbsc.rds"
[9] "insomnia.dat"           "insomnia.dta"
[11] "job_placement.csv"      "job_placement.dta"
[13] "OLS_data.csv"
```

```
## Loading the lavaan package for sem analysis
library(lavaan)
```

# Formative operationalization in lavaan ...

```
## Reading in the HBCS data subset
hbsc.complete <- readRDS(file.path(ddir, "hbsc.rds"))
hbsc <- hbsc.complete[hbsc.complete$Grade %in% c("6",
  "7"), ]
names(hbsc)
```

```
[1] "stud_id" "schl_id" "Gender" "Age" "Grade" "body1_o"
[7] "body2_o" "body3_o" "body4_o" "body5_o" "phys1_o" "phys2_o"
[13] "phys3_o" "phys4_o" "phys5_o" "phys6_o" "phys7_o" "phys8_o"
[19] "depre1_o" "depre2_o" "depre3_o" "depre4_o" "depre5_o" "depre6_o"
[25] "gotBu1_o" "gotBu2_o" "gotBu3_o" "gotBu4_o" "gotBu5_o" "gotBu6_o"
[31] "gotBu7_o" "gotBu8_o" "gotBu9_o" "bu0th1_o" "bu0th2_o" "bu0th3_o"
[37] "bu0th4_o" "bu0th5_o" "bu0th6_o" "bu0th7_o" "bu0th8_o" "bu0th9_o"
[43] "alc1_o" "alc2_o" "alc3_o" "alc4_o" "alc5_o" "body1_i"
[49] "body2_i" "body3_i" "body4_i" "body5_i" "phys1_i" "phys2_i"
[55] "phys3_i" "phys4_i" "phys5_i" "phys6_i" "phys7_i" "phys8_i"
[61] "depre1_i" "depre2_i" "depre3_i" "depre4_i" "depre5_i" "depre6_i"
[67] "gotBu1_i" "gotBu2_i" "gotBu3_i" "gotBu4_i" "gotBu5_i" "gotBu6_i"
[73] "gotBu7_i" "gotBu8_i" "gotBu9_i" "bu0th1_i" "bu0th2_i" "bu0th3_i"
[79] "bu0th4_i" "bu0th5_i" "bu0th6_i" "bu0th7_i" "bu0th8_i" "bu0th9_i"
[85] "alc1_i" "alc2_i" "alc3_i" "alc4_i" "alc5_i"
```

# Formative operationalization in lavaan ...

```
## A structural model with a formative composite in
  lavaan
## Create the model object
m1 <- '
  alcohol <~ 1*alc1_i + alc2_i + alc3_i +
            alc4_i + alc5_i

  alcohol ~ 0*alcohol

  alc1_i ~ alc2_i + alc3_i + alc4_i + alc5_i
  alc2_i ~ alc3_i + alc4_i + alc5_i
  alc3_i ~ alc4_i + alc5_i
  alc4_i ~ alc5_i

  bu0th1_i ~ alcohol '
## Use the sem() function to estimate the model
fit1 <- sem(model = m1, data = hbsc, meanstructure =
  TRUE)
```

# Formative operationalization in lavaan ...

```
## Request a summary of the results
summary(fit1, fit.measures = TRUE, standardized = TRUE)
```

```
lavaan 0.6-3 ended normally after 84 iterations
```

Optimization method	NLMINB		
Number of free parameters	27		
		Used	Total
Number of observations	2825	4284	
Estimator	ML		
Model Fit Test Statistic	0.000		
Degrees of freedom	0		

```
Model test baseline model:
```

Minimum Function Test Statistic	7782.290
Degrees of freedom	15
P-value	0.000

```
User model versus baseline model:
```

Comparative Fit Index (CFI)	1.000
Tucker-Lewis Index (TLI)	1.000

# Formative operationalization in lavaan ...

## Loglikelihood and Information Criteria:

Loglikelihood user model (H0)	-13286.722
Loglikelihood unrestricted model (H1)	-13286.722
Number of free parameters	27
Akaike (AIC)	26627.443
Bayesian (BIC)	26787.992
Sample-size adjusted Bayesian (BIC)	26702.204

## Root Mean Square Error of Approximation:

RMSEA	0.000
90 Percent Confidence Interval	0.000 0.000
P-value RMSEA $\leq$ 0.05	NA

## Standardized Root Mean Square Residual:

SRMR	0.000
------	-------

## Parameter Estimates:

Information	Expected
Information saturated (h1) model	Structured
Standard Errors	Standard



## Formative operationalization in lavaan ...

## Composites:

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
alcohol <~						
alc1_i	1.000				0.679	0.394
alc2_i	0.594	0.214	2.782	0.005	0.404	0.245
alc3_i	0.137	0.211	0.650	0.516	0.093	0.054
alc4_i	0.729	0.232	3.146	0.002	0.495	0.336
alc5_i	0.405	0.210	1.931	0.053	0.275	0.174

## Regressions:

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
bu0th1_i ~						
alcohol	0.241	0.045	5.422	0.000	0.355	0.352

## Covariances:

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
alc1_i ~						
alc2_i	0.199	0.008	26.171	0.000	0.199	0.566
alc3_i	0.212	0.007	28.497	0.000	0.212	0.635
alc4_i	0.240	0.009	27.629	0.000	0.240	0.609
alc5_i	0.225	0.008	27.881	0.000	0.225	0.616
alc2_i ~						
alc3_i	0.188	0.007	25.134	0.000	0.188	0.537
alc4_i	0.205	0.009	23.658	0.000	0.205	0.497
alc5_i	0.201	0.008	24.770	0.000	0.201	0.527

## Formative operationalization in lavaan ...

alc3_i ~						
alc4_i	0.266	0.009	29.814	0.000	0.266	0.678
alc5_i	0.256	0.008	30.529	0.000	0.256	0.702
alc4_i ~						
alc5_i	0.292	0.010	29.890	0.000	0.292	0.680
Intercepts:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
.bu0th1_i	0.723	0.047	15.442	0.000	0.723	0.715
alc1_i	1.199	0.011	109.991	0.000	1.199	2.069
alc2_i	1.240	0.011	108.762	0.000	1.240	2.046
alc3_i	1.158	0.011	106.705	0.000	1.158	2.008
alc4_i	1.254	0.013	98.048	0.000	1.254	1.845
alc5_i	1.217	0.012	102.457	0.000	1.217	1.928
alcohol	0.000				0.000	0.000
Variances:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
alcohol	0.000				0.000	0.000
.bu0th1_i	0.894	0.024	37.583	0.000	0.894	0.876
alc1_i	0.336	0.009	37.583	0.000	0.336	1.000
alc2_i	0.367	0.010	37.583	0.000	0.367	1.000
alc3_i	0.333	0.009	37.583	0.000	0.333	1.000
alc4_i	0.462	0.012	37.583	0.000	0.462	1.000
alc5_i	0.399	0.011	37.583	0.000	0.399	1.000

# Formative indicators in Mplus

```
Mplus VERSION 8.2 (Linux)
MUTHEN & MUTHEN
06/01/2019 4:46 PM

5 INPUT INSTRUCTIONS

TITLE: SEM Formative Model 01;

DATA:
10 FILE IS ../../data/hbsc-subset2.dat;
LISTWISE = ON;

VARIABLE:
NAMES ARE
15 stud_id schl_id Gender Age Grade body1r body2 body3r body4 body5r
phyhlth1 phyhlth2 phyhlth3 phyhlth4 phyhlth5 phyhlth6 phyhlth7
phyhlth8 Depress1 Depress2 Depress3 Depress4 Depress5 Depress6
Bullied1 Bullied2 Bullied3 Bullied4 Bullied5 Bullied6 Bullied7
20 Bullied8 Bullied9 Bullier1 Bullier2 Bullier3 Bullier4 Bullier5
Bullier6 Bullier7 Bullier8 Bullier9 Alc1 Alc2 Alc3 Alc4 Alc5;

USEVARIABLES ARE
Bullier1
Alc1 Alc2 Alc3 Alc4 Alc5;

25 USEOBSERVATIONS ARE (Grade == 6 OR Grade == 7);

MISSING ARE all(-999);

30 MODEL:
alcohol BY;

alcohol@0;
```

# Formative indicators in Mplus ...

```
35 alcohol ON Alc1@1.0 Alc2 Alc3 Alc4 Alc5;
```

```
Alc1 WITH Alc2 Alc3 Alc4 Alc5;
```

```
Alc2 WITH Alc3 Alc4 Alc5;
```

```
Alc3 WITH Alc4 Alc5;
```

```
Alc4 WITH Alc5;
```

```
40 Bullier1 ON alcohol;
```

```
OUTPUT:
```

```
45 STANDARDIZED;
```

```
50 INPUT READING TERMINATED NORMALLY
```

```
SEM Formative Model 01;
```

```
55 SUMMARY OF ANALYSIS
```

```
Number of groups
```

```
1
```

```
Number of observations
```

```
2825
```

```
60 Number of dependent variables
```

```
1
```

```
Number of independent variables
```

```
5
```

```
Number of continuous latent variables
```

```
1
```

```
Observed dependent variables
```

```
65 Continuous
```

```
BULLIER1
```

# Formative indicators in Mplus ...

```

Observed independent variables
  ALC1          ALC2          ALC3          ALC4          ALC5

Continuous latent variables
  ALCOHOL

Estimator                      ML
Information matrix              OBSERVED
Maximum number of iterations    1000
Convergence criterion          0.500D-04
Maximum number of steepest descent iterations 20

Input data file(s)
  ../..../data/hbsc-subset2.dat

Input data format  FREE

UNIVARIATE SAMPLE STATISTICS

UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

      Variable/      Mean/      Skewness/      Minimum/ % with      Percentiles
      Sample Size      Variance      Kurtosis      Maximum Min/Max      20%/60%      40%/80%      Median

BULLIER1      1.567      2.117      1.000      66.12%
      2825.000      1.020      3.964      5.000      4.28%      1.000      1.000      1.000
ALC1      1.199      3.902      1.000      85.73%
      2825.000      0.336      18.189      5.000      0.85%      1.000      1.000      1.000
ALC2      1.240      3.383      1.000      82.05%
      2825.000      0.367      13.830      5.000      0.71%      1.000      1.000

```

# Formative indicators in Mplus ...

ALC3	1.158	4.482	1.000	90.55%	1.000	1.000	1.000
2825.000	0.333	21.812	5.000	0.81%	1.000	1.000	
ALC4	1.254	3.323	1.000	83.68%	1.000	1.000	1.000
2825.000	0.462	12.099	5.000	1.10%	1.000	1.000	
ALC5	1.217	3.707	1.000	85.70%	1.000	1.000	1.000
2825.000	0.399	15.377	5.000	0.96%	1.000	1.000	

THE MODEL ESTIMATION TERMINATED NORMALLY

## MODEL FIT INFORMATION

Number of Free Parameters 27

## Loglikelihood

H0 Value -13286.722

H1 Value -13286.722

## Information Criteria

Akaike (AIC) 26627.443

Bayesian (BIC) 26787.992

Sample-Size Adjusted BIC 26702.204

(n\* = (n + 2) / 24)

## Chi-Square Test of Model Fit

Value 0.000

Degrees of Freedom 0

P-Value 0.0000

# Formative indicators in Mplus ...

## RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.000	
90 Percent C.I.	0.000	0.000
Probability RMSEA <= .05	0.000	

## CFI/TLI

CFI	1.000
TLI	1.000

## Chi-Square Test of Model Fit for the Baseline Model

Value	373.052
Degrees of Freedom	5
P-Value	0.0000

## SRMR (Standardized Root Mean Square Residual)

Value	0.000
-------	-------

## MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
ALCOHOL ON				
ALC1	1.000	0.000	999.000	999.000
ALC2	0.594	0.214	2.782	0.005
ALC3	0.137	0.211	0.650	0.516
ALC4	0.729	0.232	3.146	0.002
ALC5	0.405	0.210	1.931	0.053

## Formative indicators in Mplus ...

BULLIER1 ON				
ALCOHOL	0.241	0.045	5.422	0.000
ALC1 WITH				
ALC2	0.199	0.008	26.171	0.000
ALC3	0.212	0.007	28.497	0.000
ALC4	0.240	0.009	27.629	0.000
ALC5	0.225	0.008	27.881	0.000
ALC2 WITH				
ALC3	0.188	0.007	25.134	0.000
ALC4	0.205	0.009	23.658	0.000
ALC5	0.201	0.008	24.770	0.000
ALC3 WITH				
ALC4	0.266	0.009	29.814	0.000
ALC5	0.256	0.008	30.529	0.000
ALC4 WITH				
ALC5	0.292	0.010	29.890	0.000
Means				
ALC1	1.199	0.011	109.991	0.000
ALC2	1.240	0.011	108.762	0.000
ALC3	1.158	0.011	106.705	0.000
ALC4	1.254	0.013	98.048	0.000
ALC5	1.217	0.012	102.456	0.000
Intercepts				
BULLIER1	0.723	0.047	15.442	0.000
Variances				
ALC1	0.336	0.009	37.583	0.000



# Formative indicators in Mplus ...

05	ALC2	0.367	0.010	37.583	0.000
	ALC3	0.333	0.009	37.583	0.000
	ALC4	0.462	0.012	37.583	0.000
	ALC5	0.399	0.011	37.583	0.000
10	Residual Variances				
	BULLIER1	0.894	0.024	37.583	0.000
	ALCOHOL	0.000	0.000	999.000	999.000
15	STANDARDIZED MODEL RESULTS				
	STDYX Standardization				
20		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
	ALCOHOL ON				
	ALC1	0.394	0.070	5.627	0.000
25	ALC2	0.245	0.063	3.874	0.000
	ALC3	0.054	0.080	0.673	0.501
	ALC4	0.336	0.074	4.534	0.000
	ALC5	0.174	0.078	2.217	0.027
30	BULLIER1 ON				
	ALCOHOL	0.352	0.016	21.333	0.000
	ALC1 WITH				
35	ALC2	0.566	0.013	44.220	0.000
	ALC3	0.635	0.011	56.587	0.000
	ALC4	0.609	0.012	51.360	0.000
	ALC5	0.616	0.012	52.787	0.000

# Formative indicators in Mplus ...

40	ALC2	WITH				
	ALC3		0.537	0.013	40.064	0.000
	ALC4		0.497	0.014	35.089	0.000
	ALC5		0.527	0.014	38.745	0.000
45	ALC3	WITH				
	ALC4		0.678	0.010	66.576	0.000
	ALC5		0.702	0.010	73.471	0.000
50	ALC4	WITH				
	ALC5		0.680	0.010	67.256	0.000
55	Means					
	ALC1		2.069	0.033	62.059	0.000
	ALC2		2.046	0.033	61.836	0.000
	ALC3		2.008	0.033	61.451	0.000
	ALC4		1.845	0.031	59.654	0.000
	ALC5		1.928	0.032	60.606	0.000
50	Intercepts					
	BULLIER1		0.715	0.051	14.008	0.000
55	Variances					
	ALC1		1.000	0.000	999.000	999.000
	ALC2		1.000	0.000	999.000	999.000
	ALC3		1.000	0.000	999.000	999.000
	ALC4		1.000	0.000	999.000	999.000
	ALC5		1.000	0.000	999.000	999.000
70	Residual Variances					
	BULLIER1		0.876	0.012	75.558	0.000
	ALCOHOL		0.000	999.000	999.000	999.000

# Formative indicators in Mplus ...

## STDY Standardization

		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
ALCOHOL	ON				
ALC1		0.394	0.070	5.627	0.000
ALC2		0.245	0.063	3.874	0.000
ALC3		0.054	0.080	0.673	0.501
ALC4		0.336	0.074	4.534	0.000
ALC5		0.174	0.078	2.217	0.027
BULLIER1	ON				
ALCOHOL		0.352	0.016	21.333	0.000
ALC1	WITH				
ALC2		0.566	0.013	44.220	0.000
ALC3		0.635	0.011	56.587	0.000
ALC4		0.609	0.012	51.360	0.000
ALC5		0.616	0.012	52.787	0.000
ALC2	WITH				
ALC3		0.537	0.013	40.064	0.000
ALC4		0.497	0.014	35.089	0.000
ALC5		0.527	0.014	38.745	0.000
ALC3	WITH				
ALC4		0.678	0.010	66.576	0.000
ALC5		0.702	0.010	73.471	0.000
ALC4	WITH				
ALC5		0.680	0.010	67.256	0.000
Means					

# Formative indicators in Mplus ...

ALC1	2.069	0.033	62.059	0.000
ALC2	2.046	0.033	61.836	0.000
ALC3	2.008	0.033	61.451	0.000
ALC4	1.845	0.031	59.654	0.000
ALC5	1.928	0.032	60.606	0.000
Intercepts				
BULLIER1	0.715	0.051	14.008	0.000
Variances				
ALC1	1.000	0.000	999.000	999.000
ALC2	1.000	0.000	999.000	999.000
ALC3	1.000	0.000	999.000	999.000
ALC4	1.000	0.000	999.000	999.000
ALC5	1.000	0.000	999.000	999.000
Residual Variances				
BULLIER1	0.876	0.012	75.558	0.000
ALCOHOL	999.000	999.000	999.000	999.000
STD Standardization				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
ALCOHOL ON				
ALC1	0.679	0.121	5.618	0.000
ALC2	0.404	0.104	3.873	0.000
ALC3	0.093	0.138	0.673	0.501
ALC4	0.495	0.109	4.530	0.000
ALC5	0.275	0.124	2.217	0.027
BULLIER1 ON				

# Formative indicators in Mplus ...

	ALCOHOL	0.355	0.018	19.301	0.000
	ALC1 WITH				
	ALC2	0.199	0.008	26.171	0.000
45	ALC3	0.212	0.007	28.497	0.000
	ALC4	0.240	0.009	27.629	0.000
	ALC5	0.225	0.008	27.881	0.000
	ALC2 WITH				
50	ALC3	0.188	0.007	25.134	0.000
	ALC4	0.205	0.009	23.658	0.000
	ALC5	0.201	0.008	24.770	0.000
	ALC3 WITH				
55	ALC4	0.266	0.009	29.814	0.000
	ALC5	0.256	0.008	30.529	0.000
	ALC4 WITH				
50	ALC5	0.292	0.010	29.890	0.000
	Means				
	ALC1	1.199	0.011	109.991	0.000
	ALC2	1.240	0.011	108.762	0.000
	ALC3	1.158	0.011	106.705	0.000
55	ALC4	1.254	0.013	98.048	0.000
	ALC5	1.217	0.012	102.456	0.000
	Intercepts				
	BULLIER1	0.723	0.047	15.442	0.000
70					
	Variances				
	ALC1	0.336	0.009	37.583	0.000
	ALC2	0.367	0.010	37.583	0.000
	ALC3	0.333	0.009	37.583	0.000

# Formative indicators in Mplus ...

ALC4	0.462	0.012	37.583	0.000
ALC5	0.399	0.011	37.583	0.000
Residual Variances				
BULLIER1	0.894	0.024	37.583	0.000
ALCOHOL	999.000	999.000	999.000	999.000
R-SQUARE				
Observed Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
BULLIER1	0.124	0.012	10.667	0.000
Latent Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
ALCOHOL	1.000	999.000	999.000	999.000
QUALITY OF NUMERICAL RESULTS				
Condition Number for the Information Matrix (ratio of smallest to largest eigenvalue)				0.630E-04
Beginning Time: 16:46:03				
Ending Time: 16:46:03				
Elapsed Time: 00:00:00				
MUTHEN & MUTHEN				

# Formative indicators in Mplus ...

10 3463 Stoner Ave.  
Los Angeles, CA 90066

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Web: [www.StatModel.com](http://www.StatModel.com)  
15 Support: [Support@StatModel.com](mailto:Support@StatModel.com)

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# Outline

- 1 Formative Conceptualization
- 2 Formative Operationalization
  - Formative indicators in lavaan
  - Formative indicators in Mplus
- 3 An Example with the Political Democracy Data Set
  - The reflective operationalization
  - The formative operationalization
- 4 Another Example - Being Bullied Predicting Depression
- 5 References
- 6 Supplemental - Formative indicators and canonical correlations

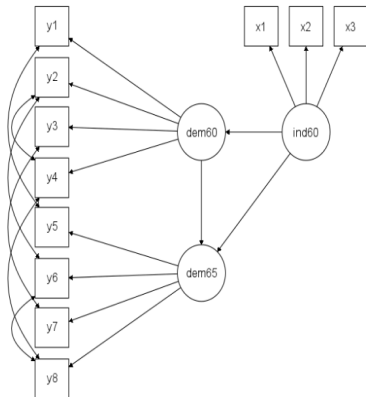


# The Industrialization and Political Democracy data set

```
head(PoliticalDemocracy , 10)
```

	y1	y2	y3	y4	y5	y6	y7	y8
1	2.50	0.000000	3.333333	0.000000	1.250000	0.000000	3.726360	3.333333
2	1.25	0.000000	3.333333	0.000000	6.250000	1.100000	6.666666	0.736999
3	7.50	8.800000	9.999998	9.199991	8.750000	8.094061	9.999998	8.211809
4	8.90	8.800000	9.999998	9.199991	8.907948	8.127979	9.999998	4.615086
5	10.00	3.333333	9.999998	6.666666	7.500000	3.333333	9.999998	6.666666
6	7.50	3.333333	6.666666	6.666666	6.250000	1.100000	6.666666	0.368500
7	7.50	3.333333	6.666666	6.666666	5.000000	2.233333	8.271257	1.485166
8	7.50	2.233333	9.999998	1.496333	6.250000	3.333333	9.999998	6.666666
9	2.50	3.333333	3.333333	3.333333	6.250000	3.333333	3.333333	3.333333
10	10.00	6.666666	9.999998	8.899991	8.750000	6.666666	9.999998	10.000000
	x1	x2	x3					
1	4.442651	3.637586	2.557615					
2	5.384495	5.062595	3.568079					
3	5.961005	6.255750	5.224433					
4	6.285998	7.567863	6.267495					
5	5.863631	6.818924	4.573679					
6	5.533389	5.135798	3.892270					
7	5.308268	5.075174	3.316213					
8	5.347108	4.852030	4.263183					
9	5.521461	5.241747	4.115168					
10	5.828946	5.370638	4.446216					

# The Industrialization and Political Democracy data set ...



```

model <- '
  # latent variables
  ind60 =~ x1 + x2 + x3
  dem60 =~ y1 + y2 + y3 + y4
  dem65 =~ y5 + y6 + y7 + y8
  # regressions
  dem60 ~ ind60
  dem65 ~ ind60 + dem60
  # residual covariances
  y1 ~~ y5
  y2 ~~ y4 + y6
  y3 ~~ y7
  y4 ~~ y8
  y6 ~~ y8
  '

fit <- sem(model,
            data=PoliticalDemocracy)
summary(fit)

```

# Structural model with reflective indicators

```
model.reflective <- '  
  ## latent variables  
  ind60 =~ x1 + x2 + x3  
  dem60 =~ y1 + y2 + y3 + y4  
  dem65 =~ y5 + y6 + y7 + y8  
  ## regressions  
  dem60 ~ ind60  
  dem65 ~ ind60 + dem60  
  ## residual covariances  
  y1 ~ y5  
  y2 ~ y4 + y6  
  y3 ~ y7  
  y4 ~ y8  
  y6 ~ y8 '  
fit.reflective <- sem(model.reflective,  
  data=PoliticalDemocracy, meanstructure = TRUE)  
summary(fit.reflective, fit.measures = TRUE,  
  standardized = TRUE)
```

## Structural model with reflective indicators ...

```

lavaan 0.6-3 ended normally after 68 iterations

  Optimization method           NLMINB
  Number of free parameters      42
5
  Number of observations         75
  Estimator                      ML
  Model Fit Test Statistic       38.125
  Degrees of freedom             35
10
  P-value (Chi-square)          0.329

Model test baseline model:

  Minimum Function Test Statistic 730.654
  Degrees of freedom              55
  P-value                         0.000

User model versus baseline model:

  Comparative Fit Index (CFI)     0.995
  Tucker-Lewis Index (TLI)       0.993
20

Loglikelihood and Information Criteria:
25

```

## Structural model with reflective indicators ...

```

Loglikelihood user model (H0)                -1547.791
Loglikelihood unrestricted model (H1)        -1528.728

Number of free parameters                    42
Akaike (AIC)                               3179.582
Bayesian (BIC)                              3276.916
Sample-size adjusted Bayesian (BIC)         3144.543

Root Mean Square Error of Approximation:

RMSEA                                       0.035
90 Percent Confidence Interval             0.000 0.092
P-value RMSEA <= 0.05                     0.611

Standardized Root Mean Square Residual:

SRMR                                       0.041

Parameter Estimates:

Information                                 Expected
Information saturated (h1) model           Structured
Standard Errors                            Standard

Latent Variables:
      Estimate  Std.Err  z-value  P(>|z|)  Std.lv  Std.all

```

## Structural model with reflective indicators ...

ind60 =~						
x1	1.000				0.670	0.920
x2	2.180	0.139	15.742	0.000	1.460	0.973
x3	1.819	0.152	11.967	0.000	1.218	0.872
dem60 =~						
y1	1.000				2.223	0.850
y2	1.257	0.182	6.889	0.000	2.794	0.717
y3	1.058	0.151	6.987	0.000	2.351	0.722
y4	1.265	0.145	8.722	0.000	2.812	0.846
dem65 =~						
y5	1.000				2.103	0.808
y6	1.186	0.169	7.024	0.000	2.493	0.746
y7	1.280	0.160	8.002	0.000	2.691	0.824
y8	1.266	0.158	8.007	0.000	2.662	0.828
Regressions:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
dem60 ~						
ind60	1.483	0.399	3.715	0.000	0.447	0.447
dem65 ~						
ind60	0.572	0.221	2.586	0.010	0.182	0.182
dem60	0.837	0.098	8.514	0.000	0.885	0.885
Covariances:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
.y1 ~						

## Structural model with reflective indicators ...

.y5	0.624	0.358	1.741	0.082	0.624	0.296
.y2 ~						
.y4	1.313	0.702	1.871	0.061	1.313	0.273
.y6	2.153	0.734	2.934	0.003	2.153	0.356
.y3 ~						
.y7	0.795	0.608	1.308	0.191	0.795	0.191
.y4 ~						
.y8	0.348	0.442	0.787	0.431	0.348	0.109
.y6 ~						
.y8	1.356	0.568	2.386	0.017	1.356	0.338
Intercepts:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
.x1	5.054	0.084	60.127	0.000	5.054	6.943
.x2	4.792	0.173	27.657	0.000	4.792	3.194
.x3	3.558	0.161	22.066	0.000	3.558	2.548
.y1	5.465	0.302	18.104	0.000	5.465	2.090
.y2	4.256	0.450	9.461	0.000	4.256	1.093
.y3	6.563	0.376	17.460	0.000	6.563	2.016
.y4	4.453	0.384	11.598	0.000	4.453	1.339
.y5	5.136	0.301	17.092	0.000	5.136	1.974
.y6	2.978	0.386	7.717	0.000	2.978	0.891
.y7	6.196	0.377	16.427	0.000	6.196	1.897
.y8	4.043	0.371	10.889	0.000	4.043	1.257
ind60	0.000				0.000	0.000
dem60	0.000				0.000	0.000

## Structural model with reflective indicators ...

.dem65	0.000				0.000	0.000
Variances:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
.x1	0.082	0.019	4.184	0.000	0.082	0.154
.x2	0.120	0.070	1.718	0.086	0.120	0.053
.x3	0.467	0.090	5.177	0.000	0.467	0.239
.y1	1.891	0.444	4.256	0.000	1.891	0.277
.y2	7.373	1.374	5.366	0.000	7.373	0.486
.y3	5.067	0.952	5.324	0.000	5.067	0.478
.y4	3.148	0.739	4.261	0.000	3.148	0.285
.y5	2.351	0.480	4.895	0.000	2.351	0.347
.y6	4.954	0.914	5.419	0.000	4.954	0.443
.y7	3.431	0.713	4.814	0.000	3.431	0.322
.y8	3.254	0.695	4.685	0.000	3.254	0.315
ind60	0.448	0.087	5.173	0.000	1.000	1.000
.dem60	3.956	0.921	4.295	0.000	0.800	0.800
.dem65	0.172	0.215	0.803	0.422	0.039	0.039



# Structural model with formative indicators

```
model.formative <- '  
## The formative indicators surveyed in 1960  
## x1 The gross national product (GNP) per capita  
## x2 The inanimate energy consumption per capita  
5 ## x3 The percentage of the labor force in industry  
  ind60 <~ 1*x1 + x2 + x3  
  ind60 ~ 0*ind60  
  
  x1 ~ x2 + x3  
  x2 ~ x3  
  
## latent variables  
  dem60 =~ y1 + y2 + y3 + y4  
  dem65 =~ y5 + y6 + y7 + y8  
15 ## regressions  
  dem60 ~ ind60  
  dem65 ~ ind60 + dem60  
## residual covariances
```

# Structural model with formative indicators ...

```

y1 ~ y5
y2 ~ y4 + y6
y3 ~ y7
y4 ~ y8
y6 ~ y8 '
fit.formative <- sem(model.formative,
  data=PoliticalDemocracy, meanstructure = TRUE)
summary(fit.formative, fit.measures = TRUE,
  standardized = TRUE)

```

```
lavaan 0.6-3 ended normally after 138 iterations
```

Optimization method	NLMINB
Number of free parameters	44
Number of observations	75
Estimator	ML
Model Fit Test Statistic	37.293
Degrees of freedom	33
P-value (Chi-square)	0.278

# Structural model with formative indicators ...

## Model test baseline model:

Minimum Function Test Statistic	730.654
Degrees of freedom	55
P-value	0.000

## User model versus baseline model:

Comparative Fit Index (CFI)	0.994
Tucker-Lewis Index (TLI)	0.989

## Loglikelihood and Information Criteria:

Loglikelihood user model (H0)	-1547.375
Loglikelihood unrestricted model (H1)	-1528.728
Number of free parameters	44
Akaike (AIC)	3182.750
Bayesian (BIC)	3284.720
Sample-size adjusted Bayesian (BIC)	3146.043

## Root Mean Square Error of Approximation:

RMSEA	0.042
90 Percent Confidence Interval	0.000 0.098
P-value RMSEA <= 0.05	0.549

## Structural model with formative indicators ...

Standardized Root Mean Square Residual:

SRMR 0.040

Parameter Estimates:

Information	Expected
Information saturated (h1) model	Structured
Standard Errors	Standard

Latent Variables:

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
dem60 =~						
y1	1.000				2.222	0.850
y2	1.256	0.183	6.875	0.000	2.790	0.716
y3	1.058	0.151	6.985	0.000	2.351	0.722
y4	1.267	0.145	8.733	0.000	2.815	0.847
dem65 =~						
y5	1.000				2.109	0.811
y6	1.179	0.168	7.027	0.000	2.487	0.744
y7	1.272	0.159	8.011	0.000	2.683	0.821
y8	1.262	0.157	8.044	0.000	2.662	0.828

Composites:

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
--	----------	---------	---------	---------	--------	---------

## Structural model with formative indicators ...

55	ind60 <~						
	x1	1.000			0.770	0.561	
	x2	0.434	0.650	0.668	0.504	0.335	0.502
	x3	-0.038	0.314	-0.121	0.904	-0.029	-0.041
70	Regressions:						
		Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
	dem60 ~						
	ind60	0.787	0.581	1.354	0.176	0.460	0.460
	dem65 ~						
75	ind60	0.277	0.223	1.242	0.214	0.171	0.171
	dem60	0.844	0.099	8.480	0.000	0.889	0.889
	Covariances:						
		Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
80	x1 ~						
	x2	0.977	0.169	5.774	0.000	0.977	0.894
	x3	0.812	0.150	5.407	0.000	0.812	0.799
	x2 ~						
	x3	1.782	0.318	5.611	0.000	1.782	0.851
85	.y1 ~						
	.y5	0.602	0.356	1.690	0.091	0.602	0.287
	.y2 ~						
	.y4	1.303	0.701	1.859	0.063	1.303	0.271
	.y6	2.173	0.736	2.952	0.003	2.173	0.358
90	.y3 ~						

## Structural model with formative indicators ...

.y7	0.802	0.609	1.317	0.188	0.802	0.191
.y4 ~						
.y8	0.346	0.441	0.784	0.433	0.346	0.108
.y6 ~						
.y8	1.369	0.570	2.402	0.016	1.369	0.340
Intercepts:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
.y1	-0.044	2.055	-0.022	0.983	-0.044	-0.017
.y2	-2.661	2.669	-0.997	0.319	-2.661	-0.683
.y3	0.736	2.245	0.328	0.743	0.736	0.226
.y4	-2.527	2.605	-0.970	0.332	-2.527	-0.760
.y5	-1.451	2.218	-0.654	0.513	-1.451	-0.558
.y6	-4.791	2.666	-1.797	0.072	-4.791	-1.433
.y7	-2.184	2.812	-0.777	0.437	-2.184	-0.669
.y8	-4.271	2.786	-1.533	0.125	-4.271	-1.328
x1	5.054	0.084	60.127	0.000	5.054	6.943
x2	4.792	0.173	27.657	0.000	4.792	3.194
x3	3.558	0.161	22.066	0.000	3.558	2.548
ind60	0.000				0.000	0.000
.dem60	0.000				0.000	0.000
.dem65	0.000				0.000	0.000
Variances:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
ind60	0.000				0.000	0.000

## Structural model with formative indicators ...

.y1	1.896	0.445	4.263	0.000	1.896	0.277
.y2	7.382	1.375	5.370	0.000	7.382	0.487
.y3	5.068	0.951	5.330	0.000	5.068	0.478
.y4	3.128	0.736	4.248	0.000	3.128	0.283
.y5	2.317	0.476	4.869	0.000	2.317	0.342
.y6	4.985	0.918	5.429	0.000	4.985	0.446
.y7	3.472	0.718	4.837	0.000	3.472	0.325
.y8	3.257	0.695	4.686	0.000	3.257	0.315
x1	0.530	0.087	6.124	0.000	0.530	1.000
x2	2.252	0.368	6.124	0.000	2.252	1.000
x3	1.950	0.318	6.124	0.000	1.950	1.000
.dem60	3.894	0.904	4.308	0.000	0.789	0.789
.dem65	0.185	0.218	0.845	0.398	0.042	0.042

# Outline

- 1 Formative Conceptualization
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- 4 Another Example - Being Bullied Predicting Depression
- 5 References
- 6 Supplemental - Formative indicators and canonical correlations



# Being bullied predicting depression

```

Mplus VERSION 8.2 (Linux)
MUTHEN & MUTHEN
06/01/2019 4:53 PM

5 INPUT INSTRUCTIONS

TITLE: SEM Formative Model 02;

DATA:
10 FILE IS ../../data/hbsc-subset2.dat;
LISTWISE = ON;

VARIABLE:
NAMES ARE
15 stud_id schl_id Gender Age Grade body1r body2 body3r body4 body5r
phyhlth1 phyhlth2 phyhlth3 phyhlth4 phyhlth5 phyhlth6 phyhlth7
phyhlth8 Depress1 Depress2 Depress3 Depress4 Depress5 Depress6
Bullied1 Bullied2 Bullied3 Bullied4 Bullied5 Bullied6 Bullied7
20 Bullied8 Bullied9 Bullier1 Bullier2 Bullier3 Bullier4 Bullier5
Bullier6 Bullier7 Bullier8 Bullier9 Alc1 Alc2 Alc3 Alc4 Alc5;

USEVARIABLES ARE
Bullied1-Bullied9
Depress1-Depress6;

25 USEOBSERVATIONS ARE (Grade == 6 OR Grade == 7);

MISSING ARE all(-999);

MODEL:
30 Bullied BY;

Bullied@0;

```

## Being bullied predicting depression ...

```

35  Bullied ON Bullied1@1.0 Bullied2-Bullied9;

    Bullied1 WITH Bullied2-Bullied9;
    Bullied2 WITH Bullied3-Bullied9;
    Bullied3 WITH Bullied4-Bullied9;
40  Bullied4 WITH Bullied5-Bullied9;
    Bullied5 WITH Bullied6-Bullied9;
    Bullied6 WITH Bullied7-Bullied9;
    Bullied7 WITH Bullied8-Bullied9;
    Bullied8 WITH Bullied9;

45  Depress BY Depress1* Depress2 Depress3 Depress4 Depress5 Depress6;

    Depress@1.0;

50  Depress ON Bullied;

    OUTPUT:
    STANDARDIZED;

55  INPUT READING TERMINATED NORMALLY

60  SEM Formative Model 02;

SUMMARY OF ANALYSIS

55  Number of groups                1
    Number of observations          2795
    Number of dependent variables   6

```

## Being bullied predicting depression ...

```

70 Number of independent variables          9
   Number of continuous latent variables  2

Observed dependent variables

   Continuous
   DEPRESS1    DEPRESS2    DEPRESS3    DEPRESS4    DEPRESS5    DEPRESS6

75 Observed independent variables
   BULLIED1    BULLIED2    BULLIED3    BULLIED4    BULLIED5    BULLIED6
   BULLIED7    BULLIED8    BULLIED9

80 Continuous latent variables
   BULLIED    DEPRESS

Estimator                                ML
35 Information matrix                      OBSERVED
Maximum number of iterations              1000
Convergence criterion                     0.500D-04
Maximum number of steepest descent iterations 20

90 Input data file(s)
   ../.. /data/hbsc-subset2.dat

Input data format  FREE

95

UNIVARIATE SAMPLE STATISTICS

00
   UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

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## Being bullied predicting depression ...

Variable/ Sample Size	Mean/ Variance	Skewness/ Kurtosis	Minimum/ Maximum	% with Min/Max	20%/60%	Percentiles 40%/80%	Median
DEPRESS1 2795.000	2.322 1.211	0.434 -0.562	1.000 5.000	28.87% 3.54%	1.000 3.000	2.000 3.000	2.000
DEPRESS2 2795.000	2.680 1.284	0.164 -0.686	1.000 5.000	18.07% 6.30%	2.000 3.000	2.000 4.000	3.000
DEPRESS3 2795.000	1.801 1.427	1.338 0.626	1.000 5.000	61.32% 5.01%	1.000 1.000	1.000 3.000	1.000
DEPRESS4 2795.000	2.209 1.690	0.672 -0.766	1.000 5.000	44.19% 6.91%	1.000 2.000	1.000 3.000	2.000
DEPRESS5 2795.000	2.500 1.874	0.401 -1.093	1.000 5.000	34.17% 10.73%	1.000 3.000	2.000 4.000	2.000
DEPRESS6 2795.000	2.481 1.788	0.457 -0.960	1.000 5.000	32.45% 10.55%	1.000 3.000	2.000 4.000	2.000
BULLIED1 2795.000	1.834 1.675	1.492 0.908	1.000 5.000	60.21% 9.45%	1.000 1.000	1.000 2.000	1.000
BULLIED2 2795.000	1.640 1.334	1.867 2.353	1.000 5.000	68.12% 6.15%	1.000 1.000	1.000 2.000	1.000
BULLIED3 2795.000	1.377 0.898	2.761 6.808	1.000 5.000	81.65% 3.76%	1.000 1.000	1.000 1.000	1.000
BULLIED4 2795.000	1.747 1.448	1.646 1.587	1.000 5.000	62.11% 7.30%	1.000 1.000	1.000 2.000	1.000
BULLIED5 2795.000	1.335 0.830	2.962 7.945	1.000 5.000	84.29% 3.33%	1.000 1.000	1.000 1.000	1.000
BULLIED6 2795.000	1.220 0.558	3.833 14.493	1.000 5.000	89.41% 2.11%	1.000 1.000	1.000 1.000	1.000
BULLIED7 2795.000	1.559 1.281	2.071 3.087	1.000 5.000	74.03% 5.94%	1.000 1.000	1.000 2.000	1.000
BULLIED8 2795.000	1.182 0.474	4.317 18.730	1.000 5.000	91.23% 1.86%	1.000 1.000	1.000 1.000	1.000
BULLIED9 2795.000	1.159 0.449	4.674 21.692	1.000 5.000	93.06% 1.90%	1.000 1.000	1.000 1.000	1.000

## Being bullied predicting depression ...

THE MODEL ESTIMATION TERMINATED NORMALLY

MODEL FIT INFORMATION

Number of Free Parameters 81

Loglikelihood

H0 Value -54138.941

H1 Value -54007.992

Information Criteria

Akaike (AIC) 108439.882

Bayesian (BIC) 108920.665

Sample-Size Adjusted BIC 108663.300

(n\* = (n + 2) / 24)

Chi-Square Test of Model Fit

Value 261.898

Degrees of Freedom 54

P-Value 0.0000

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.037

90 Percent C.I. 0.033 0.042

Probability RMSEA <= .05 1.000

CFI/TLI

## Being bullied predicting depression ...

CFI 0.953  
TLI 0.939

## Chi-Square Test of Model Fit for the Baseline Model

Value 4451.130  
Degrees of Freedom 69  
P-Value 0.0000

## SRMR (Standardized Root Mean Square Residual)

Value 0.019

## MODEL RESULTS

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY				
DEPRESS1	0.669	0.019	35.223	0.000
DEPRESS2	0.628	0.020	31.597	0.000
DEPRESS3	0.706	0.021	34.318	0.000
DEPRESS4	0.762	0.023	33.482	0.000
DEPRESS5	0.679	0.025	27.525	0.000
DEPRESS6	0.677	0.024	28.532	0.000
DEPRESS ON				
BULLIED	0.091	0.023	4.000	0.000
BULLIED ON				
BULLIED1	1.000	0.000	999.000	999.000

## Being bullied predicting depression ...

05	BULLIED2	1.292	0.482	2.681	0.007
	BULLIED3	-0.637	0.337	-1.889	0.059
	BULLIED4	1.928	0.597	3.231	0.001
	BULLIED5	1.036	0.472	2.194	0.028
	BULLIED6	-0.219	0.457	-0.481	0.631
10	BULLIED7	1.315	0.455	2.890	0.004
	BULLIED8	-0.325	0.503	-0.647	0.518
	BULLIED9	-0.662	0.540	-1.225	0.221
	<b>BULLIED1 WITH</b>				
15	BULLIED2	0.841	0.032	25.930	0.000
	BULLIED3	0.604	0.026	23.353	0.000
	BULLIED4	0.839	0.033	25.075	0.000
	BULLIED5	0.521	0.024	21.371	0.000
	BULLIED6	0.351	0.019	18.030	0.000
20	BULLIED7	0.685	0.031	22.389	0.000
	BULLIED8	0.257	0.018	14.661	0.000
	BULLIED9	0.228	0.017	13.442	0.000
	<b>BULLIED2 WITH</b>				
25	BULLIED3	0.498	0.023	21.885	0.000
	BULLIED4	0.790	0.030	26.126	0.000
	BULLIED5	0.426	0.021	19.847	0.000
	BULLIED6	0.342	0.018	19.487	0.000
	BULLIED7	0.587	0.027	21.656	0.000
30	BULLIED8	0.300	0.016	18.637	0.000
	BULLIED9	0.253	0.015	16.427	0.000
	<b>BULLIED3 WITH</b>				
35	BULLIED4	0.542	0.024	22.695	0.000
	BULLIED5	0.431	0.018	23.607	0.000
	BULLIED6	0.350	0.015	23.423	0.000
	BULLIED7	0.466	0.022	21.086	0.000
	BULLIED8	0.269	0.013	20.152	0.000

## Being bullied predicting depression ...

40	BULLIED9	0.253	0.013	19.580	0.000
	BULLIED4 WITH				
	BULLIED5	0.482	0.023	21.268	0.000
	BULLIED6	0.368	0.018	20.012	0.000
	BULLIED7	0.698	0.029	24.103	0.000
45	BULLIED8	0.329	0.017	19.518	0.000
	BULLIED9	0.303	0.016	18.594	0.000
	BULLIED5 WITH				
	BULLIED6	0.416	0.015	27.566	0.000
50	BULLIED7	0.450	0.021	21.140	0.000
	BULLIED8	0.290	0.013	22.153	0.000
	BULLIED9	0.288	0.013	22.538	0.000
	BULLIED6 WITH				
55	BULLIED7	0.355	0.017	20.450	0.000
	BULLIED8	0.279	0.011	25.225	0.000
	BULLIED9	0.271	0.011	25.160	0.000
	BULLIED7 WITH				
50	BULLIED8	0.314	0.016	19.761	0.000
	BULLIED9	0.307	0.015	19.863	0.000
	BULLIED8 WITH				
55	BULLIED9	0.304	0.010	29.122	0.000
	Means				
	BULLIED1	1.834	0.024	74.902	0.000
	BULLIED2	1.640	0.022	75.077	0.000
	BULLIED3	1.377	0.018	76.849	0.000
70	BULLIED4	1.747	0.023	76.746	0.000
	BULLIED5	1.335	0.017	77.452	0.000
	BULLIED6	1.220	0.014	86.355	0.000



## Being bullied predicting depression ...

	BULLIED7	1.559	0.021	72.826	0.000
	BULLIED8	1.182	0.013	90.797	0.000
75	BULLIED9	1.159	0.013	91.489	0.000
	<b>Intercepts</b>				
	DEPRESS1	1.805	0.039	46.249	0.000
	DEPRESS2	2.195	0.038	57.255	0.000
80	DEPRESS3	1.255	0.042	29.825	0.000
	DEPRESS4	1.620	0.045	35.777	0.000
	DEPRESS5	1.975	0.044	44.966	0.000
	DEPRESS6	1.957	0.044	44.937	0.000
	<b>Variiances</b>				
85	BULLIED1	1.675	0.045	37.383	0.000
	BULLIED2	1.334	0.036	37.383	0.000
	BULLIED3	0.898	0.024	37.383	0.000
	BULLIED4	1.448	0.039	37.383	0.000
90	BULLIED5	0.830	0.022	37.383	0.000
	BULLIED6	0.558	0.015	37.383	0.000
	BULLIED7	1.281	0.034	37.383	0.000
	BULLIED8	0.474	0.013	37.383	0.000
	BULLIED9	0.449	0.012	37.383	0.000
95	<b>Residual Variiances</b>				
	DEPRESS1	0.664	0.023	29.290	0.000
	DEPRESS2	0.802	0.025	31.575	0.000
	DEPRESS3	0.817	0.027	30.174	0.000
	DEPRESS4	0.981	0.032	30.183	0.000
00	DEPRESS5	1.311	0.040	33.055	0.000
	DEPRESS6	1.227	0.037	33.016	0.000
	BULLIED	0.000	0.000	999.000	999.000
05	DEPRESS	1.000	0.000	999.000	999.000

## Being bullied predicting depression ...

## STANDARDIZED MODEL RESULTS

## STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY				
DEPRESS1	0.672	0.014	49.769	0.000
DEPRESS2	0.613	0.015	41.874	0.000
DEPRESS3	0.654	0.014	47.362	0.000
DEPRESS4	0.648	0.014	46.141	0.000
DEPRESS5	0.548	0.016	34.274	0.000
DEPRESS6	0.560	0.016	35.818	0.000
DEPRESS ON				
BULLIED	0.427	0.018	23.892	0.000
BULLIED ON				
BULLIED1	0.251	0.061	4.076	0.000
BULLIED2	0.289	0.061	4.758	0.000
BULLIED3	-0.117	0.060	-1.940	0.052
BULLIED4	0.449	0.060	7.490	0.000
BULLIED5	0.183	0.063	2.894	0.004
BULLIED6	-0.032	0.065	-0.485	0.628
BULLIED7	0.288	0.057	5.009	0.000
BULLIED8	-0.043	0.066	-0.661	0.509
BULLIED9	-0.086	0.065	-1.316	0.188
BULLIED1 WITH				
BULLIED2	0.563	0.013	43.550	0.000
BULLIED3	0.492	0.014	34.361	0.000
BULLIED4	0.539	0.013	40.130	0.000

## Being bullied predicting depression ...

45	BULLIED5	0.442	0.015	29.037	0.000
	BULLIED6	0.363	0.016	22.086	0.000
	BULLIED7	0.467	0.015	31.625	0.000
	BULLIED8	0.289	0.017	16.646	0.000
	BULLIED9	0.263	0.018	14.931	0.000
	BULLIED2 WITH				
	BULLIED3	0.455	0.015	30.310	0.000
50	BULLIED4	0.568	0.013	44.400	0.000
	BULLIED5	0.405	0.016	25.615	0.000
	BULLIED6	0.397	0.016	24.873	0.000
	BULLIED7	0.449	0.015	29.735	0.000
	BULLIED8	0.377	0.016	23.208	0.000
	BULLIED9	0.327	0.017	19.350	0.000
55	BULLIED3 WITH				
	BULLIED4	0.475	0.015	32.461	0.000
	BULLIED5	0.499	0.014	35.132	0.000
	BULLIED6	0.494	0.014	34.571	0.000
50	BULLIED7	0.435	0.015	28.359	0.000
	BULLIED8	0.412	0.016	26.263	0.000
	BULLIED9	0.399	0.016	25.063	0.000
55	BULLIED4 WITH				
	BULLIED5	0.439	0.015	28.789	0.000
	BULLIED6	0.409	0.016	25.964	0.000
	BULLIED7	0.512	0.014	36.717	0.000
	BULLIED8	0.397	0.016	24.937	0.000
70		0.376	0.016	23.128	0.000
	BULLIED5 WITH				
	BULLIED6	0.611	0.012	51.555	0.000
	BULLIED7	0.436	0.015	28.485	0.000
	BULLIED8	0.461	0.015	31.001	0.000

## Being bullied predicting depression ...

75	BULLIED9	0.471	0.015	32.029	0.000
	BULLIED6 WITH				
	BULLIED7	0.419	0.016	26.912	0.000
	BULLIED8	0.543	0.013	40.700	0.000
80	BULLIED9	0.541	0.013	40.451	0.000
	BULLIED7 WITH				
	BULLIED8	0.403	0.016	25.436	0.000
	BULLIED9	0.405	0.016	25.649	0.000
85	BULLIED8 WITH				
	BULLIED9	0.660	0.011	61.827	0.000
	Means				
	BULLIED1	1.417	0.027	52.916	0.000
	BULLIED2	1.420	0.027	52.977	0.000
	BULLIED3	1.454	0.027	53.589	0.000
	BULLIED4	1.452	0.027	53.554	0.000
	BULLIED5	1.465	0.027	53.792	0.000
90	BULLIED6	1.633	0.029	56.524	0.000
	BULLIED7	1.378	0.026	52.168	0.000
	BULLIED8	1.717	0.030	57.717	0.000
	BULLIED9	1.731	0.030	57.893	0.000
	Intercepts				
	DEPRESS1	1.640	0.047	34.616	0.000
	DEPRESS2	1.936	0.049	39.796	0.000
	DEPRESS3	1.050	0.042	25.077	0.000
	DEPRESS4	1.246	0.043	28.864	0.000
95	DEPRESS5	1.443	0.042	34.235	0.000
	DEPRESS6	1.464	0.043	34.209	0.000
00	Variiances				

## Being bullied predicting depression ...

10	BULLIED1	1.000	0.000	999.000	999.000
	BULLIED2	1.000	0.000	999.000	999.000
	BULLIED3	1.000	0.000	999.000	999.000
	BULLIED4	1.000	0.000	999.000	999.000
	BULLIED5	1.000	0.000	999.000	999.000
	BULLIED6	1.000	0.000	999.000	999.000
15	BULLIED7	1.000	0.000	999.000	999.000
	BULLIED8	1.000	0.000	999.000	999.000
	BULLIED9	1.000	0.000	999.000	999.000

## Residual Variances

20	DEPRESS1	0.548	0.018	30.198	0.000
	DEPRESS2	0.624	0.018	34.818	0.000
	DEPRESS3	0.572	0.018	31.708	0.000
	DEPRESS4	0.580	0.018	31.898	0.000
	DEPRESS5	0.699	0.018	39.836	0.000
25	DEPRESS6	0.686	0.018	39.206	0.000
	BULLIED	0.000	999.000	999.000	999.000
	DEPRESS	0.818	0.015	53.529	0.000

## STDY Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	
35	DEPRESS BY				
	DEPRESS1	0.672	0.014	49.769	0.000
	DEPRESS2	0.613	0.015	41.874	0.000
	DEPRESS3	0.654	0.014	47.362	0.000
	DEPRESS4	0.648	0.014	46.141	0.000
40	DEPRESS5	0.548	0.016	34.274	0.000
	DEPRESS6	0.560	0.016	35.818	0.000

## Being bullied predicting depression ...

DEPRESS ON				
BULLIED	0.427	0.018	23.892	0.000
BULLIED ON				
BULLIED1	0.251	0.061	4.076	0.000
BULLIED2	0.289	0.061	4.758	0.000
BULLIED3	-0.117	0.060	-1.940	0.052
BULLIED4	0.449	0.060	7.490	0.000
BULLIED5	0.183	0.063	2.894	0.004
BULLIED6	-0.032	0.065	-0.485	0.628
BULLIED7	0.288	0.057	5.009	0.000
BULLIED8	-0.043	0.066	-0.661	0.509
BULLIED9	-0.086	0.065	-1.316	0.188
BULLIED1 WITH				
BULLIED2	0.563	0.013	43.550	0.000
BULLIED3	0.492	0.014	34.361	0.000
BULLIED4	0.539	0.013	40.130	0.000
BULLIED5	0.442	0.015	29.037	0.000
BULLIED6	0.363	0.016	22.086	0.000
BULLIED7	0.467	0.015	31.625	0.000
BULLIED8	0.289	0.017	16.646	0.000
BULLIED9	0.263	0.018	14.931	0.000
BULLIED2 WITH				
BULLIED3	0.455	0.015	30.310	0.000
BULLIED4	0.568	0.013	44.400	0.000
BULLIED5	0.405	0.016	25.615	0.000
BULLIED6	0.397	0.016	24.873	0.000
BULLIED7	0.449	0.015	29.735	0.000
BULLIED8	0.377	0.016	23.208	0.000
BULLIED9	0.327	0.017	19.350	0.000
BULLIED3 WITH				

## Being bullied predicting depression ...

BULLIED4	0.475	0.015	32.461	0.000
BULLIED5	0.499	0.014	35.132	0.000
BULLIED6	0.494	0.014	34.571	0.000
BULLIED7	0.435	0.015	28.359	0.000
BULLIED8	0.412	0.016	26.263	0.000
BULLIED9	0.399	0.016	25.063	0.000
BULLIED4 WITH				
BULLIED5	0.439	0.015	28.789	0.000
BULLIED6	0.409	0.016	25.964	0.000
BULLIED7	0.512	0.014	36.717	0.000
BULLIED8	0.397	0.016	24.937	0.000
BULLIED9	0.376	0.016	23.128	0.000
BULLIED5 WITH				
BULLIED6	0.611	0.012	51.555	0.000
BULLIED7	0.436	0.015	28.485	0.000
BULLIED8	0.461	0.015	31.001	0.000
BULLIED9	0.471	0.015	32.029	0.000
BULLIED6 WITH				
BULLIED7	0.419	0.016	26.912	0.000
BULLIED8	0.543	0.013	40.700	0.000
BULLIED9	0.541	0.013	40.451	0.000
BULLIED7 WITH				
BULLIED8	0.403	0.016	25.436	0.000
BULLIED9	0.405	0.016	25.649	0.000
BULLIED8 WITH				
BULLIED9	0.660	0.011	61.827	0.000
Means				
BULLIED1	1.417	0.027	52.916	0.000

## Being bullied predicting depression ...

	BULLIED2	1.420	0.027	52.977	0.000
	BULLIED3	1.454	0.027	53.589	0.000
	BULLIED4	1.452	0.027	53.554	0.000
	BULLIED5	1.465	0.027	53.792	0.000
15	BULLIED6	1.633	0.029	56.524	0.000
	BULLIED7	1.378	0.026	52.168	0.000
	BULLIED8	1.717	0.030	57.717	0.000
	BULLIED9	1.731	0.030	57.893	0.000
	<b>Intercepts</b>				
	DEPRESS1	1.640	0.047	34.616	0.000
	DEPRESS2	1.936	0.049	39.796	0.000
	DEPRESS3	1.050	0.042	25.077	0.000
	DEPRESS4	1.246	0.043	28.864	0.000
25	DEPRESS5	1.443	0.042	34.235	0.000
	DEPRESS6	1.464	0.043	34.209	0.000
	<b>Variances</b>				
	BULLIED1	1.000	0.000	999.000	999.000
30	BULLIED2	1.000	0.000	999.000	999.000
	BULLIED3	1.000	0.000	999.000	999.000
	BULLIED4	1.000	0.000	999.000	999.000
	BULLIED5	1.000	0.000	999.000	999.000
	BULLIED6	1.000	0.000	999.000	999.000
35	BULLIED7	1.000	0.000	999.000	999.000
	BULLIED8	1.000	0.000	999.000	999.000
	BULLIED9	1.000	0.000	999.000	999.000
	<b>Residual Variances</b>				
40	DEPRESS1	0.548	0.018	30.198	0.000
	DEPRESS2	0.624	0.018	34.818	0.000
	DEPRESS3	0.572	0.018	31.708	0.000
	DEPRESS4	0.580	0.018	31.898	0.000
	DEPRESS5	0.699	0.018	39.836	0.000



## Being bullied predicting depression ...

45	DEPRESS6	0.686	0.018	39.206	0.000
	BULLIED	999.000	999.000	999.000	999.000
	DEPRESS	0.818	0.015	53.529	0.000

## STD Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	
55	DEPRESS BY				
	DEPRESS1	0.740	0.021	35.834	0.000
	DEPRESS2	0.694	0.022	32.064	0.000
	DEPRESS3	0.781	0.022	34.721	0.000
	DEPRESS4	0.842	0.025	34.175	0.000
50	DEPRESS5	0.751	0.027	27.947	0.000
	DEPRESS6	0.749	0.026	28.820	0.000
	DEPRESS ON				
	BULLIED	0.427	0.018	23.892	0.000
55	BULLIED ON				
	BULLIED1	0.194	0.047	4.075	0.000
	BULLIED2	0.250	0.053	4.756	0.000
	BULLIED3	-0.123	0.064	-1.940	0.052
70	BULLIED4	0.373	0.050	7.472	0.000
	BULLIED5	0.200	0.069	2.895	0.004
	BULLIED6	-0.042	0.088	-0.485	0.628
	BULLIED7	0.254	0.051	5.008	0.000
	BULLIED8	-0.063	0.095	-0.661	0.509
75	BULLIED9	-0.128	0.097	-1.316	0.188
	BULLIED1 WITH				
	BULLIED2	0.841	0.032	25.930	0.000

## Being bullied predicting depression ...

30	BULLIED3	0.604	0.026	23.353	0.000
	BULLIED4	0.839	0.033	25.075	0.000
	BULLIED5	0.521	0.024	21.371	0.000
	BULLIED6	0.351	0.019	18.030	0.000
	BULLIED7	0.685	0.031	22.389	0.000
	BULLIED8	0.257	0.018	14.661	0.000
35	BULLIED9	0.228	0.017	13.442	0.000
	<b>BULLIED2 WITH</b>				
	BULLIED3	0.498	0.023	21.885	0.000
	BULLIED4	0.790	0.030	26.126	0.000
90	BULLIED5	0.426	0.021	19.847	0.000
	BULLIED6	0.342	0.018	19.487	0.000
	BULLIED7	0.587	0.027	21.656	0.000
	BULLIED8	0.300	0.016	18.637	0.000
	BULLIED9	0.253	0.015	16.427	0.000
95	<b>BULLIED3 WITH</b>				
	BULLIED4	0.542	0.024	22.695	0.000
	BULLIED5	0.431	0.018	23.607	0.000
00	BULLIED6	0.350	0.015	23.423	0.000
	BULLIED7	0.466	0.022	21.086	0.000
	BULLIED8	0.269	0.013	20.152	0.000
	BULLIED9	0.253	0.013	19.580	0.000
05	<b>BULLIED4 WITH</b>				
	BULLIED5	0.482	0.023	21.268	0.000
	BULLIED6	0.368	0.018	20.012	0.000
	BULLIED7	0.698	0.029	24.103	0.000
	BULLIED8	0.329	0.017	19.518	0.000
10	BULLIED9	0.303	0.016	18.594	0.000
	<b>BULLIED5 WITH</b>				
	BULLIED6	0.416	0.015	27.566	0.000

## Being bullied predicting depression ...

	BULLIED7	0.450	0.021	21.140	0.000
	BULLIED8	0.290	0.013	22.153	0.000
15	BULLIED9	0.288	0.013	22.538	0.000
	<b>BULLIED6 WITH</b>				
	BULLIED7	0.355	0.017	20.450	0.000
	BULLIED8	0.279	0.011	25.225	0.000
20	BULLIED9	0.271	0.011	25.160	0.000
	<b>BULLIED7 WITH</b>				
	BULLIED8	0.314	0.016	19.761	0.000
	BULLIED9	0.307	0.015	19.863	0.000
25					
	<b>BULLIED8 WITH</b>				
	BULLIED9	0.304	0.010	29.122	0.000
	<b>Means</b>				
30	BULLIED1	1.834	0.024	74.902	0.000
	BULLIED2	1.640	0.022	75.077	0.000
	BULLIED3	1.377	0.018	76.849	0.000
	BULLIED4	1.747	0.023	76.746	0.000
	BULLIED5	1.335	0.017	77.452	0.000
35	BULLIED6	1.220	0.014	86.355	0.000
	BULLIED7	1.559	0.021	72.826	0.000
	BULLIED8	1.182	0.013	90.797	0.000
	BULLIED9	1.159	0.013	91.489	0.000
40					
	<b>Intercepts</b>				
	DEPRESS1	1.805	0.039	46.249	0.000
	DEPRESS2	2.195	0.038	57.255	0.000
	DEPRESS3	1.255	0.042	29.825	0.000
	DEPRESS4	1.620	0.045	35.777	0.000
45	DEPRESS5	1.975	0.044	44.966	0.000
	DEPRESS6	1.957	0.044	44.937	0.000

## Being bullied predicting depression ...

Variances				
BULLIED1	1.675	0.045	37.383	0.000
BULLIED2	1.334	0.036	37.383	0.000
BULLIED3	0.898	0.024	37.383	0.000
BULLIED4	1.448	0.039	37.383	0.000
BULLIED5	0.830	0.022	37.383	0.000
BULLIED6	0.558	0.015	37.383	0.000
BULLIED7	1.281	0.034	37.383	0.000
BULLIED8	0.474	0.013	37.383	0.000
BULLIED9	0.449	0.012	37.383	0.000
Residual Variances				
DEPRESS1	0.664	0.023	29.290	0.000
DEPRESS2	0.802	0.025	31.575	0.000
DEPRESS3	0.817	0.027	30.174	0.000
DEPRESS4	0.981	0.032	30.183	0.000
DEPRESS5	1.311	0.040	33.055	0.000
DEPRESS6	1.227	0.037	33.016	0.000
BULLIED	999.000	999.000	999.000	999.000
DEPRESS	0.818	0.015	53.529	0.000
R-SQUARE				
Observed Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS1	0.452	0.018	24.885	0.000
DEPRESS2	0.376	0.018	20.937	0.000
DEPRESS3	0.428	0.018	23.681	0.000
DEPRESS4	0.420	0.018	23.071	0.000
DEPRESS5	0.301	0.018	17.137	0.000
DEPRESS6	0.314	0.018	17.909	0.000

## Being bullied predicting depression ...

Latent Variable	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
BULLIED	1.000	999.000	999.000	999.000
DEPRESS	0.182	0.015	11.946	0.000

## QUALITY OF NUMERICAL RESULTS

Condition Number for the Information Matrix                    0.589E-05  
 (ratio of smallest to largest eigenvalue)

Beginning Time: 16:53:29  
 Ending Time: 16:53:30  
 Elapsed Time: 00:00:01

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## Being bullied predicting depression ...

```

m3 <- '
## Being bullied at school
  bullied <~ 1*gotBu1_i + gotBu2_i + gotBu3_i +
            gotBu4_i + gotBu5_i + gotBu6_i +
            gotBu7_i + gotBu8_i + gotBu9_i

  bullied ~ 0*bullied

  gotBu1_i ~ gotBu2_i + gotBu3_i + gotBu4_i +
            gotBu5_i + gotBu6_i + gotBu7_i +
            gotBu8_i + gotBu9_i

  gotBu2_i ~ gotBu3_i + gotBu4_i + gotBu5_i +
            gotBu6_i + gotBu7_i + gotBu8_i +
            gotBu9_i

  gotBu3_i ~ gotBu4_i + gotBu5_i + gotBu6_i +
            gotBu7_i + gotBu8_i + gotBu9_i

```

## Being bullied predicting depression ...

gotBu4\_i  $\sim$  gotBu5\_i + gotBu6\_i + gotBu7\_i +  
gotBu8\_i + gotBu9\_i

gotBu5\_i  $\sim$  gotBu6\_i + gotBu7\_i + gotBu8\_i +  
gotBu9\_i

gotBu6\_i  $\sim$  gotBu7\_i + gotBu8\_i + gotBu9\_i

gotBu7\_i  $\sim$  gotBu8\_i + gotBu9\_i

gotBu8\_i  $\sim$  gotBu9\_i

## Depression latent factor

depression  $\sim$  NA\*depre1\_o + depre2\_o + depre3\_o +  
depre4\_o + depre5\_o + depre6\_o

depression  $\sim$  1\*depression

## Regression

## Being bullied predicting depression ...

```

depression ~ bullied '
## Use the sem() function to estimate the model
fit3 <- sem(model = m3, data = hb3c, meanstructure =
  TRUE)
## Request a summary of the results
summary(fit3, fit.measures = TRUE, standardized = TRUE)

```

```
lavaan 0.6-3 ended normally after 174 iterations
```

Optimization method	NLMINB	
Number of free parameters	93	
	Used	Total
Number of observations	2795	4284
Estimator	DWLS	Robust
Model Fit Test Statistic	176.789	274.513
Degrees of freedom	54	54
P-value (Chi-square)	0.000	0.000
Scaling correction factor		0.684
Shift parameter		16.230
for simple second-order correction (Mplus variant)		



# Being bullied predicting depression ...

Model test baseline model:

Minimum Function Test Statistic	29163.881	10174.709
Degrees of freedom	105	105
P-value	0.000	0.000

User model versus baseline model:

Comparative Fit Index (CFI)	0.996	0.978
Tucker-Lewis Index (TLI)	0.992	0.957

Robust Comparative Fit Index (CFI)		NA
Robust Tucker-Lewis Index (TLI)		NA

Root Mean Square Error of Approximation:

RMSEA	0.029	0.038
90 Percent Confidence Interval	0.024 0.033	0.034
0.043		
P-value RMSEA $\leq$ 0.05	1.000	1.000

Robust RMSEA		NA
90 Percent Confidence Interval		NA
NA		

Standardized Root Mean Square Residual:

## Being bullied predicting depression ...

SRMR				0.021		0.021
Parameter Estimates:						
Information				Expected		
Information saturated (h1) model				Unstructured		
Standard Errors				Robust.sem		
Latent Variables:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
depression =~						
depre1_o	0.643	0.013	49.673	0.000	0.704	0.704
depre2_o	0.593	0.013	45.605	0.000	0.649	0.649
depre3_o	0.685	0.014	50.483	0.000	0.750	0.750
depre4_o	0.646	0.014	46.875	0.000	0.707	0.707
depre5_o	0.546	0.015	35.658	0.000	0.597	0.597
depre6_o	0.561	0.015	37.328	0.000	0.614	0.614
Composites:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
bullied <~						
gotBu1_i	1.000				0.196	0.254
gotBu2_i	1.267	0.424	2.986	0.003	0.248	0.287
gotBu3_i	-0.584	0.315	-1.856	0.063	-0.114	-0.108
gotBu4_i	1.915	0.553	3.464	0.001	0.375	0.452

## Being bullied predicting depression ...

gotBu5_i	1.004	0.426	2.357	0.018	0.197	0.179
gotBu6_i	-0.309	0.389	-0.792	0.428	-0.060	-0.045
gotBu7_i	1.309	0.429	3.050	0.002	0.257	0.290
gotBu8_i	-0.317	0.440	-0.721	0.471	-0.062	-0.043
gotBu9_i	-0.681	0.438	-1.554	0.120	-0.133	-0.089
Regressions:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
depression ~						
bullied	0.087	0.020	4.289	0.000	0.407	0.407
Covariances:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
gotBu1_i ~						
gotBu2_i	0.841	0.046	18.298	0.000	0.841	0.563
gotBu3_i	0.604	0.034	17.735	0.000	0.604	0.492
gotBu4_i	0.839	0.047	17.894	0.000	0.839	0.539
gotBu5_i	0.521	0.032	16.269	0.000	0.521	0.442
gotBu6_i	0.351	0.022	16.076	0.000	0.351	0.363
gotBu7_i	0.685	0.042	16.380	0.000	0.685	0.467
gotBu8_i	0.257	0.018	14.151	0.000	0.257	0.289
gotBu9_i	0.228	0.017	13.706	0.000	0.228	0.263
gotBu2_i ~						
gotBu3_i	0.498	0.026	18.899	0.000	0.498	0.455
gotBu4_i	0.790	0.041	19.439	0.000	0.790	0.568
gotBu5_i	0.426	0.025	17.202	0.000	0.426	0.405

## Being bullied predicting depression ...

gotBu6_i	0.342	0.019	17.914	0.000	0.342	0.397
gotBu7_i	0.587	0.034	17.086	0.000	0.587	0.449
gotBu8_i	0.300	0.017	17.514	0.000	0.300	0.377
gotBu9_i	0.253	0.016	15.909	0.000	0.253	0.327
gotBu3_i ~						
gotBu4_i	0.542	0.029	18.772	0.000	0.542	0.475
gotBu5_i	0.431	0.021	20.982	0.000	0.431	0.499
gotBu6_i	0.350	0.015	23.138	0.000	0.350	0.494
gotBu7_i	0.466	0.026	17.987	0.000	0.466	0.435
gotBu8_i	0.269	0.012	21.890	0.000	0.269	0.412
gotBu9_i	0.253	0.012	20.645	0.000	0.253	0.399
gotBu4_i ~						
gotBu5_i	0.482	0.027	17.760	0.000	0.482	0.439
gotBu6_i	0.368	0.020	18.160	0.000	0.368	0.409
gotBu7_i	0.698	0.039	17.926	0.000	0.698	0.512
gotBu8_i	0.329	0.019	17.529	0.000	0.329	0.397
gotBu9_i	0.303	0.018	17.108	0.000	0.303	0.376
gotBu5_i ~						
gotBu6_i	0.416	0.016	25.463	0.000	0.416	0.611
gotBu7_i	0.450	0.025	17.906	0.000	0.450	0.436
gotBu8_i	0.290	0.013	22.851	0.000	0.290	0.461
gotBu9_i	0.288	0.013	22.379	0.000	0.288	0.471
gotBu6_i ~						
gotBu7_i	0.355	0.019	18.649	0.000	0.355	0.419
gotBu8_i	0.279	0.010	27.813	0.000	0.279	0.543
gotBu9_i	0.271	0.010	27.261	0.000	0.271	0.541

## Being bullied predicting depression ...

gotBu7_i ~						
gotBu8_i	0.314	0.017	18.030	0.000	0.314	0.403
gotBu9_i	0.307	0.018	17.394	0.000	0.307	0.405
gotBu8_i ~						
gotBu9_i	0.304	0.010	31.100	0.000	0.304	0.660
Intercepts:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
.depre1_o	0.000				0.000	0.000
.depre2_o	0.000				0.000	0.000
.depre3_o	0.000				0.000	0.000
.depre4_o	0.000				0.000	0.000
.depre5_o	0.000				0.000	0.000
.depre6_o	0.000				0.000	0.000
gotBu1_i	1.834	0.051	36.243	0.000	1.834	1.417
gotBu2_i	1.640	0.049	33.497	0.000	1.640	1.420
gotBu3_i	1.377	0.049	28.166	0.000	1.377	1.454
gotBu4_i	1.747	0.046	37.934	0.000	1.747	1.452
gotBu5_i	1.335	0.050	26.555	0.000	1.335	1.465
gotBu6_i	1.220	0.043	28.515	0.000	1.220	1.633
gotBu7_i	1.559	0.054	28.865	0.000	1.559	1.378
gotBu8_i	1.182	0.041	28.873	0.000	1.182	1.717
gotBu9_i	1.159	0.045	25.531	0.000	1.159	1.731
bullied	0.000				0.000	0.000
.depression	0.000				0.000	0.000

## Being bullied predicting depression ...

45 Thresholds :

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
depre1_o t1	-0.092	0.043	-2.123	0.034	-0.092	-0.092
depre1_o t2	0.621	0.042	14.732	0.000	0.621	0.621
depre1_o t3	1.561	0.044	35.410	0.000	1.561	1.561
depre1_o t4	2.272	0.054	41.945	0.000	2.272	2.272
depre2_o t1	-0.484	0.043	-11.196	0.000	-0.484	-0.484
depre2_o t2	0.250	0.040	6.195	0.000	0.250	0.250
depre2_o t3	1.178	0.041	28.727	0.000	1.178	1.178
depre2_o t4	1.959	0.047	41.263	0.000	1.959	1.959
depre3_o t1	0.784	0.044	17.639	0.000	0.784	0.784
depre3_o t2	1.188	0.045	26.299	0.000	1.188	1.188
depre3_o t3	1.673	0.047	35.640	0.000	1.673	1.673
depre3_o t4	2.140	0.052	41.218	0.000	2.140	2.140
depre4_o t1	0.321	0.043	7.485	0.000	0.321	0.321
depre4_o t2	0.721	0.042	16.989	0.000	0.721	0.721
depre4_o t3	1.373	0.043	31.581	0.000	1.373	1.373
depre4_o t4	1.950	0.048	40.490	0.000	1.950	1.950
depre5_o t1	-0.013	0.040	-0.330	0.742	-0.013	-0.013
depre5_o t2	0.448	0.039	11.508	0.000	0.448	0.448
depre5_o t3	1.051	0.040	26.415	0.000	1.051	1.051
depre5_o t4	1.636	0.043	37.881	0.000	1.636	1.636
depre6_o t1	-0.049	0.041	-1.218	0.223	-0.049	-0.049
depre6_o t2	0.491	0.040	12.317	0.000	0.491	0.491
depre6_o t3	1.133	0.040	28.175	0.000	1.133	1.133
depre6_o t4	1.656	0.043	38.173	0.000	1.656	1.656

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70

## Being bullied predicting depression ...

## Variances :

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
bullied	0.000				0.000	0.000
.depression	1.000				0.835	0.835
.depre1_o	0.504				0.504	0.504
.depre2_o	0.579				0.579	0.579
.depre3_o	0.437				0.437	0.437
.depre4_o	0.501				0.501	0.501
.depre5_o	0.643				0.643	0.643
.depre6_o	0.623				0.623	0.623
gotBu1_i	1.675	0.077	21.813	0.000	1.675	1.000
gotBu2_i	1.334	0.054	24.607	0.000	1.334	1.000
gotBu3_i	0.898	0.031	28.754	0.000	0.898	1.000
gotBu4_i	1.448	0.059	24.744	0.000	1.448	1.000
gotBu5_i	0.830	0.029	28.581	0.000	0.830	1.000
gotBu6_i	0.558	0.016	35.448	0.000	0.558	1.000
gotBu7_i	1.281	0.054	23.630	0.000	1.281	1.000
gotBu8_i	0.474	0.012	38.272	0.000	0.474	1.000
gotBu9_i	0.449	0.012	35.906	0.000	0.449	1.000

## Scales y\*:

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
depre1_o	1.000				1.000	1.000
depre2_o	1.000				1.000	1.000
depre3_o	1.000				1.000	1.000

# Being bullied predicting depression ...

depre4_o	1.000	1.000	1.000
depre5_o	1.000	1.000	1.000
depre6_o	1.000	1.000	1.000



# Outline

- 1 Formative Conceptualization
- 2 Formative Operationalization
  - Formative indicators in lavaan
  - Formative indicators in Mplus
- 3 An Example with the Political Democracy Data Set
  - The reflective operationalization
  - The formative operationalization
- 4 Another Example - Being Bullied Predicting Depression
- 5 References
- 6 Supplemental - Formative indicators and canonical correlations

# References

- Bollen, K. A. (1989). *Structural equations with latent variables*. New York: Wiley.
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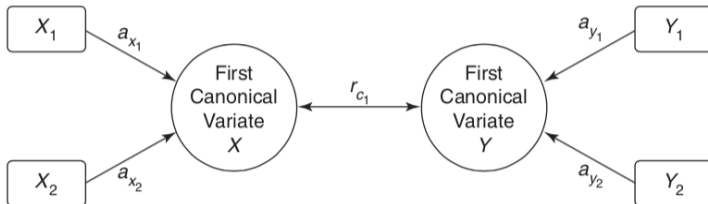
# References ...

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston, MA: Pearson.

# Outline

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# Canonical correlation analysis



$X_i$  = Variable in  $X$  set

$Y_i$  = Variable in  $Y$  set

$a_{x_i}$  = Loading of (correlation with)  $i$ th  $X$  variable on canonical variate  $X$

$a_{y_i}$  = Loading of (correlation with)  $i$ th  $Y$  variable on canonical variate  $Y$

$r_{c_1}$  = Canonical correlation for the first pair of canonical variates

**FIGURE 12.1 Relationships among variables, canonical variates, and the first pair of canonical variates.**

7

<sup>7</sup>Tabachnick and Fidell (2013, p. 583)

# Canonical correlations - Single outcome

```
## Loading the CCA package for conanical correlation
  analysis
library(CCA)
## Subset complete cases
dat.cc.1 <-
  hbsc[complete.cases(hbsc[c("alc1_i", "alc2_i",
    "alc3_i", "alc4_i", "alc5_i", "bu0th1_i")]), ]
## Create x and y objects for cc()
x.1 <-
  dat.cc.1[c("alc1_i", "alc2_i", "alc3_i", "alc4_i",
    "alc5_i")]
y.1 <-
  dat.cc.1["bu0th1_i"]
## Supply x and y to the cc() function
## and save the canonical correlation estimates
## to an output object
out.cc.1 <- cc(x.1, y.1)
## Request the loading estimates
```

# Canonical correlations - Single outcome ...

```
## of the alcohol variables
## These estimates are comparable to lavaan (Std.lv)
## and Mplus (STD Standardization) estimates
abs(round(out.cc.1$xcoef[ , 1], 3))
```

```
alc1_i alc2_i alc3_i alc4_i alc5_i
0.679 0.404 0.093 0.495 0.275
```

```
## Request the canonical correlation estimate
## This estimate is comparable to lavaan (Std.all)
## and Mplus (STDYX and STDY) estimates
abs(round(out.cc.1$scores$corr.Y.xscores[ , 1], 3))
```

```
bu0th1_i
0.352
```

# Canonical correlations - Multiple outcomes

```

## Subset complete cases
dat.cc.2 <-
  hbsc[complete.cases(hbsc[c("alc1_i", "alc2_i",
    "alc3_i", "alc4_i", "alc5_i", "bu0th1_i",
    "bu0th2_i", "bu0th3_i", "bu0th4_i", "bu0th5_i",
    "bu0th6_i", "bu0th7_i", "bu0th8_i", "bu0th9_i"))],
  ]
## Create x and y objects for cc()
5 x.2 <-
  dat.cc.2[c("alc1_i", "alc2_i", "alc3_i", "alc4_i",
    "alc5_i")]
y.2 <-
  dat.cc.2[c("bu0th1_i", "bu0th2_i", "bu0th3_i",
    "bu0th4_i", "bu0th5_i", "bu0th6_i", "bu0th7_i",
    "bu0th8_i", "bu0th9_i")]
## Supply x and y to the cc() function
10 out.cc.2 <- cc(x.2, y.2)
abs(round(out.cc.2$xcoef[ , 1], 3))

```



# Canonical correlations - Multiple outcomes ...

```
alc1_i alc2_i alc3_i alc4_i alc5_i
0.308  0.496  0.606  0.407  0.181
```

```
abs(round(out.cc.2$scores$corr.Y.xscores[ , 1], 3))
```

```
bu0th1_i bu0th2_i bu0th3_i bu0th4_i bu0th5_i bu0th6_i bu0th7_i bu0th8_i
0.336     0.311     0.340     0.329     0.335     0.350     0.325     0.330
bu0th9_i
0.305
```

```
m3 <-
' alcohol <~ 1*alc1_i + alc2_i + alc3_i +
             alc4_i + alc5_i

alcohol ~ 0*alcohol

alc1_i ~ alc2_i + alc3_i + alc4_i + alc5_i
alc2_i ~ alc3_i + alc4_i + alc5_i
alc3_i ~ alc4_i + alc5_i
```

## Canonical correlations - Multiple outcomes ...

```
alc4_i ~ alc5_i

bu0th1_i ~ alcohol
bu0th2_i ~ alcohol
bu0th3_i ~ alcohol
bu0th4_i ~ alcohol
bu0th5_i ~ alcohol
bu0th6_i ~ alcohol
bu0th7_i ~ alcohol
bu0th8_i ~ alcohol
bu0th9_i ~ alcohol
,
## Use the sem() function to estimate the model
fit3 <- sem(model = m3, data = hbsc, meanstructure =
  TRUE)
## Request a summary of the results
summary(fit3, fit.measures = TRUE, standardized = TRUE)
```

# Canonical correlations - Multiple outcomes ...

```

lavaan 0.6-3 ended normally after 221 iterations

  Optimization method          NLMINB
  Number of free parameters          87

  Number of observations          Used      Total
                                2756      4284

  Estimator                      ML
  Model Fit Test Statistic        150.462
  Degrees of freedom              32
  P-value (Chi-square)            0.000

Model test baseline model:

  Minimum Function Test Statistic    22742.326
  Degrees of freedom                 91
  P-value                            0.000

User model versus baseline model:

  Comparative Fit Index (CFI)        0.995
  Tucker-Lewis Index (TLI)          0.985

Loglikelihood and Information Criteria:

```

## Canonical correlations - Multiple outcomes ...

Loglikelihood user model (H0)	-29053.720
Loglikelihood unrestricted model (H1)	-28978.489
Number of free parameters	87
Akaike (AIC)	58281.440
Bayesian (BIC)	58796.614
Sample-size adjusted Bayesian (BIC)	58520.186

## Root Mean Square Error of Approximation:

RMSEA	0.037
90 Percent Confidence Interval	0.031 0.043
P-value RMSEA <= 0.05	1.000

## Standardized Root Mean Square Residual:

SRMR	0.009
------	-------

## Parameter Estimates:

Information	Expected
Information saturated (h1) model	Structured
Standard Errors	Standard

## Composites:

## Canonical correlations - Multiple outcomes ...

	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
alcohol <~						
alc1_i	1.000				0.308	0.176
alc2_i	1.614	0.661	2.442	0.015	0.496	0.297
alc3_i	1.971	0.809	2.437	0.015	0.606	0.346
alc4_i	1.325	0.561	2.363	0.018	0.408	0.275
alc5_i	0.588	0.406	1.447	0.148	0.181	0.112
Regressions:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
bu0th1_i ~						
alcohol	0.104	0.034	3.041	0.002	0.338	0.336
bu0th2_i ~						
alcohol	0.086	0.028	3.033	0.002	0.280	0.311
bu0th3_i ~						
alcohol	0.084	0.028	3.042	0.002	0.273	0.340
bu0th4_i ~						
alcohol	0.076	0.025	3.039	0.002	0.247	0.329
bu0th5_i ~						
alcohol	0.072	0.024	3.041	0.002	0.235	0.335
bu0th6_i ~						
alcohol	0.067	0.022	3.044	0.002	0.217	0.350
bu0th7_i ~						
alcohol	0.076	0.025	3.038	0.002	0.248	0.325
bu0th8_i ~						
alcohol	0.061	0.020	3.039	0.002	0.199	0.330

## Canonical correlations - Multiple outcomes ...

bu0th9_i ~						
alcohol	0.057	0.019	3.031	0.002	0.184	0.305
Covariances:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
alc1_i ~						
alc2_i	0.195	0.008	26.032	0.000	0.195	0.571
alc3_i	0.209	0.007	28.317	0.000	0.209	0.641
alc4_i	0.233	0.009	27.140	0.000	0.233	0.604
alc5_i	0.220	0.008	27.571	0.000	0.220	0.617
alc2_i ~						
alc3_i	0.181	0.007	24.670	0.000	0.181	0.532
alc4_i	0.202	0.009	23.526	0.000	0.202	0.501
alc5_i	0.194	0.008	24.266	0.000	0.194	0.521
alc3_i ~						
alc4_i	0.262	0.009	29.549	0.000	0.262	0.681
alc5_i	0.250	0.008	30.237	0.000	0.250	0.705
alc4_i ~						
alc5_i	0.287	0.010	29.634	0.000	0.287	0.684
.bu0th1_i ~						
.bu0th2_i	0.427	0.017	24.499	0.000	0.427	0.528
.bu0th3_i	0.351	0.015	23.120	0.000	0.351	0.491
.bu0th4_i	0.258	0.014	18.881	0.000	0.258	0.385
.bu0th5_i	0.245	0.013	19.200	0.000	0.245	0.393
.bu0th6_i	0.189	0.011	17.051	0.000	0.189	0.343
.bu0th7_i	0.279	0.014	19.875	0.000	0.279	0.409

## Canonical correlations - Multiple outcomes ...

.bu0th8_i	0.165	0.011	15.374	0.000	0.165	0.306
.bu0th9_i	0.172	0.011	15.806	0.000	0.172	0.316
.bu0th2_i ~						
.bu0th3_i	0.288	0.013	21.391	0.000	0.288	0.446
.bu0th4_i	0.298	0.013	23.156	0.000	0.298	0.491
.bu0th5_i	0.241	0.012	20.603	0.000	0.241	0.427
.bu0th6_i	0.214	0.010	20.801	0.000	0.214	0.432
.bu0th7_i	0.267	0.013	20.845	0.000	0.267	0.433
.bu0th8_i	0.187	0.010	18.786	0.000	0.187	0.383
.bu0th9_i	0.177	0.010	17.824	0.000	0.177	0.361
.bu0th3_i ~						
.bu0th4_i	0.248	0.011	22.052	0.000	0.248	0.463
.bu0th5_i	0.250	0.011	23.532	0.000	0.250	0.501
.bu0th6_i	0.210	0.009	22.628	0.000	0.210	0.478
.bu0th7_i	0.279	0.012	23.932	0.000	0.279	0.512
.bu0th8_i	0.188	0.009	21.016	0.000	0.188	0.437
.bu0th9_i	0.198	0.009	21.780	0.000	0.198	0.456
.bu0th4_i ~						
.bu0th5_i	0.267	0.010	26.001	0.000	0.267	0.570
.bu0th6_i	0.242	0.009	26.600	0.000	0.242	0.588
.bu0th7_i	0.265	0.011	24.130	0.000	0.265	0.518
.bu0th8_i	0.204	0.009	23.724	0.000	0.204	0.507
.bu0th9_i	0.203	0.009	23.448	0.000	0.203	0.499
.bu0th5_i ~						
.bu0th6_i	0.275	0.009	30.549	0.000	0.275	0.716
.bu0th7_i	0.278	0.011	26.466	0.000	0.278	0.584

## Canonical correlations - Multiple outcomes ...

30	.bu0th8_i	0.220	0.008	26.467	0.000	0.220	0.584
	.bu0th9_i	0.221	0.008	26.418	0.000	0.221	0.582
	.bu0th6_i ~						
	.bu0th7_i	0.228	0.009	25.123	0.000	0.228	0.545
	.bu0th8_i	0.212	0.007	28.332	0.000	0.212	0.641
35	.bu0th9_i	0.211	0.008	28.093	0.000	0.211	0.633
	.bu0th7_i ~						
	.bu0th8_i	0.198	0.009	22.805	0.000	0.198	0.482
	.bu0th9_i	0.216	0.009	24.302	0.000	0.216	0.522
	.bu0th8_i ~						
40	.bu0th9_i	0.230	0.008	30.200	0.000	0.230	0.703
Intercepts:							
		Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
	.bu0th1_i	0.744	0.047	15.683	0.000	0.744	0.741
45	.bu0th2_i	0.728	0.043	17.010	0.000	0.728	0.809
	.bu0th3_i	0.624	0.038	16.447	0.000	0.624	0.776
	.bu0th4_i	0.658	0.036	18.542	0.000	0.658	0.878
	.bu0th5_i	0.623	0.033	18.799	0.000	0.623	0.888
	.bu0th6_i	0.622	0.029	21.342	0.000	0.622	1.003
50	.bu0th7_i	0.643	0.036	17.796	0.000	0.643	0.843
	.bu0th8_i	0.664	0.029	23.248	0.000	0.664	1.100
	.bu0th9_i	0.692	0.029	24.049	0.000	0.692	1.147
	alc1_i	1.195	0.011	109.619	0.000	1.195	2.088
	alc2_i	1.235	0.011	108.538	0.000	1.235	2.067
55	alc3_i	1.156	0.011	106.390	0.000	1.156	2.027



# Canonical correlations - Multiple outcomes ...

alc4_i	1.251	0.013	97.272	0.000	1.251	1.853
alc5_i	1.212	0.012	102.382	0.000	1.212	1.950
alcohol	0.000				0.000	0.000
Variances:						
	Estimate	Std.Err	z-value	P(> z )	Std.lv	Std.all
alcohol	0.000				0.000	0.000
.bu0th1_i	0.895	0.024	37.121	0.000	0.895	0.887
.bu0th2_i	0.731	0.020	37.121	0.000	0.731	0.903
.bu0th3_i	0.571	0.015	37.121	0.000	0.571	0.884
.bu0th4_i	0.502	0.014	37.121	0.000	0.502	0.892
.bu0th5_i	0.436	0.012	37.121	0.000	0.436	0.888
.bu0th6_i	0.338	0.009	37.121	0.000	0.338	0.877
.bu0th7_i	0.520	0.014	37.121	0.000	0.520	0.895
.bu0th8_i	0.324	0.009	37.121	0.000	0.324	0.891
.bu0th9_i	0.330	0.009	37.121	0.000	0.330	0.907
alc1_i	0.328	0.009	37.121	0.000	0.328	1.000
alc2_i	0.357	0.010	37.121	0.000	0.357	1.000
alc3_i	0.325	0.009	37.121	0.000	0.325	1.000
alc4_i	0.456	0.012	37.121	0.000	0.456	1.000
alc5_i	0.386	0.010	37.121	0.000	0.386	1.000

# Session

```
sessionInfo()
```

```
R version 3.5.2 (2018-12-20)
Platform: x86_64-redhat-linux-gnu (64-bit)
Running under: CentOS Linux 7 (Core)

Matrix products: default
BLAS/LAPACK: /usr/lib64/R/lib/libRblas.so

locale:
 [1] LC_CTYPE=en_US.UTF-8      LC_NUMERIC=C
 [3] LC_TIME=en_US.UTF-8      LC_COLLATE=en_US.UTF-8
 [5] LC_MONETARY=en_US.UTF-8  LC_MESSAGES=en_US.UTF-8
 [7] LC_PAPER=en_US.UTF-8     LC_NAME=C
 [9] LC_ADDRESS=C             LC_TELEPHONE=C
[11] LC_MEASUREMENT=en_US.UTF-8 LC_IDENTIFICATION=C

attached base packages:
[1] grid      splines    stats      graphics  grDevices  utils      datasets
[8] methods  base

other attached packages:
[1] CCA_1.2          fields_9.6      maps_3.3.0      spam_2.2-1
[5] dotCall64_1.0-0 fda_2.4.8       Matrix_1.2-17   lavaan_0.6-3
```

## Session ...

```
[9] stationery_0.98.8
```

```
loaded via a namespace (and not attached):
```

```
[1] Rcpp_1.0.0      knitr_1.21      kutils_1.64     MASS_7.3-51.4
[5] mnormt_1.5-5    pbivnorm_0.6.0 xtable_1.8-3    lattice_0.20-38
[9] plyr_1.8.4      tools_3.5.2     xfun_0.5        htmltools_0.3.6
[13] digest_0.6.19   zip_2.0.0       evaluate_0.13   rmarkdown_1.11
[17] openxlsx_4.1.0  compiler_3.5.2 stats4_3.5.2    foreign_0.8-71
```