1

Mplus Annotated Output

This document provides annotated Mplus output for the moderately vigorous physical activity example communication in Chapter 25. The analysis applies MSEM using Bayes estimation with uninformative priors. I assume you have read Chapter 25. For interpretation of Mplus output more generally, see the Output tab on my webpage. The annotations I added appear in **red:**

Mplus first repeats the input syntax.

```
INPUT INSTRUCTIONS

  TITLE: MSEM analysis ;
  DATA:
  FILE IS mvpa.dat ;
    VARIABLE:
    NAMES ARE
      mvpa peers advant treat school  ;
    USEVARIABLES ARE
      mvpa peers advant treat ;
    CLUSTER is school ;
    BETWEEN IS treat ;         ! specify global/integral level 2 variables
   ANALYSIS:
   TYPE = TWOLEVEL ;
   ESTIMATOR = BAYES ;
   BITERATIONS=100000 (50000); BCONVERGENCE =.01;
   MODEL :
   %WITHIN%                  ! specify within cluster model
   mvpa ;                   ! estimate within disturb var of outcome
   mvpa ON advant peers (p1wc p2wc); ! regress mvpa on within mediators
   peers WITH advant ;               ! correlate predictors
   %BETWEEN%                            ! specify between cluster model
   [mvpa] ;                            ! estimate outcome intercept
   [advant] ;  [peers] ;               ! estimate mediator intercepts
   mvpa ;                              ! estimate disturb var of outcome
   advant ;  peers ;                   ! estimate disturb var of mediators
   mvpa ON advant peers (p3bc p4bc) ; ! regress outcome onto mediators
   advant ON treat (p1bc) ;            ! regress advant onto treatment
   peers ON treat (p2bc) ;             ! regress peers onto treatment
   advant WITH peers;                  ! correlate disturbances
   MODEL CONSTRAINT:                     ! define contrasts
```

```
   NEW (medadv medpeer tot con1 con2) ; ! give names to contrasts
   medadv = p1bc*p3bc ;                 ! omnibus mediation for advant
   medpeer = p2bc*p4bc ;                ! omnibus mediation for peers
   tot = medadv + medpeer ;             ! total effect of treatment
   con1 = p3bc-p1wc ;                   ! context effect 1
   con2 = p4bc-p2wc ;                   ! context effect 2
   OUTPUT: STAND(STDYX) RESIDUAL CINTERVAL(HPD) TECH4 TECH8 ;
```

Mplus issues two warnings, but they are not problematic. Mplus reminds me that the models on the between and within levels are different and that variables on the between cluster level are endogenous but those same variables are exogenous on the within cluster level. This fits with my analysis plan.

```
*** WARNING in MODEL command
  In the MODEL command, the following variable is a y-variable on the BETWEEN
  level and an x-variable on the WITHIN level.  This variable will be treated
  as a y-variable on both levels:  PEERS
*** WARNING in MODEL command
  In the MODEL command, the following variable is a y-variable on the BETWEEN
  level and an x-variable on the WITHIN level.  This variable will be treated
  as a y-variable on both levels:  ADVANT
   2 WARNING(S) FOUND IN THE INPUT INSTRUCTIONS
```

Mplus repeats the title line at the top of new pages. I delete them after this one in the interest of saving space

```
MSEM analysis ;

SUMMARY OF ANALYSIS
```

Mplus will do single group or multiple group analyses. Below it tells us that it is doing a single group analysis with N = 1500.

```
Number of groups                                                 1
Number of observations                                        1000
```

Mplus indicates below the number of endogenous (dependent) variables in the model, the number of exogenous (independent) variables in the model, and the number of latent continuous variables.

```
Number of dependent variables                                    3
Number of independent variables                                  1
Number of continuous latent variables                            0
```

Mplus identifies the names of variables that are in different categories.

```
Observed dependent variables

  Continuous
  MVPA        PEERS       ADVANT

Observed independent variables
   TREAT

Observed independent variables
   CQ1         PA1         PK1         PE1         TREAT       BS1

Variables with special functions

  Cluster variable      SCHOOL

  Between variables
   TREAT
```

Mplus tells you the estimator it used and then provides some technical information.

```
Estimator                                                BAYES
Specifications for Bayesian Estimation
  Point estimate                                        MEDIAN
  Number of Markov chain Monte Carlo (MCMC) chains           2
  Random seed for the first chain                            0
  Starting value information                        UNPERTURBED
  Algorithm used for Markov chain Monte Carlo        GIBBS(PX1)
  Convergence criterion                               0.100D-01
  Maximum number of iterations                           100000
  K-th iteration used for thinning                           1
```

Mplus tells you the input data file it used and the format it was in.

```
Input data file(s)
  mvpa.dat ;

Input data format  FREE


SUMMARY OF DATA
```

Mplus tells you information about the clusters, including the number of clusters. To the right are the IDs of each cluster (1 through 50) and to the left are their sample sizes. In this case, each cluster has an equal sample size.

```
   Number of clusters                          50

       Size (s)    Cluster ID with Size s

         20        1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
                   22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39
                   40 41 42 43 44 45 46 47 48 49 501
```

Mplus provides more detailed descriptive statistics below. Each variable listed on the left has two rows of information. The labels at the top of the table described the contents of the first row of information (Mean, Skewness, Minimum, % with Minimum Score, 20th percentile, 40th percentile, Median) followed by a / and then the labels for the content of the second row of information for that variable (Sample Size, Variance, Kurtosis, Maximum, % with Maximum Score, 60th percentile, 80th percentile). I use a smaller font here to make everything fit in this table; Mplus uses its standard font.

UNIVARIATE SAMPLE STATISTICS

UNIVARIATE HIGHER-ORDER MOMENT DESCRIPTIVE STATISTICS

Variable/ Sample Size	Mean/ Variance	Skewness/ Kurtosis	Minimum/ Maximum	% with Min/Max	Percentiles 20%/60%	40%/80%	Median
MVPA	51.834	0.001	0.224	0.10%	36.659	47.591	51.869
1000.000	299.642	-0.002	114.044	0.10%	56.593	66.610	
PEERS	-0.001	-0.077	-4.479	0.10%	-1.327	-0.315	0.074
1000.000	2.370	-0.159	4.818	0.10%	0.417	1.333	
ADVANT	0.226	0.038	-4.259	0.10%	-1.022	-0.143	0.229
1000.000	2.183	0.110	5.000	0.20%	0.574	1.451	
TREAT	0.480	0.080	0.000	52.00%	0.000	0.000	0.000
50.000	0.250	-1.994	1.000	48.00%	1.000	1.000	

Mplus tells us that estimation terminated normally and suggests perhaps increasing the number of iterations and checking the PSR values. I already overrode the number of default iterations to increase them and I also will look at the PSR values below.

```
THE MODEL ESTIMATION TERMINATED NORMALLY

     USE THE FBITERATIONS OPTION TO INCREASE THE NUMBER OF ITERATIONS BY A FACTOR
     OF AT LEAST TWO TO CHECK CONVERGENCE AND THAT THE PSR VALUE DOES NOT
     INCREASE.
```

I place here an output section that appears at the end of the output regarding model convergence. I also edit to eliminate a large number of lies that show the results of every hundredth mediation out of 50,000 iterations. I want the PSR value at the final iteration to be less than 1.05.

TECHNICAL 8 OUTPUT FOR BAYES ESTIMATION

CHAIN	BSEED
1	0
2	285380

ITERATION	POTENTIAL SCALE REDUCTION	PARAMETER WITH HIGHEST PSR
100	1.009	9
200	1.046	10
300	1.015	8
400	1.006	8
500	1.005	4
600	1.008	4
700	1.004	4
800	1.004	4
900	1.001	2
1000	1.001	12
1100	1.003	5
1200	1.005	5
1300	1.005	10
1400	1.003	7
	.	
	.	
	.	
45000	1.000	5
45100	1.000	5
45200	1.000	5
45300	1.000	5
45400	1.000	5
45500	1.000	5
45600	1.000	5
45700	1.000	5
45800	1.000	5
45900	1.000	5
46000	1.000	5
46100	1.000	5
46200	1.000	5
46300	1.000	5
46400	1.000	5
46500	1.000	16
46600	1.000	5
46700	1.000	5
46800	1.000	5
46900	1.000	5
47000	1.000	5
47100	1.000	5
47200	1.000	5

47300	1.000	5
47400	1.000	5
47500	1.000	5
47600	1.000	5
47700	1.000	5
47800	1.000	5
47900	1.000	5
48000	1.000	5
48100	1.000	5
48200	1.000	5
48300	1.000	5
48400	1.000	5
48500	1.000	3
48600	1.000	3
48700	1.000	3
48800	1.000	3
48900	1.000	3
49000	1.000	3
49100	1.000	7
49200	1.000	3
49300	1.000	5
49400	1.000	5
49500	1.000	3
49600	1.000	3
49700	1.000	3
49800	1.000	3
49900	1.000	3
50000	1.000	3

The largest PSR value on the final iteration is 1.000. This is consistent with convergence. I also check the plots I discuss in the main text and they also suggest convergence. Now, back to the original order of the output.

MODEL FIT INFORMATION

Number of Free Parameters 25

The global model fit indices are reported and they are discussed in the text. The confidence interval for the chi square should contain zero and roughly be centered around zero. This was the case, The posterior predictive p value should be "non-significant," which is the case here. The DIC is used primarily for comparing models so I do not make use of it here.

Bayesian Posterior Predictive Checking using Chi-Square

95% Confidence Interval for the Difference Between
the Observed and the Replicated Chi-Square Values

-17.902 18.391

Posterior Predictive P-Value 0.489

Information Criteria

Deviance (DIC) 13220.446
Estimated Number of Parameters (pD) 149.171

MODEL RESULTS

Below are the unstandardized coefficients and parameter estimates for the model The Posterior S.D. column is analogous to a standard error. A result is "statistically significant" if its 95% credible interval does not contain zero. The one-tailed p value is described in the main text. One section provides information about the within-cluster effects and the other provides information about the between-cluster effects.

	Estimate	Posterior S.D.	One-Tailed P-Value	95% C.I. Lower 2.5%	95% C.I. Upper 2.5%	Significance
Within Level						
MVPA ON						
ADVANT	4.874	0.354	0.000	4.180	5.558	*
PEERS	4.634	0.341	0.000	3.962	5.299	*
PEERS WITH						
ADVANT	0.278	0.034	0.000	0.212	0.344	*
Variances						
PEERS	1.036	0.048	0.000	0.943	1.130	*
ADVANT	0.961	0.044	0.000	0.878	1.052	*
Residual Variances						
MVPA	104.576	4.818	0.000	95.392	114.171	*
Between Level						
MVPA ON						
ADVANT	4.601	1.191	0.000	2.291	6.973	*
PEERS	5.303	1.145	0.000	3.089	7.604	*
ADVANT ON						
TREAT	0.731	0.329	0.014	0.078	1.376	*

PEERS ON						
TREAT	0.775	0.343	0.013	0.097	1.449	*
ADVANT WITH						
PEERS	0.037	0.222	0.430	-0.401	0.485	
Intercepts						
MVPA	50.808	1.319	0.000	48.284	53.467	*
PEERS	-0.373	0.238	0.057	-0.848	0.090	
ADVANT	-0.127	0.228	0.286	-0.570	0.321	
Residual Variances						
MVPA	74.839	18.221	0.000	45.192	113.349	*
PEERS	1.378	0.331	0.000	0.861	2.109	*
ADVANT	1.266	0.304	0.000	0.784	1.918	*

This subsection of MODEL RESULTS provides the parameter estimates and credible intervals for the MODEL CONSTRAINT commands. Their interpretation are covered in the main text.

New/Additional Parameters						
MEDADV	3.204	1.784	0.014	0.190	7.079	*
MEDPEER	3.961	2.052	0.013	0.245	8.256	*
TOT	7.344	2.719	0.002	2.412	13.067	*
CON1	-0.272	1.243	0.412	-2.681	2.189	
CON2	0.674	1.196	0.286	-1.643	3.058	

Mplus then reports the standardized coefficients for the model, following the same format as above but with the addition of squared multiple correlations.

STANDARDIZED MODEL RESULTS

STDYX Standardization

	Estimate	Posterior S.D.	One-Tailed P-Value	95% C.I. Lower 2.5%	Upper 2.5%	Significance
Within Level						
MVPA ON						
ADVANT	0.375	0.026	0.000	0.325	0.425	*
PEERS	0.370	0.026	0.000	0.319	0.420	*
PEERS WITH						
ADVANT	0.279	0.030	0.000	0.221	0.338	*
Variances						
PEERS	1.000	0.000	0.000	1.000	1.000	
ADVANT	1.000	0.000	0.000	1.000	1.000	
Residual Variances						
MVPA	0.644	0.025	0.000	0.596	0.694	*

Between Level

MVPA ON						
ADVANT	0.434	0.107	0.000	0.219	0.636	*
PEERS	0.524	0.102	0.000	0.316	0.711	*
ADVANT ON						
TREAT	0.310	0.126	0.014	0.058	0.544	*
PEERS ON						
TREAT	0.314	0.125	0.013	0.052	0.537	*
ADVANT WITH						
PEERS	0.028	0.155	0.430	-0.271	0.332	
Intercepts						
MVPA	4.002	0.469	0.000	3.103	4.934	*
PEERS	-0.301	0.182	0.057	-0.644	0.062	
ADVANT	-0.107	0.185	0.286	-0.456	0.261	
Residual Variances						
MVPA	0.469	0.106	0.000	0.277	0.685	*
PEERS	0.901	0.075	0.000	0.752	1.000	*
ADVANT	0.904	0.074	0.000	0.754	1.000	*

R-SQUARE

Within Level

Variable	Estimate	Posterior S.D.	One-Tailed P-Value	95% C.I. Lower 2.5%	Upper 2.5%
MVPA	0.356	0.025	0.000	0.306	0.404

Between Level

Variable	Estimate	Posterior S.D.	One-Tailed P-Value	95% C.I. Lower 2.5%	Upper 2.5%
MVPA	0.531	0.106	0.000	0.315	0.723
PEERS	0.099	0.075	0.000	0.000	0.248
ADVANT	0.096	0.074	0.000	0.000	0.246

Mplus next reports the credible intervals for the unstandardized model results using the Mplus standard formatting for confidence intervals.

CREDIBILITY INTERVALS OF MODEL RESULTS

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%	Upper .5%
Within Level							
MVPA ON							
ADVANT	3.972	4.180	4.300	4.874	5.463	5.558	5.789
PEERS	3.767	3.962	4.082	4.634	5.205	5.299	5.513
PEERS WITH							
ADVANT	0.192	0.212	0.223	0.278	0.334	0.344	0.367

Variances							
PEERS	0.919	0.943	0.957	1.036	1.114	1.130	1.163
ADVANT	0.853	0.878	0.889	0.961	1.035	1.052	1.081
Residual Variances							
MVPA	92.671	95.392	96.757	104.576	112.475	114.171	117.757
Between Level							
MVPA ON							
ADVANT	1.492	2.291	2.617	4.601	6.515	6.973	7.740
PEERS	2.273	3.089	3.478	5.303	7.233	7.604	8.262
ADVANT ON							
TREAT	-0.106	0.078	0.189	0.731	1.264	1.376	1.624
PEERS ON							
TREAT	-0.133	0.097	0.209	0.775	1.334	1.449	1.674
ADVANT WITH							
PEERS	-0.577	-0.401	-0.318	0.037	0.401	0.485	0.681
Intercepts							
MVPA	47.442	48.284	48.725	50.808	53.054	53.467	54.312
PEERS	-0.992	-0.848	-0.766	-0.373	0.016	0.090	0.257
ADVANT	-0.735	-0.570	-0.504	-0.127	0.243	0.321	0.462
Residual Variances							
MVPA	39.597	45.192	49.063	74.839	105.235	113.349	133.566
PEERS	0.761	0.861	0.907	1.378	1.925	2.109	2.468
ADVANT	0.703	0.784	0.821	1.266	1.758	1.918	2.274
New/Additional Parameters							
MEDADV	-0.573	0.190	0.538	3.204	6.241	7.079	8.854
MEDPEER	-0.876	0.245	0.884	3.961	7.514	8.256	10.089
TOT	0.950	2.412	2.977	7.344	11.834	13.067	15.303
CON1	-3.521	-2.681	-2.311	-0.272	1.741	2.189	2.993
CON2	-2.393	-1.643	-1.316	0.674	2.601	3.058	3.865

These are followed by the credible intervals for the standardized results.

CREDIBILITY INTERVALS OF STANDARDIZED MODEL RESULTS

STDYX Standardization

	Lower .5%	Lower 2.5%	Lower 5%	Estimate	Upper 5%	Upper 2.5%	Upper .5%
Within Level							
MVPA ON							
ADVANT	0.309	0.325	0.333	0.375	0.417	0.425	0.441
PEERS	0.304	0.319	0.328	0.370	0.413	0.420	0.437
PEERS WITH							
ADVANT	0.199	0.221	0.230	0.279	0.329	0.338	0.354
Variances							
PEERS	1.000	1.000	1.000	1.000	1.000	1.000	1.000
ADVANT	1.000	1.000	1.000	1.000	1.000	1.000	1.000

Residual Variances							
MVPA	0.581	0.596	0.603	0.644	0.685	0.694	0.709
Between Level							
MVPA ON							
ADVANT	0.151	0.219	0.262	0.434	0.612	0.636	0.701
PEERS	0.246	0.316	0.360	0.524	0.690	0.711	0.764
ADVANT ON							
TREAT	-0.040	0.058	0.100	0.310	0.511	0.544	0.583
PEERS ON							
TREAT	-0.030	0.052	0.110	0.314	0.517	0.537	0.600
ADVANT WITH							
PEERS	-0.369	-0.271	-0.224	0.028	0.285	0.332	0.407
Intercepts							
MVPA	2.871	3.103	3.228	4.002	4.762	4.934	5.289
PEERS	-0.741	-0.644	-0.599	-0.301	-0.005	0.062	0.190
ADVANT	-0.543	-0.456	-0.402	-0.107	0.203	0.261	0.398
Residual Variances							
MVPA	0.236	0.277	0.303	0.469	0.647	0.685	0.759
PEERS	0.683	0.752	0.786	0.901	1.000	1.000	1.000
ADVANT	0.688	0.754	0.790	0.904	1.000	1.000	1.000

RESIDUAL OUTPUT

ESTIMATED

Below are the model's predicted parameter values at the within-cluster level and the between-cluster level.

WITHIN LEVEL

Means

MVPA	PEERS	ADVANT	TREAT
0.000	0.000	0.000	0.000

Covariances

	MVPA	PEERS	ADVANT	TREAT
MVPA	162.203			
PEERS	6.154	1.036		
ADVANT	5.972	0.278	0.961	
TREAT	0.000	0.000	0.000	0.000

Correlations

	MVPA	PEERS	ADVANT	TREAT
MVPA	1.000			
PEERS	0.475	1.000		
ADVANT	0.478	0.279	1.000	
TREAT	0.000	0.000	0.000	0.000

BETWEEN LEVEL

Means

MVPA	PEERS	ADVANT	TREAT
51.834	-0.001	0.224	0.480

Covariances

	MVPA	PEERS	ADVANT	TREAT
MVPA	156.141			
PEERS	8.925	1.528		
ADVANT	7.383	0.178	1.399	
TREAT	1.866	0.194	0.183	0.250

Correlations

	MVPA	PEERS	ADVANT	TREAT
MVPA	1.000			
PEERS	0.578	1.000		
ADVANT	0.500	0.122	1.000	
TREAT	0.299	0.313	0.309	1.000

Mplus then reports the TECH1 output and the starting values, which I do not reproduce here because of their marginal relevance for our purposes. Mplus then reports the prior distributions it used.

R

PRIORS FOR ALL PARAMETERS	PRIOR MEAN	PRIOR VARIANCE	PRIOR STD. DEV.
Parameter 1~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 2~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 3~IG(-1.000,0.000)	infinity	infinity	infinity
Parameter 4~IW(0.000,-3)	infinity	infinity	infinity
Parameter 5~IW(0.000,-3)	infinity	infinity	infinity
Parameter 6~IW(0.000,-3)	infinity	infinity	infinity

Parameter 7~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 8~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 9~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 10~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 11~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 12~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 13~N(0.000,infinity)	0.0000	infinity	infinity
Parameter 14~IG(-1.000,0.000)	infinity	infinity	infinity
Parameter 15~IW(0.000,-3)	infinity	infinity	infinity
Parameter 16~IW(0.000,-3)	infinity	infinity	infinity
Parameter 17~IW(0.000,-3)	infinity	infinity	infinity

TECHNICAL 4 OUTPUT

The Tech4 output provides the predicted means, covariances, and correlations for the model at both the within cluster level and the between cluster level.

ESTIMATES DERIVED FROM THE MODEL FOR WITHIN

ESTIMATED MEANS FOR THE LATENT VARIABLES

MVPA	PEERS	ADVANT	TREAT
0.000	0.000	0.000	0.000

ESTIMATED COVARIANCE MATRIX FOR THE LATENT VARIABLES

	MVPA	PEERS	ADVANT	TREAT
MVPA	162.203			
PEERS	6.154	1.036		
ADVANT	5.972	0.278	0.961	
TREAT	0.000	0.000	0.000	0.000

ESTIMATED CORRELATION MATRIX FOR THE LATENT VARIABLES

	MVPA	PEERS	ADVANT	TREAT
MVPA	1.000			
PEERS	0.475	1.000		
ADVANT	0.478	0.279	1.000	
TREAT	0.000	0.000	0.000	0.000

ESTIMATES DERIVED FROM THE MODEL FOR BETWEEN

ESTIMATED MEANS FOR THE LATENT VARIABLES

MVPA	PEERS	ADVANT	TREAT
51.834	-0.001	0.224	0.480

ESTIMATED COVARIANCE MATRIX FOR THE LATENT VARIABLES

	MVPA	PEERS	ADVANT	TREAT
MVPA	156.141			
PEERS	8.925	1.528		
ADVANT	7.383	0.178	1.399	
TREAT	1.866	0.194	0.183	0.250

ESTIMATED CORRELATION MATRIX FOR THE LATENT VARIABLES

	MVPA	PEERS	ADVANT	TREAT
MVPA	1.000			
PEERS	0.578	1.000		
ADVANT	0.500	0.122	1.000	
TREAT	0.299	0.313	0.309	1.000

The next section Mplus reports is the PSR values, which I already presented above so I skip that section here. This is the end of the output.