

**Example 7a: Multiple Group CFA Invariance Example (data from Brown Chapter 7) using MLR in Mplus 8.8:
Major Depression Criteria across Men and Women ($n = 345$ each)
(Complete data, syntax, and output files using Mplus and R lavaan are available electronically)**

9 items rated by clinicians on a scale of 0 to 8 (0 = none, 8 = very severely disturbing/disabling)

1. Depressed mood
2. Loss of interest in usual activities
3. Weight/appetite change
4. Sleep disturbance
5. Psychomotor agitation/retardation
6. Fatigue/loss of energy
7. Feelings of worthless/guilt
8. Concentration difficulties
9. Thoughts of death/suicidality

Note: Mplus v. 7 and up offers a simplified set of syntax commands to assess invariance. However, I will teach you the manual version so that you learn what you are doing first (then you can take their shortcuts on your own).

Likewise, R lavaan also has shortcuts that I am not using via the semTools package. However, because the modification indices I am using to diagnose non-invariant parameters do not match those of Mplus, I am showing only Mplus results here.

Mplus Code to Read in Data:

```

TITLE:      CFA Multiple Group Invariance
DATA:      FILE = Example7a.csv;           ! Don't need path if data in same folder
              FORMAT = FREE;                 ! Default
              TYPE = INDIVIDUAL;             ! Default

VARIABLE:  NAMES = PersonID sex item1-item9;   ! Every variable in DATA SET
              USEVARIABLES = item1-item9;         ! Every variable in MODEL only
              GROUPING = sex (0=Women 1=Men);     ! Identify grouping variable
              MISSING = ALL (99999);             ! Identify missing values
              IDVARIABLE = PersonID;             ! Identify person ID variable

ANALYSIS:  ESTIMATOR = MLR;                 ! For continuous items whose residuals may not be normal

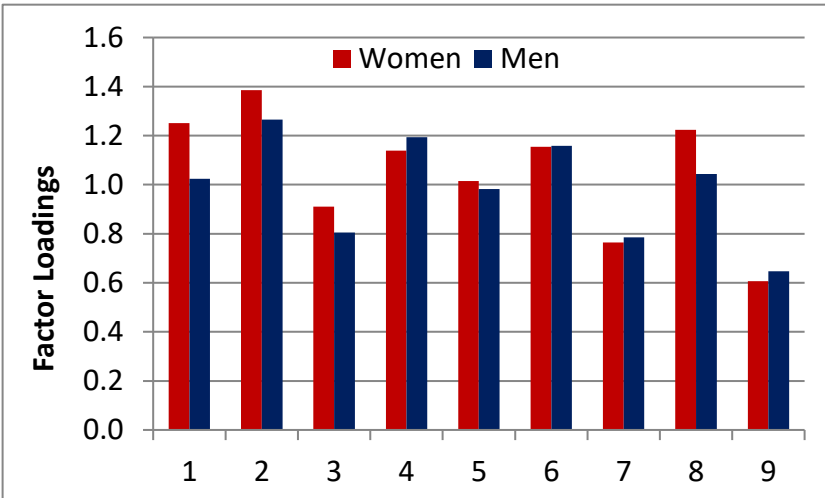
OUTPUT:    MODINDICES(3.84);                ! Used here to detect noninvariance (p<.05 for DF=1)
              STDYX;                            ! Requests fully standardized solution (not shown here)
              RESIDUAL;                          ! Requests normalized residuals for local fit (not shown here)

MODEL:     !(model syntax goes here, to be changed for each model)

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In each case, the model for the women reference group is the same—what changes is how the men (alt group) are allowed to differ. There are two ways to constrain parameters across groups. One is to leave it off the men alternative group, and the other is to use labeled constraints: () after the parameter. We will use the latter because it is more general. Note that if the groups have different items, you will need to use a general MODEL and then separate group-specific MODELS as well (see Mplus manual for examples).

Model 1. Configural Invariance Model (all parameters are estimated separately across groups except those for identification)

<pre> ! WOMEN REFERENCE GROUP: CONFIGURAL MODEL MODEL: ! Factor loadings all freely estimated, just labeled DEPRESS BY item1-item9* (L1-L9); ! Item intercepts all freely estimated, just labeled [item1-item9*] (I1-I9); ! Residual variances all freely estimated, just labeled item1-item9* (E1-E9); ! Residual covariance (free for 1&2), just labeled item1 WITH item2* (ECOV12); ! Factor variance fixed to 1 for identification DEPRESS@1; ! Factor mean fixed to 0 for identification (Mplus forces) [DEPRESS@0]; </pre>	<pre> ! MEN ALTERNATIVE GROUP: 1 CONFIGURAL MODEL MODEL Men: ! Factor loadings all freely estimated, not labeled DEPRESS BY item1-item9*; ! Item intercepts all freely estimated, not labeled [item1-item9*]; ! Residual variances all freely estimated, not labeled item1-item9*; ! Residual covariance (free for 1&2), not labeled item1 WITH item2*; ! Factor variance fixed to 1 for identification DEPRESS@1; ! Factor mean fixed to 0 for identification [DEPRESS@0]; </pre>																														
<pre> Number of Free Parameters 56 Loglikelihood H0 Value -13706.898 H0 Scaling Correction Factor 0.9808 for MLR H1 Value -13657.442 H1 Scaling Correction Factor 1.0143 for MLR Information Criteria Akaike (AIC) 27525.796 Bayesian (BIC) 27784.520 Sample-Size Adjusted BIC 27606.698 (n* = (n + 2) / 24) Chi-Square Test of Model Fit Value 94.175* Degrees of Freedom 52 P-Value 0.0003 Scaling Correction Factor 1.0503 for MLR Chi-Square Contributions From Each Group W 50.418 M 43.756 </pre>	<pre> RMSEA (Root Mean Square Error Of Approximation) Estimate 0.047 90 Percent C.I. 0.031 0.061 Probability RMSEA <= .05 0.632 CFI/TLI CFI 0.963 TLI 0.949 </pre>  <table border="1"> <caption>Factor Loadings by Item and Group</caption> <thead> <tr> <th>Item</th> <th>Women</th> <th>Men</th> </tr> </thead> <tbody> <tr><td>1</td><td>1.25</td><td>1.02</td></tr> <tr><td>2</td><td>1.38</td><td>1.28</td></tr> <tr><td>3</td><td>0.92</td><td>0.81</td></tr> <tr><td>4</td><td>1.15</td><td>1.20</td></tr> <tr><td>5</td><td>1.01</td><td>0.98</td></tr> <tr><td>6</td><td>1.16</td><td>1.16</td></tr> <tr><td>7</td><td>0.78</td><td>0.80</td></tr> <tr><td>8</td><td>1.22</td><td>1.05</td></tr> <tr><td>9</td><td>0.61</td><td>0.65</td></tr> </tbody> </table>	Item	Women	Men	1	1.25	1.02	2	1.38	1.28	3	0.92	0.81	4	1.15	1.20	5	1.01	0.98	6	1.16	1.16	7	0.78	0.80	8	1.22	1.05	9	0.61	0.65
Item	Women	Men																													
1	1.25	1.02																													
2	1.38	1.28																													
3	0.92	0.81																													
4	1.15	1.20																													
5	1.01	0.98																													
6	1.16	1.16																													
7	0.78	0.80																													
8	1.22	1.05																													
9	0.61	0.65																													

UNSTANDARDIZED MODEL RESULTS – NOTE ALL PARAMETERS DIFFER ACROSS GROUPS (EXCEPT FACTOR MEANS AND VARIANCES)

Group Women					Group Men				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY (FACTOR LOADINGS)					DEPRESS BY				
ITEM1	1.251	0.095	13.156	0.000	ITEM1	1.024	0.099	10.384	0.000
ITEM2	1.385	0.103	13.427	0.000	ITEM2	1.266	0.112	11.283	0.000
ITEM3	0.911	0.104	8.775	0.000	ITEM3	0.805	0.115	7.011	0.000
ITEM4	1.139	0.115	9.873	0.000	ITEM4	1.193	0.123	9.729	0.000
ITEM5	1.015	0.106	9.613	0.000	ITEM5	0.982	0.113	8.678	0.000
ITEM6	1.155	0.103	11.238	0.000	ITEM6	1.159	0.116	10.010	0.000
ITEM7	0.764	0.115	6.621	0.000	ITEM7	0.785	0.131	5.995	0.000
ITEM8	1.224	0.113	10.817	0.000	ITEM8	1.043	0.121	8.610	0.000
ITEM9	0.606	0.094	6.413	0.000	ITEM9	0.647	0.102	6.359	0.000
ITEM1 WITH (RESIDUAL COVARIANCE)					ITEM1 WITH				
ITEM2	0.393	0.166	2.362	0.018	ITEM2	0.920	0.205	4.499	0.000
Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)					Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	0.000	0.000	999.000	999.000
Intercepts (ITEM MEANS PER GROUP IN THIS SCALING)					Intercepts				
ITEM1	4.184	0.089	47.258	0.000	ITEM1	4.171	0.082	50.608	0.000
ITEM2	3.725	0.104	35.848	0.000	ITEM2	3.685	0.104	35.414	0.000
ITEM3	1.952	0.108	18.058	0.000	ITEM3	1.739	0.108	16.098	0.000
ITEM4	3.589	0.114	31.458	0.000	ITEM4	3.357	0.115	29.160	0.000
ITEM5	2.256	0.110	20.522	0.000	ITEM5	2.235	0.109	20.560	0.000
ITEM6	3.955	0.103	38.237	0.000	ITEM6	3.661	0.109	33.598	0.000
ITEM7	3.869	0.106	36.382	0.000	ITEM7	3.421	0.118	29.014	0.000
ITEM8	3.595	0.111	32.331	0.000	ITEM8	3.517	0.112	31.372	0.000
ITEM9	1.205	0.092	13.053	0.000	ITEM9	1.259	0.092	13.649	0.000
Variances (FACTOR VARIANCE FIXED=1 FOR IDENTIFICATION)					Variances (FACTOR VARIANCE FIXED=1 FOR IDENTIFICATION)				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	1.000	0.000	999.000	999.000
Residual Variances (ITEM ERROR VARIANCES)					Residual Variances				
ITEM1	1.375	0.194	7.089	0.000	ITEM1	1.499	0.216	6.932	0.000
ITEM2	2.132	0.236	9.048	0.000	ITEM2	2.459	0.274	8.989	0.000
ITEM3	3.551	0.201	17.679	0.000	ITEM3	3.727	0.205	18.167	0.000
ITEM4	3.584	0.272	13.166	0.000	ITEM4	3.547	0.291	12.189	0.000
ITEM5	3.501	0.223	15.734	0.000	ITEM5	3.467	0.236	14.717	0.000
ITEM6	2.677	0.269	9.967	0.000	ITEM6	3.111	0.296	10.521	0.000
ITEM7	3.658	0.276	13.271	0.000	ITEM7	4.599	0.279	16.457	0.000
ITEM8	3.137	0.291	10.785	0.000	ITEM8	3.626	0.296	12.267	0.000
ITEM9	2.831	0.195	14.539	0.000	ITEM9	2.770	0.208	13.291	0.000

Model 2. Metric Invariance Model (now factor loadings are held equal across groups, so factor variance estimated in alternative group)

<pre> ! WOMEN REFERENCE GROUP: CONFIGURAL MODEL MODEL: ! Factor loadings all freely estimated, just labeled DEPRESS BY item1-item9* (L1-L9); ! Item intercepts all freely estimated, just labeled [item1-item9*] (I1-I9); ! Residual variances all freely estimated, just labeled item1-item9* (E1-E9); ! Residual covariance (free for 1&2), just labeled item1 WITH item2* (ECOV12); ! Factor variance fixed to 1 for identification DEPRESS@1; ! Factor mean fixed to 0 for identification [DEPRESS@0]; </pre>	<pre> ! MEN ALTERNATIVE GROUP: 2 METRIC MODEL MODEL Men: ! Factor loadings NOW labeled to be constrained to women's DEPRESS BY item1-item9* (L1-L9); ! Item intercepts all freely estimated, not labeled [item1-item9*]; ! Residual variances all freely estimated, not labeled item1-item9*; ! Residual covariance (free for 1&2), not labeled item1 WITH item2*; ! Factor variance CAN NOW BE FREELY ESTIMATED DEPRESS*; ! Factor mean fixed to 0 for identification [DEPRESS@0]; </pre>																														
<pre> Number of Free Parameters 48 Loglikelihood H0 Value -13708.862 H0 Scaling Correction Factor 0.9906 for MLR H1 Value -13657.442 H1 Scaling Correction Factor 1.0143 for MLR Information Criteria Akaike (AIC) 27513.724 Bayesian (BIC) 27735.488 Sample-Size Adjusted BIC 27583.069 (n* = (n + 2) / 24) Did model fit get significantly worse than configural? Nope. -2ΔLL(df=8) = 4.26, p = .83 Chi-Square Test of Model Fit Value 99.532* Degrees of Freedom 60 P-Value 0.0010 Scaling Correction Factor 1.0332 for MLR Chi-Square Contributions From Each Group W 52.985 M 46.547 </pre>	<pre> RMSEA (Root Mean Square Error Of Approximation) Estimate 0.042 90 Percent C.I. 0.027 0.056 Probability RMSEA <= .05 0.814 CFI/TLI CFI 0.966 TLI 0.959 </pre> <table border="1"> <caption>Item Intercepts Data</caption> <thead> <tr> <th>Item</th> <th>Women</th> <th>Men</th> </tr> </thead> <tbody> <tr><td>1</td><td>4.2</td><td>4.1</td></tr> <tr><td>2</td><td>3.7</td><td>3.6</td></tr> <tr><td>3</td><td>1.9</td><td>1.7</td></tr> <tr><td>4</td><td>3.5</td><td>3.3</td></tr> <tr><td>5</td><td>2.2</td><td>2.1</td></tr> <tr><td>6</td><td>3.9</td><td>3.6</td></tr> <tr><td>7</td><td>3.8</td><td>3.4</td></tr> <tr><td>8</td><td>3.5</td><td>3.4</td></tr> <tr><td>9</td><td>1.2</td><td>1.2</td></tr> </tbody> </table>	Item	Women	Men	1	4.2	4.1	2	3.7	3.6	3	1.9	1.7	4	3.5	3.3	5	2.2	2.1	6	3.9	3.6	7	3.8	3.4	8	3.5	3.4	9	1.2	1.2
Item	Women	Men																													
1	4.2	4.1																													
2	3.7	3.6																													
3	1.9	1.7																													
4	3.5	3.3																													
5	2.2	2.1																													
6	3.9	3.6																													
7	3.8	3.4																													
8	3.5	3.4																													
9	1.2	1.2																													

UNSTANDARDIZED MODEL RESULTS – NOTE NOW FACTOR LOADINGS ARE HELD EQUAL (but standardized loadings won't be yet)

Group Women					Group Men				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY					DEPRESS BY				
ITEM1	1.180	0.082	14.455	0.000	ITEM1	1.180	0.082	14.455	0.000
ITEM2	1.386	0.088	15.667	0.000	ITEM2	1.386	0.088	15.667	0.000
ITEM3	0.888	0.084	10.542	0.000	ITEM3	0.888	0.084	10.542	0.000
ITEM4	1.202	0.091	13.153	0.000	ITEM4	1.202	0.091	13.153	0.000
ITEM5	1.035	0.084	12.301	0.000	ITEM5	1.035	0.084	12.301	0.000
ITEM6	1.191	0.084	14.198	0.000	ITEM6	1.191	0.084	14.198	0.000
ITEM7	0.792	0.092	8.642	0.000	ITEM7	0.792	0.092	8.642	0.000
ITEM8	1.186	0.094	12.595	0.000	ITEM8	1.186	0.094	12.595	0.000
ITEM9	0.647	0.073	8.813	0.000	ITEM9	0.647	0.073	8.813	0.000
ITEM1 WITH					ITEM1 WITH				
ITEM2	0.439	0.158	2.777	0.005	ITEM2	0.862	0.187	4.610	0.000
Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)					Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	0.000	0.000	999.000	999.000
Intercepts					Intercepts				
ITEM1	4.184	0.089	47.258	0.000	ITEM1	4.171	0.082	50.608	0.000
ITEM2	3.725	0.104	35.848	0.000	ITEM2	3.685	0.104	35.414	0.000
ITEM3	1.952	0.108	18.058	0.000	ITEM3	1.739	0.108	16.098	0.000
ITEM4	3.589	0.114	31.458	0.000	ITEM4	3.357	0.115	29.160	0.000
ITEM5	2.256	0.110	20.522	0.000	ITEM5	2.235	0.109	20.560	0.000
ITEM6	3.955	0.103	38.237	0.000	ITEM6	3.661	0.109	33.598	0.000
ITEM7	3.869	0.106	36.382	0.000	ITEM7	3.421	0.118	29.014	0.000
ITEM8	3.595	0.111	32.331	0.000	ITEM8	3.517	0.112	31.372	0.000
ITEM9	1.205	0.092	13.053	0.000	ITEM9	1.259	0.092	13.649	0.000
Variances (FACTOR VARIANCE FIXED=1 FOR IDENTIFICATION)					Variances (FACTOR VARIANCE CAN NOW BE ESTIMATED)				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	0.863	0.112	7.728	0.000
Residual Variances					Residual Variances				
ITEM1	1.444	0.189	7.646	0.000	ITEM1	1.436	0.203	7.060	0.000
ITEM2	2.151	0.220	9.794	0.000	ITEM2	2.412	0.245	9.854	0.000
ITEM3	3.556	0.190	18.738	0.000	ITEM3	3.731	0.196	19.064	0.000
ITEM4	3.540	0.261	13.543	0.000	ITEM4	3.617	0.258	14.027	0.000
ITEM5	3.479	0.206	16.850	0.000	ITEM5	3.488	0.216	16.176	0.000
ITEM6	2.648	0.261	10.140	0.000	ITEM6	3.161	0.270	11.688	0.000
ITEM7	3.656	0.271	13.482	0.000	ITEM7	4.619	0.260	17.798	0.000
ITEM8	3.153	0.275	11.465	0.000	ITEM8	3.587	0.276	12.998	0.000
ITEM9	2.827	0.195	14.492	0.000	ITEM9	2.781	0.208	13.395	0.000

Modification indices do not suggest that freeing any loadings between groups would help, so we proceed with loadings fully invariant.

Model 3A (i.e., foreshadowing with the letter A). Scalar Invariance Model (all loadings and intercepts held equal across groups)

<pre> ! WOMEN REFERENCE GROUP: CONFIGURAL MODEL MODEL: ! Factor loadings all freely estimated, just labeled DEPRESS BY item1-item9* (L1-L9); ! Item intercepts all freely estimated, just labeled [item1-item9*] (I1-I9); ! Residual variances all freely estimated, just labeled item1-item9* (E1-E9); ! Residual covariance (free for 1&2), just labeled item1 WITH item2* (ECOV12); ! Factor variance fixed to 1 for identification DEPRESS@1; ! Factor mean fixed to 0 for identification [DEPRESS@0]; </pre>	<pre> ! MEN ALTERNATIVE GROUP: 3A SCALAR MODEL MODEL Men: ! Factor loadings still labeled (constrained to women's) DEPRESS BY item1-item9* (L1-L9); ! Item intercepts NOW labeled to be constrained to women's [item1-item9*] (I1-I9); ! Residual variances all freely estimated, not labeled item1-item9*; ! Residual covariance (free for 1&2), not labeled item1 WITH item2*; ! Factor variance CAN STILL BE FREELY ESTIMATED DEPRESS*; ! Factor mean CAN NOW BE FREELY ESTIMATED [DEPRESS*]; </pre>
<pre> Number of Free Parameters 40 Loglikelihood H0 Value -13715.097 H0 Scaling Correction Factor 0.9875 for MLR H1 Value -13657.442 H1 Scaling Correction Factor 1.0143 for MLR Information Criteria Akaike (AIC) 27510.194 Bayesian (BIC) 27694.997 Sample-Size Adjusted BIC 27567.981 (n* = (n + 2) / 24) Did model fit get significantly worse than metric? Nope. -2ΔLL(df=8) = 12.39, p = .13 However... Chi-Square Test of Model Fit Value 111.950* Degrees of Freedom 68 P-Value 0.0006 Scaling Correction Factor 1.0300 for MLR Chi-Square Contributions From Each Group W 58.945 M 53.006 </pre>	<pre> RMSEA (Root Mean Square Error Of Approximation) Estimate 0.042 90 Percent C.I. 0.027 0.055 Probability RMSEA <= .05 0.842 CFI/TLI CFI 0.962 TLI 0.959 Although the overall test of scalar invariance holds, modification indices suggest that freeing the intercept for item 7 between groups would help significantly MODEL MODIFICATION INDICES Minimum M.I. value for printing the modification index 3.840 M.I. E.P.C. Std E.P.C. StdYX E.P.C. Group Women Means/Intercepts/Thresholds [ITEM7] 5.896 0.158 0.158 0.076 Group Men Means/Intercepts/Thresholds [ITEM7] 5.894 -0.219 -0.219 -0.096 So old Intercept 7: 3.711 New Women Intercept 7: 3.869 (≈3.711 + 0.158) New Men Intercept 7: 3.492 (≈3.711 + -0.219) </pre>

UNSTANDARDIZED MODEL RESULTS – NOTE NOW FACTOR LOADINGS AND INTERCEPTS ARE HELD EQUAL

Group Women					Group Men				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY					DEPRESS BY				
ITEM1	1.171	0.081	14.385	0.000	ITEM1	1.171	0.081	14.385	0.000
ITEM2	1.377	0.089	15.534	0.000	ITEM2	1.377	0.089	15.534	0.000
ITEM3	0.894	0.084	10.622	0.000	ITEM3	0.894	0.084	10.622	0.000
ITEM4	1.209	0.091	13.344	0.000	ITEM4	1.209	0.091	13.344	0.000
ITEM5	1.033	0.084	12.276	0.000	ITEM5	1.033	0.084	12.276	0.000
ITEM6	1.199	0.083	14.424	0.000	ITEM6	1.199	0.083	14.424	0.000
ITEM7	0.803	0.091	8.853	0.000	ITEM7	0.803	0.091	8.853	0.000
ITEM8	1.184	0.094	12.534	0.000	ITEM8	1.184	0.094	12.534	0.000
ITEM9	0.640	0.074	8.604	0.000	ITEM9	0.640	0.074	8.604	0.000
ITEM1 WITH					ITEM1 WITH				
ITEM2	0.454	0.159	2.852	0.004	ITEM2	0.879	0.185	4.754	0.000
Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)					Means (NOW ESTIMATED TO REPRESENT DIFFERENCE IN FACTOR MEANS)				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	-0.112	0.083	-1.345	0.179
Intercepts					Intercepts				
ITEM1	4.240	0.077	54.986	0.000	ITEM1	4.240	0.077	54.986	0.000
ITEM2	3.773	0.092	41.112	0.000	ITEM2	3.773	0.092	41.112	0.000
ITEM3	1.897	0.087	21.735	0.000	ITEM3	1.897	0.087	21.735	0.000
ITEM4	3.541	0.096	37.066	0.000	ITEM4	3.541	0.096	37.066	0.000
ITEM5	2.303	0.090	25.622	0.000	ITEM5	2.303	0.090	25.622	0.000
ITEM6	3.882	0.091	42.556	0.000	ITEM6	3.882	0.091	42.556	0.000
ITEM7	3.711	0.087	42.428	0.000	ITEM7	3.711	0.087	42.428	0.000
ITEM8	3.620	0.094	38.567	0.000	ITEM8	3.620	0.094	38.567	0.000
ITEM9	1.268	0.072	17.592	0.000	ITEM9	1.268	0.072	17.592	0.000
Variances (FACTOR VARIANCE FIXED=1 FOR IDENTIFICATION)					Variances (FACTOR VARIANCE CAN STILL BE ESTIMATED)				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	0.864	0.112	7.720	0.000
Residual Variances					Residual Variances				
ITEM1	1.460	0.193	7.576	0.000	ITEM1	1.451	0.200	7.258	0.000
ITEM2	2.166	0.223	9.726	0.000	ITEM2	2.431	0.240	10.124	0.000
ITEM3	3.555	0.191	18.619	0.000	ITEM3	3.730	0.196	19.058	0.000
ITEM4	3.535	0.261	13.520	0.000	ITEM4	3.611	0.258	13.975	0.000
ITEM5	3.478	0.206	16.880	0.000	ITEM5	3.489	0.216	16.165	0.000
ITEM6	2.648	0.260	10.183	0.000	ITEM6	3.161	0.276	11.468	0.000
ITEM7	3.683	0.268	13.767	0.000	ITEM7	4.657	0.277	16.832	0.000
ITEM8	3.155	0.277	11.376	0.000	ITEM8	3.588	0.274	13.119	0.000
ITEM9	2.834	0.192	14.790	0.000	ITEM9	2.788	0.213	13.105	0.000

Model 3B. Partial Scalar Invariance Model (all loadings and intercepts held equal across groups EXCEPT INTERCEPT FOR ITEM 7)

<p>! WOMEN REFERENCE GROUP: CONFIGURAL MODEL MODEL: ! Factor loadings all freely estimated, just labeled DEPRESS BY item1-item9* (L1-L9); ! Item intercepts all freely estimated, just labeled [item1-item9*] (I1-I9); ! Residual variances all freely estimated, just labeled item1-item9* (E1-E9); ! Residual covariance (free for 1&2), just labeled item1 WITH item2* (ECOV12); ! Factor variance fixed to 1 for identification DEPRESS@1; ! Factor mean fixed to 0 for identification [DEPRESS@0];</p>	<p>! MEN ALTERNATIVE GROUP: 3B SCALAR MODEL MODEL Men: ! Factor loadings still labeled (constrained to women's) DEPRESS BY item1-item9* (L1-L9); ! Item intercepts NOW constrained to women's, but not 7 [item1-item9*] (I1-I6 I7m I8-I9); ! Residual variances all freely estimated, not labeled item1-item9*; ! Residual covariance (free for 1&2), not labeled item1 WITH item2*; ! Factor variance CAN STILL BE FREELY ESTIMATED DEPRESS*; ! Factor mean CAN STILL BE FREELY ESTIMATED [DEPRESS*];</p>																																																							
<p>Number of Free Parameters 41</p> <p>Loglikelihood</p> <p>H0 Value -13712.050</p> <p>H0 Scaling Correction Factor 0.9885 for MLR</p> <p>H1 Value -13657.442</p> <p>H1 Scaling Correction Factor 1.0143 for MLR</p> <p>Information Criteria</p> <p>Akaike (AIC) 27506.100</p> <p>Bayesian (BIC) 27695.523</p> <p>Sample-Size Adjusted BIC 27565.332 (n* = (n + 2) / 24)</p> <p>Did B model fit get significantly better than A full scalar? Yep. -2ΔLL(df=1) = 5.93, p = .01</p> <p>Did B model fit get significantly worse than metric? Nope. -2ΔLL(df=7) = 6.36, p = .50</p> <p>Chi-Square Test of Model Fit</p> <p>Value 106.031*</p> <p>Degrees of Freedom 67</p> <p>P-Value 0.0017</p> <p>Scaling Correction Factor 1.0300 for MLR</p>	<p>Chi-Square Contributions From Each Group</p> <p>W 56.211</p> <p>M 49.820</p> <p>RMSEA (Root Mean Square Error Of Approximation)</p> <p>Estimate 0.039</p> <p>90 Percent C.I. 0.024 0.053</p> <p>Probability RMSEA <= .05 0.892</p> <p>CFI/TLI</p> <p>CFI 0.966</p> <p>TLI 0.963</p> <p>Relevant new output:</p> <table border="1"> <thead> <tr> <th></th> <th>Estimate</th> <th>S.E.</th> <th>Est./S.E.</th> <th>Two-Tailed P-Value</th> </tr> </thead> <tbody> <tr> <td colspan="5">Group Women</td> </tr> <tr> <td colspan="5">Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)</td> </tr> <tr> <td>DEPRESS</td> <td>0.000</td> <td>0.000</td> <td>999.000</td> <td>999.000</td> </tr> <tr> <td colspan="5">Intercepts</td> </tr> <tr> <td>M7</td> <td>3.869</td> <td>0.106</td> <td>36.382</td> <td>0.000</td> </tr> <tr> <td colspan="5">Group Men</td> </tr> <tr> <td colspan="5">Means (STILL FREE, BUT WITH SMALLER DIFFERENCE IN FACTOR MEANS)</td> </tr> <tr> <td>DEPRESS</td> <td>-0.090</td> <td>0.083</td> <td>-1.087</td> <td>0.277</td> </tr> <tr> <td colspan="5">Intercepts</td> </tr> <tr> <td>M7</td> <td>3.493</td> <td>0.123</td> <td>28.376</td> <td>0.000</td> </tr> </tbody> </table>		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	Group Women					Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)					DEPRESS	0.000	0.000	999.000	999.000	Intercepts					M7	3.869	0.106	36.382	0.000	Group Men					Means (STILL FREE, BUT WITH SMALLER DIFFERENCE IN FACTOR MEANS)					DEPRESS	-0.090	0.083	-1.087	0.277	Intercepts					M7	3.493	0.123	28.376	0.000
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UNSTANDARDIZED MODEL RESULTS - NOTE NOW FACTOR LOADINGS, INTERCEPTS (except 7), AND RESIDUAL VARIANCES (except 7) ARE HELD EQUAL

Group WOMEN					Group MEN				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY					DEPRESS BY				
ITEM1	1.167	0.082	14.180	0.000	ITEM1	1.167	0.082	14.180	0.000
ITEM2	1.372	0.089	15.357	0.000	ITEM2	1.372	0.089	15.357	0.000
ITEM3	0.888	0.083	10.656	0.000	ITEM3	0.888	0.083	10.656	0.000
ITEM4	1.203	0.090	13.342	0.000	ITEM4	1.203	0.090	13.342	0.000
ITEM5	1.031	0.084	12.316	0.000	ITEM5	1.031	0.084	12.316	0.000
ITEM6	1.197	0.083	14.494	0.000	ITEM6	1.197	0.083	14.494	0.000
ITEM7	0.787	0.092	8.594	0.000	ITEM7	0.787	0.092	8.594	0.000
ITEM8	1.178	0.093	12.608	0.000	ITEM8	1.178	0.093	12.608	0.000
ITEM9	0.639	0.074	8.601	0.000	ITEM9	0.639	0.074	8.601	0.000
ITEM1 WITH (EQUAL TO RESIDUAL CORRELATION=.266)					ITEM1 WITH (EQUAL TO RESIDUAL CORRELATION=.456)				
ITEM2	0.485	0.160	3.034	0.002	ITEM2	0.833	0.151	5.500	0.000
Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)					Means (FREELY ESTIMATED TO BE FACTOR MEAN DIFFERENCE)				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	-0.091	0.084	-1.083	0.279
Intercepts					Intercepts				
ITEM1	4.228	0.078	53.945	0.000	ITEM1	4.228	0.078	53.945	0.000
ITEM2	3.763	0.093	40.534	0.000	ITEM2	3.763	0.093	40.534	0.000
ITEM3	1.886	0.087	21.609	0.000	ITEM3	1.886	0.087	21.609	0.000
ITEM4	3.528	0.096	36.879	0.000	ITEM4	3.528	0.096	36.879	0.000
ITEM5	2.292	0.090	25.454	0.000	ITEM5	2.292	0.090	25.454	0.000
ITEM6	3.862	0.091	42.537	0.000	ITEM6	3.862	0.091	42.537	0.000
ITEM7	3.869	0.106	36.382	0.000	ITEM7	3.493	0.123	28.380	0.000
ITEM8	3.609	0.094	38.325	0.000	ITEM8	3.609	0.094	38.325	0.000
ITEM9	1.261	0.071	17.668	0.000	ITEM9	1.261	0.071	17.668	0.000
Variances (FACTOR VARIANCE FIXED=1 FOR IDENTIFICATION)					Variances (FREELY ESTIMATED)				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	0.882	0.111	7.937	0.000
Residual Variances					Residual Variances				
ITEM1	1.448	0.145	9.955	0.000	ITEM1	1.448	0.145	9.955	0.000
ITEM2	2.301	0.177	12.966	0.000	ITEM2	2.301	0.177	12.966	0.000
ITEM3	3.646	0.143	25.449	0.000	ITEM3	3.646	0.143	25.449	0.000
ITEM4	3.574	0.197	18.123	0.000	ITEM4	3.574	0.197	18.123	0.000
ITEM5	3.479	0.161	21.647	0.000	ITEM5	3.479	0.161	21.647	0.000
ITEM6	2.903	0.199	14.558	0.000	ITEM6	2.903	0.199	14.558	0.000
ITEM7	3.653	0.271	13.463	0.000	ITEM7	4.629	0.260	17.814	0.000
ITEM8	3.367	0.207	16.292	0.000	ITEM8	3.367	0.207	16.292	0.000
ITEM9	2.809	0.143	19.650	0.000	ITEM9	2.809	0.143	19.650	0.000

Modification indices do not suggest that freeing any other residual variances between groups would help, so we proceed with them fully invariant.

Model 5. Residual Covariance Invariance Model (error covariance for items 1–2 now held equal)

<pre>! WOMEN REFERENCE GROUP: CONFIGURAL MODEL MODEL: ! Factor loadings all freely estimated, just labeled DEPRESS BY item1-item9* (L1-L9); ! Item intercepts all freely estimated, just labeled [item1-item9*] (I1-I9); ! Residual variances all freely estimated, just labeled item1-item9* (E1-E9); ! Residual covariance (free for 1&2), just labeled item1 WITH item2* (ECOV12); ! Factor variance fixed to 1 for identification DEPRESS@1; ! Factor mean fixed to 0 for identification [DEPRESS@0];</pre>	<pre>! MEN ALTERNATIVE GROUP: 5 RESIDUAL COVARIANCE MODEL MODEL Men: ! Factor loadings still labeled (constrained to women's) DEPRESS BY item1-item9* (L1-L9); ! Item intercepts still constrained to women's, but not 7 [item1-item9*] (I1-I6 I7m I8-I9); ! Residual variances still constrained to women's, not 7 item1-item9* (E1-E6 E7m E8-E9); ! Residual covariance (free for 1&2) NOW equal to women's item1 WITH item2 (ECOV12)*; ! Factor variance CAN STILL BE FREELY ESTIMATED DEPRESS*; ! Factor mean CAN STILL BE FREELY ESTIMATED [DEPRESS*];</pre>
<pre>Number of Free Parameters 32 Loglikelihood H0 Value -13719.118 H0 Scaling Correction Factor 0.9672 for MLR H1 Value -13657.442 H1 Scaling Correction Factor 1.0143 for MLR Information Criteria Akaike (AIC) 27502.235 Bayesian (BIC) 27650.078 Sample-Size Adjusted BIC 27548.465 (n* = (n + 2) / 24)</pre> <p>Did model fit get significantly worse than residual variance? $-2\Delta LL(df=1) = 4.18, p = .04$ Yes, so we leave the residual covariance between items 1 and 2 separate by group.</p>	<pre>Chi-Square Test of Model Fit Value 119.281* Degrees of Freedom 76 P-Value 0.0011 Scaling Correction Factor 1.0341 for MLR Chi-Square Contributions From Each Group W 62.953 M 56.328 RMSEA (Root Mean Square Error Of Approximation) Estimate 0.039 90 Percent C.I. 0.025 0.052 Probability RMSEA <= .05 0.916 CFI/TLI CFI 0.962 TLI 0.964</pre>

		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	
M1	WITH					
	M2	0.671	0.132	5.075	0.000	→ constrained residual covariance estimate (correlation=.366)

STRUCTURAL INVARIANCE TESTS
Model 6. Factor Variance Invariance Model

<pre> ! WOMEN REFERENCE GROUP: CONFIGURAL MODEL MODEL: ! Factor loadings all freely estimated, just labeled DEPRESS BY item1-item9* (L1-L9); ! Item intercepts all freely estimated, just labeled [item1-item9*] (I1-I9); ! Residual variances all freely estimated, just labeled item1-item9* (E1-E9); ! Residual covariance (free for 1&2), just labeled item1 WITH item2* (ECOV12); ! Factor variance fixed to 1 for identification DEPRESS@1; ! Factor mean fixed to 0 for identification [DEPRESS@0]; </pre>	<pre> ! MEN ALTERNATIVE GROUP: 6 FACTOR VARIANCE MODEL MODEL Men: ! Factor loadings still labeled (constrained to women's) DEPRESS BY item1-item9* (L1-L9); ! Item intercepts still constrained to women's, but not 7 [item1-item9*] (I1-I6 I7m I8-I9); ! Residual variances still constrained to women's, not 7 item1-item9* (E1-E6 E7m E8-E9); ! Residual covariance (free for 1&2) NOT equal to women's item1 WITH item2*; ! Factor variance NOW CONSTRAINED EQUAL TO WOMEN'S DEPRESS@1; ! Factor mean CAN STILL BE FREELY ESTIMATED [DEPRESS*]; </pre>
<pre> Number of Free Parameters 32 Loglikelihood H0 Value -13714.894 H0 Scaling Correction Factor 1.0106 for MLR H1 Value -13657.442 H1 Scaling Correction Factor 1.0143 for MLR Information Criteria Akaike (AIC) 27493.789 Bayesian (BIC) 27641.631 Sample-Size Adjusted BIC 27540.019 (n* = (n + 2) / 24) Did model fit get significantly worse? Nope. -2ΔLL(df=1) = 1.01, p = .32 Chi-Square Test of Model Fit Value 113.113* Degrees of Freedom 76 P-Value 0.0037 Scaling Correction Factor 1.0158 for MLR </pre>	<pre> Chi-Square Contributions From Each Group W 60.260 M 52.853 RMSEA (Root Mean Square Error Of Approximation) Estimate 0.036 90 Percent C.I. 0.021 0.049 Probability RMSEA <= .05 0.957 CFI/TLI CFI 0.968 TLI 0.969 Foreshadowing... Estimate S.E. Est./S.E. Two-Tailed Group WOMEN Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION) DEPRESS 0.000 0.000 999.000 999.000 Group MEN Means (FREELY ESTIMATED TO BE FACTOR MEAN DIFFERENCE) DEPRESS -0.094 0.085 -1.097 0.272 </pre>

Unstandardized Results from Model 6 (Factor Variance Invariance): WILL BE OUR FINAL MODEL

Group WOMEN					Group MEN				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
DEPRESS BY					DEPRESS BY				
ITEM1	1.131	0.069	16.493	0.000	ITEM1	1.131	0.069	16.493	0.000
ITEM2	1.332	0.076	17.632	0.000	ITEM2	1.332	0.076	17.632	0.000
ITEM3	0.861	0.076	11.269	0.000	ITEM3	0.861	0.076	11.269	0.000
ITEM4	1.169	0.083	14.123	0.000	ITEM4	1.169	0.083	14.123	0.000
ITEM5	1.000	0.076	13.226	0.000	ITEM5	1.000	0.076	13.226	0.000
ITEM6	1.162	0.077	15.169	0.000	ITEM6	1.162	0.077	15.169	0.000
ITEM7	0.765	0.086	8.890	0.000	ITEM7	0.765	0.086	8.890	0.000
ITEM8	1.142	0.082	13.922	0.000	ITEM8	1.142	0.082	13.922	0.000
ITEM9	0.620	0.069	8.931	0.000	ITEM9	0.620	0.069	8.931	0.000
ITEM1 WITH (EQUAL TO CORRELATION=.268)					ITEM1 WITH (EQUAL TO CORRELATION=.456)				
ITEM2	0.491	0.159	3.080	0.002	ITEM2	0.834	0.152	5.485	0.000
Means (FACTOR MEAN FIXED=0 FOR IDENTIFICATION)					Means (FREELY ESTIMATED TO BE FACTOR MEAN DIFFERENCE)				
DEPRESS	0.000	0.000	999.000	999.000	DEPRESS	-0.094	0.085	-1.097	0.272
Intercepts					Intercepts				
ITEM1	4.229	0.078	53.982	0.000	ITEM1	4.229	0.078	53.982	0.000
ITEM2	3.763	0.093	40.555	0.000	ITEM2	3.763	0.093	40.555	0.000
ITEM3	1.886	0.087	21.615	0.000	ITEM3	1.886	0.087	21.615	0.000
ITEM4	3.528	0.096	36.886	0.000	ITEM4	3.528	0.096	36.886	0.000
ITEM5	2.292	0.090	25.463	0.000	ITEM5	2.292	0.090	25.463	0.000
ITEM6	3.862	0.091	42.541	0.000	ITEM6	3.862	0.091	42.541	0.000
ITEM7	3.869	0.106	36.382	0.000	ITEM7	3.493	0.123	28.385	0.000
ITEM8	3.610	0.094	38.347	0.000	ITEM8	3.610	0.094	38.347	0.000
ITEM9	1.261	0.071	17.671	0.000	ITEM9	1.261	0.071	17.671	0.000
Variances (FACTOR VARIANCE=1 FOR IDENTIFICATION)					Variances (FACTOR VARIANCE NOT DIFFERENT THAN 1)				
DEPRESS	1.000	0.000	999.000	999.000	DEPRESS	1.000	0.000	999.000	999.000
Residual Variances					Residual Variances				
ITEM1	1.452	0.145	9.989	0.000	ITEM1	1.452	0.145	9.989	0.000
ITEM2	2.302	0.178	12.927	0.000	ITEM2	2.302	0.178	12.927	0.000
ITEM3	3.646	0.143	25.467	0.000	ITEM3	3.646	0.143	25.467	0.000
ITEM4	3.571	0.197	18.119	0.000	ITEM4	3.571	0.197	18.119	0.000
ITEM5	3.478	0.161	21.625	0.000	ITEM5	3.478	0.161	21.625	0.000
ITEM6	2.899	0.199	14.536	0.000	ITEM6	2.899	0.199	14.536	0.000
ITEM7	3.655	0.271	13.481	0.000	ITEM7	4.626	0.260	17.771	0.000
ITEM8	3.368	0.207	16.280	0.000	ITEM8	3.368	0.207	16.280	0.000
ITEM9	2.809	0.143	19.649	0.000	ITEM9	2.809	0.143	19.649	0.000

STRUCTURAL INVARIANCE TESTS
Model 7. Factor Mean Invariance Model

<pre> ! WOMEN REFERENCE GROUP: CONFIGURAL MODEL MODEL: ! Factor loadings all freely estimated, just labeled DEPRESS BY item1-item9* (L1-L9); ! Item intercepts all freely estimated, just labeled [item1-item9*] (I1-I9); ! Residual variances all freely estimated, just labeled item1-item9* (E1-E9); ! Residual covariance (free for 1&2), just labeled item1 WITH item2* (ECOV12); ! Factor variance fixed to 1 for identification DEPRESS@1; ! Factor mean fixed to 0 for identification [DEPRESS@0]; </pre>	<pre> ! MEN ALTERNATIVE GROUP: 7 FACTOR MEAN MODEL MODEL Men: ! Factor loadings still labeled (constrained to women's) DEPRESS BY item1-item9* (L1-L9); ! Item intercepts still constrained to women's, but not 7 [item1-item9*] (I1-I6 I7m I8-I9); ! Residual variances still constrained to women's, not 7 item1-item9* (E1-E6 E7m E8-E9); ! Residual covariance (free for 1&2) NOT equal to women's item1 WITH item2*; ! Factor variance still constrained equal to women's DEPRESS@1; ! Factor mean NOW CONSTRAINED EQUAL TO WOMEN'S [DEPRESS@0]; </pre>																																																										
<table border="0"> <tr> <td>Number of Free Parameters</td> <td style="text-align: right;">31</td> </tr> <tr> <td>Loglikelihood</td> <td></td> </tr> <tr> <td> H0 Value</td> <td style="text-align: right;">-13715.514</td> </tr> <tr> <td> H0 Scaling Correction Factor</td> <td style="text-align: right;">1.0106</td> </tr> <tr> <td> for MLR</td> <td></td> </tr> <tr> <td> H1 Value</td> <td style="text-align: right;">-13657.442</td> </tr> <tr> <td> H1 Scaling Correction Factor</td> <td style="text-align: right;">1.0143</td> </tr> <tr> <td> for MLR</td> <td></td> </tr> <tr> <td>Information Criteria</td> <td></td> </tr> <tr> <td> Akaike (AIC)</td> <td style="text-align: right;">27493.027</td> </tr> <tr> <td> Bayesian (BIC)</td> <td style="text-align: right;">27636.250</td> </tr> <tr> <td> Sample-Size Adjusted BIC</td> <td style="text-align: right;">27537.813</td> </tr> <tr> <td> (n* = (n + 2) / 24)</td> <td></td> </tr> </table> <p>Did model fit get significantly worse? Nope (as the Wald test foreshadowed, which could have been used in this case). $-2\Delta LL(df=1) = 1.23, p = .27$</p>	Number of Free Parameters	31	Loglikelihood		H0 Value	-13715.514	H0 Scaling Correction Factor	1.0106	for MLR		H1 Value	-13657.442	H1 Scaling Correction Factor	1.0143	for MLR		Information Criteria		Akaike (AIC)	27493.027	Bayesian (BIC)	27636.250	Sample-Size Adjusted BIC	27537.813	(n* = (n + 2) / 24)		<table border="0"> <tr> <td colspan="2">Chi-Square Test of Model Fit</td> </tr> <tr> <td> Value</td> <td style="text-align: right;">114.340*</td> </tr> <tr> <td> Degrees of Freedom</td> <td style="text-align: right;">77</td> </tr> <tr> <td> P-Value</td> <td style="text-align: right;">0.0037</td> </tr> <tr> <td> Scaling Correction Factor</td> <td style="text-align: right;">1.0158</td> </tr> <tr> <td> for MLR</td> <td></td> </tr> <tr> <td colspan="2">Chi-Square Contributions From Each Group</td> </tr> <tr> <td> W</td> <td style="text-align: right;">60.831</td> </tr> <tr> <td> M</td> <td style="text-align: right;">53.509</td> </tr> <tr> <td colspan="2">RMSEA (Root Mean Square Error Of Approximation)</td> </tr> <tr> <td> Estimate</td> <td style="text-align: right;">0.036</td> </tr> <tr> <td> 90 Percent C.I.</td> <td style="text-align: right;">0.021 0.049</td> </tr> <tr> <td> Probability RMSEA <= .05</td> <td style="text-align: right;">0.960</td> </tr> <tr> <td colspan="2">CFI/TLI</td> </tr> <tr> <td> CFI</td> <td style="text-align: right;">0.967</td> </tr> <tr> <td> TLI</td> <td style="text-align: right;">0.970</td> </tr> </table>	Chi-Square Test of Model Fit		Value	114.340*	Degrees of Freedom	77	P-Value	0.0037	Scaling Correction Factor	1.0158	for MLR		Chi-Square Contributions From Each Group		W	60.831	M	53.509	RMSEA (Root Mean Square Error Of Approximation)		Estimate	0.036	90 Percent C.I.	0.021 0.049	Probability RMSEA <= .05	0.960	CFI/TLI		CFI	0.967	TLI	0.970
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All done!

Example Results of CFA with MLR Multiple Group Invariance Model Comparisons (Table 1 for model fit in Excel workbook):

The extent to which a single-factor model of depression (measured using nine items with a nine-point response scale) exhibited measurement and structural invariance between groups of women and men was examined using *Mplus* v. 8.8 (Muthén & Muthén, 1998–2017). Robust maximum likelihood (MLR) estimation was used for all analyses; accordingly, nested model comparisons were conducted using the $-2\Delta LL$ rescaled difference test. Women served as the reference group in all invariance models. A configural invariance model was initially specified in which single-factor models were estimated simultaneously within each group; the factor mean was fixed to 0 and the factor variance was fixed to 1 for identification within each group. A residual covariance between items 1 and 2 was also estimated in each group as suggested by previous results. As shown in Table 1, the configural model had good fit, and thus a series of parameter constraints were then applied in successive models to examine potential decreases in fit resulting from measurement or structural non-invariance.

Equality of the unstandardized item factor loadings across groups was then examined in a metric invariance model in which the factor variance was fixed to 1 in women but was freely estimated in men; the factor means were fixed to 0 in both groups. All factor loadings were constrained to be equal across groups; all intercepts and residual variances (and the residual covariance between items 1 and 2) were still permitted to vary across groups. The metric invariance model fit well (see Table 1) and did not result in a significant decrease in fit relative to the configural model, $-2\Delta LL(8) = 4.26$, $p = .83$. The modification indices suggested no points of localized strain among the constrained loadings. The fact that metric invariance (i.e., “weak invariance”) held indicates that the items were related to the latent factor equivalently across groups, or more simply, that the same latent factor was being measured in each group.

Equality of the unstandardized item intercepts across groups was then examined in a scalar invariance model. The factor mean and variance were fixed to 0 and 1, respectively, for identification in the women, but the factor mean and variance were then estimated in the men. All factor loadings and item intercepts were constrained to be equal across groups; all residual variances (and the residual covariance between items 1 and 2) were still permitted to differ across groups. The scalar invariance model fit well (see Table 1) and did not result in a significant decrease in fit relative to the metric invariance model, $-2\Delta LL(8) = 12.39$, $p = .13$. However, examination of the modification indices suggested a point of localized strain; accordingly, a partial scalar invariance model was thus estimated in which the intercept for item 7 (“feelings of worthless or guilt”) was allowed to differ between groups, resulting in a good-fitting model and a significantly better-fitting model relative to the full scalar invariance model, $-2\Delta LL(1) = 5.93$, $p = .01$. The partial scalar invariance did not fit significantly worse than the metric invariance model, $-2\Delta LL(7) = 6.36$, $p = .50$, indicating that partial scalar invariance did hold. The fact that partial scalar invariance (i.e., “strong invariance”) held indicates that both groups have the same expected item response at the same absolute level of the trait, or more simply, that the observed group differences in item means were due to factor mean differences only. The exception was item 7, for which women were expected to have a higher item response than men at the same absolute trait level of depression.

Equality of the unstandardized residual variances across groups was then examined in a residual variance invariance model. As in the partial scalar invariance model, the factor mean and variance were fixed to 0 and 1, respectively, for identification in the women, but the factor mean and variance were still estimated in the men. All factor loadings, item intercepts (except for item 7), and all residual variances (except for item 7) were constrained to be equal across groups; the residual covariance between item 1 and 2 was still permitted to differ across groups. The residual variance invariance model fit well (see Table 1) and did not result in significant decrease in fit relative to the partial scalar invariance model, $-2\Delta LL(8) = 5.27$, $p = .73$. The modification indices suggested no points of localized strain among the constrained residual variances. The fact that residual variance invariance (i.e., “strict invariance”) held indicates that the amount of item variance not accounted for by the factor was the same across groups. Finally, equality of the residual covariance between items 1 and 2 across groups was tested and resulted in a significant decrease in fit relative to the residual invariance model, $-2\Delta LL(1) = 4.18$, $p = .04$, indicating that the residual relationship between items 1 and 2 differed significantly between men and women. The residual covariance between items 1 and 2 was thus permitted to vary across groups in further models.

After achieving partial measurement invariance as just described, structural invariance was then tested with two additional models. First, the factor variance in men (which had been estimated freely) was constrained to 1 (i.e., to be equal to the factor variance in the women), resulting in a nonsignificant decrease in fit relative to the residual invariance model, $-2\Delta LL(1) = 1.01$, $p = .31$. Thus, men and women had equivalent variability (i.e., amount of individual differences) in depression. Second, the factor mean in men (which had been estimated freely) was constrained to 0 (i.e., to be equal to the factor mean in women), resulting in a nonsignificant decrease in fit relative to the factor variance invariance model, $-2\Delta LL(1) = 1.23$, $p = .27$, indicating that men and women had comparable

amounts of depression on average. Thus, in conclusion, these analyses showed that partial measurement invariance was obtained between groups of men and women—that is, the relationships of the items to the latent trait of depression were largely equivalent in both groups (except for the intercept and residual variance for item 7). These analyses also showed that full structural invariance was obtained between men and women, such that both groups had the same average amount of depression and extent of interindividual variation in depression as measured by these nine items. The fact that both the factor variances and item residual variances could be constrained equal across groups also indicates equal reliability of the items (i.e., equal standardized factor loadings) across groups, with the exception of item 7. Model parameters from the final invariance model are given in Table 2.

Reference: Muthén, L. K., & Muthén, B.O. (1998–2017). *Mplus user's guide* (8th ed.). Los Angeles, CA: Muthén & Muthén.

Table 1

Model fit statistics for tests of multiple group measurement and structural invariance

Model	# Free Parms	Chi-Square Value	Chi-Square Scale Factor	Chi-Square DF	Chi-Square p-value	CFI	RMSEA Estimate	RMSEA Lower CI	RMSEA Higher CI	RMSEA p-value
1. Configural Model	56	94.175	1.0503	52	0.0003	0.963	0.047	0.031	0.061	0.632
2a. Metric Model	48	99.532	1.0332	60	0.0010	0.966	0.042	0.027	0.056	0.814
3a. Scalar Model	40	111.950	1.0300	68	0.0006	0.962	0.042	0.027	0.055	0.842
3b. Partial Scalar (no Item 7)	41	106.031	1.0300	67	0.0017	0.966	0.039	0.024	0.053	0.892
4a. Residual (no Item 7)	33	112.019	1.0182	75	0.0036	0.968	0.036	0.021	0.050	0.954
5a. Residual Covariance	32	119.281	1.0341	76	0.0011	0.962	0.039	0.025	0.052	0.916
6a. Factor Variance	32	113.113	1.0158	76	0.0037	0.968	0.036	0.021	0.049	0.957
7a. Factor Mean	31	114.340	1.0158	77	0.0037	0.967	0.036	0.021	0.049	0.960

Table 2 would have actual model parameters.... (unstandardized and standardized estimates and their SEs, so 4 columns)

You might also replace all the nested model comparisons tests in the text with a table that provides them instead.