

**Example 7c: Testing Multiple-Group Measurement Invariance in Item Factor Models using WLSMV in Mplus v. 8.8 (complete syntax and output for Mplus and R lavaan is available electronically, but their results don't match)**

This example comes from the [Octogenarian Twin Study of Aging](#) in Sweden. The current analysis includes 634 older adults (age 80–100 years) on 7 items measuring the Instrumental Activities of Daily Living (IADL), as also used in Example 6a. We are examining differences for men (N=214) versus women (N=420) using four response options →

Item	0=Can't Do It		1=Big Problems		2=Some Problems		3=Can Do It	
	Men	Women	Men	Women	Men	Women	Men	Women
1 Housework	0.11	0.08	0.09	0.08	0.25	0.26	0.56	0.59
2 Bedmaking	0.09	0.06	0.04	0.04	0.12	0.11	0.75	0.78
3 Cooking	0.12	0.07	0.08	0.04	0.24	0.11	0.57	0.78
4 Everyday shopping	0.11	0.10	0.05	0.11	0.14	0.22	0.70	0.58
5 Walking to places	0.05	0.06	0.12	0.18	0.16	0.24	0.67	0.52
6 Handling banking	0.05	0.06	0.07	0.09	0.10	0.13	0.78	0.72
7 Using a telephone	0.02	0.01	0.04	0.02	0.06	0.08	0.88	0.89

**Multiple Group IFA Model Syntax and Truncated Output:**

```

TITLE: Assess invariance for polytomous ordinal IADL items using WLSMV
DATA: FILE = Example7cd.csv; ! Don't need path if data in same folder
        FORMAT = free; TYPE = INDIVIDUAL; ! Defaults

VARIABLE: NAMES = case female dial-dia7 cial-cia7; ! All vars in data
        USEVARIABLES = cial-cia7; ! All vars in model
        CATEGORICAL = cial-cia7; ! All ordinal outcomes
        GROUPING = female (0=Men 1=Women); ! Grouping variable
        MISSING = ALL (9999); ! Missing value code
        IDVARIABLE = case; ! Person ID variable
!PLOT: TYPE = PLOT1 PLOT2 PLOT3; ! Get all the plots
OUTPUT: STDYX RESIDUAL MODINDICES(6.635); ! Constraints to drop p<.01

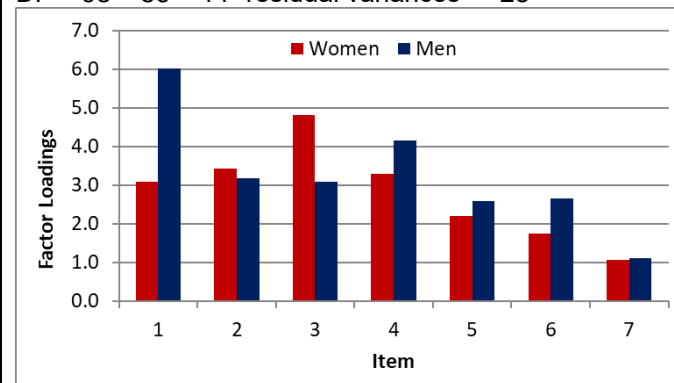
ANALYSIS: ESTIMATOR=WLSMV; PARAMETERIZATION=THETA; ! Limited-info version
        CONVERGENCE = 0.0000001; ! For OS comparability
SAVEDATA: DIFFTEST=Configural.dat; ! Save configural info to compare

MODEL: ! MEN REFERENCE GROUP MODEL (WILL STAY SAME)
! Factor loadings all freely estimated, just labeled
        IADL BY cial-cia7* (L_I1-L_I7);
! Item thresholds all freely estimated, just labeled
        [cial$1-cia7$1*] (T1_I1-T1_I7);
        [cial$2-cia7$2*] (T2_I1-T2_I7);
        [cial$3-cia7$3*] (T3_I1-T3_I7);
! Item residual variances all fixed=1 for identification
        cial-cia7@1;
! Factor mean=0 and variance=1 for identification
        [IADL@0]; IADL@1;

! WOMEN ALTERNATIVE GROUP: 1 CONFIGURAL MODEL
MODEL WOMEN:
! Factor loadings all freely estimated
        IADL BY cial-cia7*;
! Item thresholds all freely estimated
        [cial$1-cia7$1*];
        [cial$2-cia7$2*];
        [cial$3-cia7$3*];
! Item residual variances all fixed=1 for identification
        cial-cia7@1;
! Factor mean=0 and variance=1 for identification
        [IADL@0]; IADL@1;
    
```

MODEL FIT INFORMATION		
Number of Free Parameters		56
Chi-Square Test of Model Fit		
Value		72.897*
Degrees of Freedom		28
P-Value		0.0000
Chi-Square Contributions From Each Group		
MEN		24.965
WOMEN		47.932
RMSEA (Root Mean Square Error Of Approximation)		
Estimate		0.071
90 Percent C.I.		0.051 0.091
Probability RMSEA <= .05		0.040
CFI/TLI		
CFI		0.999
TLI		0.998
SRMR (Standardized Root Mean Square Residual)		
Value		0.020

This will be our baseline configural model.  
 56 parameters estimated = 2\*[7 loadings + 21 thresholds] = 56  
 Possible parameters = 2\* ([7\*(7+1)] / 2) + 21 thresholds = 98  
 DF = 98 – 56 – 14 “residual variances” = 28



Model 1. Configural Invariance Model
(Everything separate across groups \*except\* for parameters needed to be constrained for identification)

Table with two main columns: UNSTANDARDIZED MODEL RESULTS (IFA MODEL SOLUTION) for Group MEN and UNSTANDARDIZED MODEL RESULTS (IFA MODEL SOLUTION) for Group WOMEN. Each column contains sub-sections for Factor Loadings, Means, Thresholds, Variances, and Residual Variances, with associated statistical values like Estimate, S.E., and P-Value.

**Model 2a. Metric Invariance Model (IFA loadings held equal across groups – Mplus IRT discriminations still vary via factor variances)**

<pre> <b>ANALYSIS:</b> DIFFTEST=Configural.dat; ! Compare with 1 configural <b>SAVEDATA:</b> DIFFTEST=MetricA.dat; ! Save 2a full metric info <b>MODEL:</b> ! MEN REFERENCE GROUP MODEL (WILL STAY SAME) ! Factor loadings all freely estimated, just labeled IADL BY cial-cia7* (L_I1-L_I7); ! Item thresholds all freely estimated, just labeled [cial\$1-cia7\$1*] (T1_I1-T1_I7); [cial\$2-cia7\$2*] (T2_I1-T2_I7); [cial\$3-cia7\$3*] (T3_I1-T3_I7); ! Item residual variances all fixed=1 for identification cial-cia7@1; ! Factor mean=0 and variance=1 for identification [IADL@0]; IADL@1;  ! WOMEN ALTERNATIVE GROUP: 2A METRIC MODEL <b>MODEL WOMEN:</b> ! Factor loadings NOW CONSTRAINED EQUAL TO MEN VIA SAME LABEL IADL BY cial-cia7* (L_I1-L_I7); ! Item thresholds all freely estimated [cial\$1-cia7\$1*]; [cial\$2-cia7\$2*]; [cial\$3-cia7\$3*]; ! Item residual variances all fixed=1 for identification cial-cia7@1; ! Factor mean=0 for identification ! Factor variance NOW ESTIMATED [IADL@0]; IADL*;         </pre>	<table border="0"> <tr> <td>Number of Free Parameters</td> <td>50</td> </tr> <tr> <td>Chi-Square Test of Model Fit</td> <td></td> </tr> <tr> <td>Value</td> <td>64.667*</td> </tr> <tr> <td>Degrees of Freedom</td> <td>34</td> </tr> <tr> <td>P-Value</td> <td>0.0012</td> </tr> <tr> <td>Chi-Square Contributions From Each Group</td> <td></td> </tr> <tr> <td>MEN</td> <td>30.854</td> </tr> <tr> <td>WOMEN</td> <td>33.813</td> </tr> <tr> <td colspan="2"><b>THIS IS THE TEST OF 1 CONFIGURAL VS. 2A FULL METRIC INVARIANCE</b></td> </tr> <tr> <td>Chi-Square Test for Difference Testing</td> <td></td> </tr> <tr> <td>Value</td> <td>9.401</td> </tr> <tr> <td>Degrees of Freedom</td> <td>6</td> </tr> <tr> <td>P-Value</td> <td>0.1522</td> </tr> <tr> <td>RMSEA (Root Mean Square Error Of Approximation)</td> <td></td> </tr> <tr> <td>Estimate</td> <td>0.053</td> </tr> <tr> <td>90 Percent C.I.</td> <td>0.033 0.073</td> </tr> <tr> <td>Probability RMSEA &lt;= .05</td> <td>0.367</td> </tr> <tr> <td>CFI/TLI</td> <td></td> </tr> <tr> <td>CFI</td> <td>0.999</td> </tr> <tr> <td>TLI</td> <td>0.999</td> </tr> <tr> <td>SRMR (Standardized Root Mean Square Residual)</td> <td></td> </tr> <tr> <td>Value</td> <td>0.023</td> </tr> </table> <p>Although the DIFFTEST omnibus chi-square is nonsignificant, the modification indices suggest freeing the loading for cia3 between groups:</p> <table border="0"> <tr> <td colspan="6">MODEL MODIFICATION INDICES</td> </tr> <tr> <td></td> <td></td> <td>M.I.</td> <td>E.P.C.</td> <td>Std E.P.C.</td> <td>StdYX E.P.C.</td> </tr> <tr> <td colspan="6">Group MEN</td> </tr> <tr> <td>BY Statements</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>IADL</td> <td>BY CIA3</td> <td>7.734</td> <td>-2.379</td> <td>-2.379</td> <td>-0.488</td> </tr> <tr> <td colspan="6">Group WOMEN</td> </tr> <tr> <td>BY Statements</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> <tr> <td>IADL</td> <td>BY CIA3</td> <td>7.734</td> <td>1.531</td> <td>1.275</td> <td>0.311</td> </tr> </table>	Number of Free Parameters	50	Chi-Square Test of Model Fit		Value	64.667*	Degrees of Freedom	34	P-Value	0.0012	Chi-Square Contributions From Each Group		MEN	30.854	WOMEN	33.813	<b>THIS IS THE TEST OF 1 CONFIGURAL VS. 2A FULL METRIC INVARIANCE</b>		Chi-Square Test for Difference Testing		Value	9.401	Degrees of Freedom	6	P-Value	0.1522	RMSEA (Root Mean Square Error Of Approximation)		Estimate	0.053	90 Percent C.I.	0.033 0.073	Probability RMSEA <= .05	0.367	CFI/TLI		CFI	0.999	TLI	0.999	SRMR (Standardized Root Mean Square Residual)		Value	0.023	MODEL MODIFICATION INDICES								M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.	Group MEN						BY Statements						IADL	BY CIA3	7.734	-2.379	-2.379	-0.488	Group WOMEN						BY Statements						IADL	BY CIA3	7.734	1.531	1.275	0.311
Number of Free Parameters	50																																																																																												
Chi-Square Test of Model Fit																																																																																													
Value	64.667*																																																																																												
Degrees of Freedom	34																																																																																												
P-Value	0.0012																																																																																												
Chi-Square Contributions From Each Group																																																																																													
MEN	30.854																																																																																												
WOMEN	33.813																																																																																												
<b>THIS IS THE TEST OF 1 CONFIGURAL VS. 2A FULL METRIC INVARIANCE</b>																																																																																													
Chi-Square Test for Difference Testing																																																																																													
Value	9.401																																																																																												
Degrees of Freedom	6																																																																																												
P-Value	0.1522																																																																																												
RMSEA (Root Mean Square Error Of Approximation)																																																																																													
Estimate	0.053																																																																																												
90 Percent C.I.	0.033 0.073																																																																																												
Probability RMSEA <= .05	0.367																																																																																												
CFI/TLI																																																																																													
CFI	0.999																																																																																												
TLI	0.999																																																																																												
SRMR (Standardized Root Mean Square Residual)																																																																																													
Value	0.023																																																																																												
MODEL MODIFICATION INDICES																																																																																													
		M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.																																																																																								
Group MEN																																																																																													
BY Statements																																																																																													
IADL	BY CIA3	7.734	-2.379	-2.379	-0.488																																																																																								
Group WOMEN																																																																																													
BY Statements																																																																																													
IADL	BY CIA3	7.734	1.531	1.275	0.311																																																																																								

**Model 2b. Metric Invariance Model (IFA loadings held equal across groups except cia3)**

```

ANALYSIS: DIFFTEST=Configural.dat; ! Compare with 1 configural
SAVEDATA: DIFFTEST=MetricB.dat; ! Save 2b partial metric info

MODEL: ! MEN REFERENCE GROUP MODEL (WILL STAY SAME)
! Factor loadings all freely estimated, just labeled
IADL BY cial-cia7* (L_I1-L_I7);
! Item thresholds all freely estimated, just labeled
[cial$1-cia7$1*] (T1_I1-T1_I7);
[cial$2-cia7$2*] (T2_I1-T2_I7);
[cial$3-cia7$3*] (T3_I1-T3_I7);
! Item residual variances all fixed=1 for identification
cial-cia7@1;
! Factor mean=0 and variance=1 for identification
[IADL@0]; IADL@1;

! WOMEN ALTERNATIVE GROUP: 2B PARTIAL METRIC MODEL
MODEL WOMEN:
! Factor loadings NOW CONSTRAINED EQUAL TO MEN EXCEPT 3
IADL BY cial-cia7* (L_I1-L_I2 L_I3w L_I4-L_I7); ! 2b: Free item 3
! Item thresholds all freely estimated
[cial$1-cia7$1*];
[cial$2-cia7$2*];
[cial$3-cia7$3*];
! Item residual variances all fixed=1 for identification
cial-cia7@1;
! Factor mean=0 for identification
! Factor variance NOW ESTIMATED
[IADL@0]; IADL*;
    
```

Here is an additional test comparing Metric B to Metric A to see if freeing the loading of item 3 helped improve fit: (by running Metric A again, adding these commands):

```

ANALYSIS: DIFFTEST=MetricB.dat; ! Compare with 2b partial metric
SAVEDATA: DIFFTEST=MetricA.dat; ! Save 2a full metric info
    
```

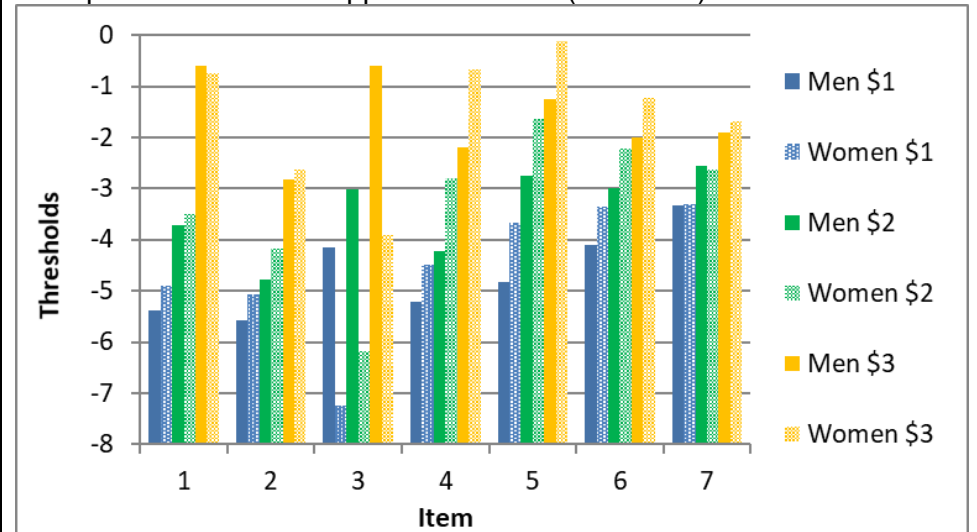
Chi-Square Test for Difference Testing	
Value	5.560*
Degrees of Freedom	1
P-Value	0.0184

Number of Free Parameters	51
Chi-Square Test of Model Fit	
Value	58.607*
Degrees of Freedom	33
P-Value	0.0039
Chi-Square Contribution From Each Group	
MEN	24.931
WOMEN	33.676

**THIS IS THE TEST OF 1 CONFIGURAL VS. 2B PARTIAL METRIC INVARIANCE**

Chi-Square Test for Difference Testing	
Value	5.527
Degrees of Freedom	5
P-Value	0.3550
RMSEA (Root Mean Square Error Of Approximation)	
Estimate	0.049
90 Percent C.I.	0.028 0.070
Probability RMSEA <= .05	0.490
CFI/TLI	
CFI	0.999
TLI	0.999
SRMR (Standardized Root Mean Square Residual)	
Value	0.023

No new modification indices, so we are done with metric!  
Let's preview what will happen with scalar (threshold) invariance:



**2b Partial metric invariance solution (all factor loadings constrained except item 3)**

Group MEN					Group WOMEN				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
IADL BY: CHANGE IN PROBIT FOR ONE-UNIT CHANGE IN THETA					IADL BY				
CIA1	4.195	0.456	9.207	0.000	CIA1	4.195	0.456	9.207	0.000
CIA2	4.026	0.556	7.239	0.000	CIA2	4.026	0.556	7.239	0.000
<b>CIA3</b>	<b>3.327</b>	<b>0.518</b>	<b>6.428</b>	<b>0.000</b>	<b>CIA3</b>	<b>6.227</b>	<b>1.253</b>	<b>4.969</b>	<b>0.000</b>
CIA4	4.168	0.506	8.240	0.000	CIA4	4.168	0.506	8.240	0.000
CIA5	2.713	0.301	9.012	0.000	CIA5	2.713	0.301	9.012	0.000
CIA6	2.339	0.261	8.946	0.000	CIA6	2.339	0.261	8.946	0.000
CIA7	1.256	0.174	7.227	0.000	CIA7	1.256	0.174	7.227	0.000
Means MEAN OF THETA FIXED=0 FOR IDENTIFICATION					Means: MEAN OF THETA FIXED=0 FOR IDENTIFICATION				
IADL	0.000	0.000	999.000	999.000	IADL	0.000	0.000	999.000	999.000
Thresholds: EXPECTED PROBIT OF Y=0 IF THETA=0					Thresholds				
CIA1\$1	-5.393	0.615	-8.770	0.000	CIA1\$1	-4.889	0.429	-11.389	0.000
CIA1\$2	-3.716	0.552	-6.730	0.000	CIA1\$2	-3.510	0.361	-9.735	0.000
CIA1\$3	-0.602	0.422	-1.429	0.153	CIA1\$3	-0.754	0.236	-3.187	0.001
CIA2\$1	-5.574	0.673	-8.285	0.000	CIA2\$1	-5.080	0.486	-10.462	0.000
CIA2\$2	-4.785	0.644	-7.432	0.000	CIA2\$2	-4.170	0.430	-9.691	0.000
CIA2\$3	-2.814	0.530	-5.313	0.000	CIA2\$3	-2.622	0.360	-7.275	0.000
CIA3\$1	-4.152	0.547	-7.597	0.000	CIA3\$1	-7.242	1.230	-5.888	0.000
CIA3\$2	-3.007	0.504	-5.972	0.000	CIA3\$2	-6.176	1.103	-5.598	0.000
CIA3\$3	-0.604	0.352	-1.718	0.086	CIA3\$3	-3.902	0.854	-4.569	0.000
CIA4\$1	-5.219	0.605	-8.625	0.000	CIA4\$1	-4.488	0.367	-12.214	0.000
CIA4\$2	-4.220	0.555	-7.609	0.000	CIA4\$2	-2.809	0.301	-9.331	0.000
CIA4\$3	-2.192	0.474	-4.625	0.000	CIA4\$3	-0.679	0.236	-2.880	0.004
CIA5\$1	-4.824	0.489	-9.856	0.000	CIA5\$1	-3.662	0.259	-14.126	0.000
CIA5\$2	-2.743	0.352	-7.801	0.000	CIA5\$2	-1.649	0.179	-9.200	0.000
CIA5\$3	-1.245	0.291	-4.285	0.000	CIA5\$3	-0.115	0.148	-0.780	0.435
CIA6\$1	-4.115	0.415	-9.904	0.000	CIA6\$1	-3.349	0.256	-13.090	0.000
CIA6\$2	-2.987	0.339	-8.809	0.000	CIA6\$2	-2.212	0.197	-11.205	0.000
CIA6\$3	-1.996	0.303	-6.594	0.000	CIA6\$3	-1.227	0.168	-7.321	0.000
CIA7\$1	-3.339	0.355	-9.394	0.000	CIA7\$1	-3.300	0.287	-11.506	0.000
CIA7\$2	-2.547	0.253	-10.085	0.000	CIA7\$2	-2.626	0.200	-13.111	0.000
CIA7\$3	-1.908	0.219	-8.716	0.000	CIA7\$3	-1.692	0.142	-11.901	0.000
Variances: VARIANCE OF THETA FIXED=1 FOR IDENTIFICATION					Variances: VARIANCE OF THETA NOW ESTIMATED				
IADL	1.000	0.000	999.000	999.000	<b>IADL</b>	<b>0.623</b>	<b>0.139</b>	<b>4.471</b>	<b>0.000</b>
Residual Variances ALL FIXED=1 FOR IDENTIFICATION					Residual Variances ALL FIXED=1 FOR IDENTIFICATION				
CIA1	1.000	0.000	999.000	999.000	CIA1	1.000	0.000	999.000	999.000
CIA2	1.000	0.000	999.000	999.000	CIA2	1.000	0.000	999.000	999.000
CIA3	1.000	0.000	999.000	999.000	CIA3	1.000	0.000	999.000	999.000
CIA4	1.000	0.000	999.000	999.000	CIA4	1.000	0.000	999.000	999.000
CIA5	1.000	0.000	999.000	999.000	CIA5	1.000	0.000	999.000	999.000
CIA6	1.000	0.000	999.000	999.000	CIA6	1.000	0.000	999.000	999.000
CIA7	1.000	0.000	999.000	999.000	CIA7	1.000	0.000	999.000	999.000

**Model 3a. Full Threshold Invariance Model (all IFA thresholds held equal across groups – Mplus IRT difficulties will still vary)**

<pre> ANALYSIS: DIFFTEST=MetricB.dat; ! Compare with 2b partial metric SAVEDATA: DIFFTEST=ScalarA.dat; ! Save 3a full scalar info  MODEL: ! MEN REFERENCE GROUP MODEL (WILL STAY SAME) ! Factor loadings all freely estimated, just labeled IADL BY cial-cia7* (L_I1-L_I7); ! Item thresholds all freely estimated, just labeled [cial\$1-cia7\$1*] (T1_I1-T1_I7); [cial\$2-cia7\$2*] (T2_I1-T2_I7); [cial\$3-cia7\$3*] (T3_I1-T3_I7); ! Item residual variances all fixed=1 for identification cial-cia7@1; ! Factor mean=0 and variance=1 for identification [IADL@0]; IADL@1;  ! WOMEN ALTERNATIVE GROUP: 3A FULL SCALAR MODEL MODEL WOMEN: ! Factor loadings still constrained equal to men (except 3) IADL BY cial-cia7* (L_I1-L_I2 L_I3w L_I4-L_I7); ! 2b: Free item 3 ! Item thresholds NOW CONSTRAINED EQUAL TO MEN BY OMISSION  ! Item residual variances all fixed=1 for identification cial-cia7@1; ! Factor mean NOW ESTIMATED ! Factor variance still estimated [IADL*]; IADL*;  The DIFFTEST chi-square is significant, and the modification indices suggest that item 3 threshold 3 is the biggest problem. This is not surprising given that its loading differed, too (but I thought I'd try to constrain item 3's thresholds anyway given that there are only seven items). Note that the imbalance in sample size (more women than men) weighted the common item 3 threshold 3 towards that of women.         </pre>	<pre> MODEL FIT INFORMATION Number of Free Parameters                31  Chi-Square Test of Model Fit Value                                   134.477* Degrees of Freedom                       53 P-Value                                   0.0000  Chi-Square Contributions From Each Group MEN                                       88.178 WOMEN                                    46.299  THIS IS THE TEST OF 2B PARTIAL METRIC VS. 3A FULL SCALAR INVARIANCE Chi-Square Test for Difference Testing Value                                   91.663 Degrees of Freedom                       20 P-Value                                   0.0000  RMSEA (Root Mean Square Error Of Approximation) Estimate                                 0.070 90 Percent C.I.                         0.055 0.084 Probability RMSEA &lt;= .05                 0.014  CFI/TLI CFI                                       0.998 TLI                                       0.998  SRMR (Standardized Root Mean Square Residual) Value                                    0.032  MODEL MODIFICATION INDICES M.I.      E.P.C.   Std E.P.C.   StdYX E.P.C. Group MEN Means/Intercepts/Thresholds [ IADL      ]      40.777   -4.610   -4.610   -4.610 [ CIA1\$3    ]       6.825    0.628    0.628    0.159 [ CIA3\$3    ]      26.583    3.043    3.043    0.417 [ CIA5\$3    ]       8.185   -0.460   -0.460   -0.164  Group WOMEN Means/Intercepts/Thresholds [ CIA1\$3    ]       6.825   -0.599   -0.599   -0.181 [ CIA3\$3    ]      26.583   -1.146   -1.146   -0.266 [ CIA5\$3    ]       8.185    0.458    0.458    0.193         </pre>
-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

**Note: As of Mplus v 7, there is an “automatic” option to do invariance testing. For WLSMV, at this step (scalar), their version simultaneously constrains the thresholds while freeing the residual variances in the alternative group (which are now possible to be separately identified). I disagree with this logic, and thus these results will not match those of the automated testing. Instead, I test scalar first, and then test (added estimated) residual variances in a separate step. Reasonable people may disagree with this choice, but to me the residual variances are of much less importance given that they are not even estimated parameters ever in the full-information version of these models.**

**Model 3b. Partial Threshold Invariance Model (freeing all item 3 thresholds between groups)**

<pre> ANALYSIS: DIFFTEST=MetricB.dat; ! Compare with 2b partial metric SAVEDATA: DIFFTEST=ScalarB.dat; ! Save 3b partial scalar info  MODEL: ! MEN REFERENCE GROUP MODEL (WILL STAY SAME) ! Factor loadings all freely estimated, just labeled IADL BY cial-cia7* (L_I1-L_I7); ! Item thresholds all freely estimated, just labeled [cia1\$1-cia7\$1*] (T1_I1-T1_I7); [cia1\$2-cia7\$2*] (T2_I1-T2_I7); [cia1\$3-cia7\$3*] (T3_I1-T3_I7); ! Item residual variances all fixed=1 for identification cial-cia7@1; ! Factor mean=0 and variance=1 for identification [IADL@0]; IADL@1;  ! WOMEN ALTERNATIVE GROUP: 3B PARTIAL SCALAR MODEL MODEL WOMEN: ! Factor loadings still constrained equal to men (except 3) IADL BY cial-cia7* (L_I1-L_I2 L_I3w L_I4-L_I7); ! 2b: Free item 3 ! Item thresholds otherwise CONSTRAINED EQUAL TO MEN BY OMISSION [cia3\$1* cia3\$2* cia3\$3*]; ! 3b: Free item 3  ! Item residual variances all fixed=1 cial-cia7@1; ! Factor mean NOW ESTIMATED ! Factor variance still estimated [IADL*]; IADL*;         </pre>	<pre> MODEL FIT INFORMATION Number of Free Parameters          34  Chi-Square Test of Model Fit Value                             96.674* Degrees of Freedom                 50 P-Value                            0.0001  Chi-Square Contributions From Each Group MEN                                53.401 WOMEN                              43.271  <b>THIS IS THE TEST OF 2B PARTIAL METRIC VS. 3B PARTIAL SCALAR INVARIANCE</b> Chi-Square Test for Difference Testing Value                             44.798 Degrees of Freedom                 17 P-Value                            0.0003  RMSEA (Root Mean Square Error Of Approximation) Estimate                           0.054 90 Percent C.I.                    0.038  0.070 Probability RMSEA &lt;= .05           0.315  CFI/TLI CFI                                0.999 TLI                                0.999  SRMR (Standardized Root Mean Square Residual) Value                               0.026  MODEL MODIFICATION INDICES M.I.    E.P.C.    Std E.P.C.    StdYX E.P.C. Group MEN Means/Intercepts/Thresholds [ CIA1\$3 ]    10.582    0.855    0.855    0.196 Group WOMEN Means/Intercepts/Thresholds [ CIA1\$3 ]    10.582    -0.781    -0.781    -0.227         </pre> <p>The DIFFTEST chi-square is still significant, and the modification indices suggest that item 1 threshold 3 is the next to go...</p>
<pre> Threshold for Men... CIA3\$1      -4.112    0.526    -7.814    0.000 CIA3\$2      -2.978    0.487    -6.114    0.000 CIA3\$3      -0.599    0.347    -1.727    0.084 Threshold for Women... CIA3\$1      -8.823    1.576    -5.598    0.000 CIA3\$2      -7.745    1.448    -5.349    0.000 CIA3\$3      -5.446    1.208    -4.508    0.000         </pre>	

**Model 3c. Partial Threshold Invariance Model (also freeing item 1 threshold 3 between groups)**

<pre> ANALYSIS: DIFFTEST=MetricB.dat; ! Compare with 2b partial metric SAVEDATA: DIFFTEST=ScalarC.dat; ! Save 3c partial scalar info  MODEL: ! MEN REFERENCE GROUP MODEL (WILL STAY SAME) ! Factor loadings all freely estimated, just labeled IADL BY cial-cia7* (L_I1-L_I7); ! Item thresholds all freely estimated, just labeled [cia1\$1-cia7\$1*] (T1_I1-T1_I7); [cia1\$2-cia7\$2*] (T2_I1-T2_I7); [cia1\$3-cia7\$3*] (T3_I1-T3_I7); ! Item residual variances all fixed=1 for identification cial-cia7@1; ! Factor mean=0 and variance=1 for identification [IADL@0]; IADL@1;  ! WOMEN ALTERNATIVE GROUP: 3C PARTIAL SCALAR MODEL MODEL WOMEN: ! Factor loadings still constrained equal to men (except 3) IADL BY cial-cia7* (L_I1-L_I2 L_I3w L_I4-L_I7); ! 2b: Free item 3 ! Item thresholds otherwise CONSTRAINED EQUAL TO MEN BY OMISSION [cia3\$1* cia3\$2* cia3\$3*]; ! 3b: Free item 3 [cia1\$3*]; ! 3c: Free item 1 threshold 3  ! Item residual variances all fixed=1 cial-cia7@1; ! Factor mean NOW ESTIMATED ! Factor variance still estimated [IADL*]; IADL*;  Thresholds for Men... CIA1\$1      -5.906      0.583      -10.127      0.000 CIA1\$2      -4.468      0.530      -8.426      0.000 CIA1\$3      -0.620      0.434      -1.429      0.153  Thresholds for Women... CIA1\$1      -5.906      0.583      -10.127      0.000 CIA1\$2      -4.468      0.530      -8.426      0.000 CIA1\$3      -1.936      0.462      -4.193      0.000         </pre>	<pre> MODEL FIT INFORMATION  Number of Free Parameters                35  Chi-Square Test of Model Fit Value                                    87.761* Degrees of Freedom                       49 P-Value                                   0.0006  Chi-Square Contributions From Each Group MEN                                       46.385 WOMEN                                    41.376  <b>THIS IS THE TEST OF 2B PARTIAL METRIC VS. 3C PARTIAL SCALAR INVARIANCE</b> Chi-Square Test for Difference Testing Value                                    32.462 Degrees of Freedom                       16 P-Value                                   0.0087  RMSEA (Root Mean Square Error Of Approximation) Estimate                                 0.050 90 Percent C.I.                         0.033 0.067 Probability RMSEA &lt;= .05                0.480  CFI/TLI CFI                                       0.999 TLI                                       0.999  SRMR (Standardized Root Mean Square Residual) Value                                    0.025  MODEL MODIFICATION INDICES - after re-running with 3.841 (p&lt;.05) cutoff:  Group MEN Means/Intercepts/Thresholds [ CIA2\$3 ]                                5.146    0.635    0.635    0.147  Group WOMEN Means/Intercepts/Thresholds [ CIA2\$3 ]                                5.146   -0.490   -0.490   -0.148  The DIFFTEST chi-square is still significant, and the modification indices suggest that item 2 threshold 3 is the next to go...         </pre>
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------



**Model 3d. Partial Threshold Invariance Model (also freeing item 2 threshold 3 between groups)**

<pre> ANALYSIS: DIFFTEST=MetricB.dat; ! Compare with 2b partial metric SAVEDATA: DIFFTEST=ScalarD.dat; ! Save 3d partial scalar info  MODEL: ! MEN REFERENCE GROUP MODEL (WILL STAY SAME) ! Factor loadings all freely estimated, just labeled IADL BY cial-cia7* (L_I1-L_I7); ! Item thresholds all freely estimated, just labeled [cia1\$1-cia7\$1*] (T1_I1-T1_I7); [cia1\$2-cia7\$2*] (T2_I1-T2_I7); [cia1\$3-cia7\$3*] (T3_I1-T3_I7); ! Item residual variances all fixed=1 for identification cial-cia7@1; ! Factor mean=0 and variance=1 for identification [IADL@0]; IADL@1;  ! WOMEN ALTERNATIVE GROUP: 3D PARTIAL SCALAR MODEL MODEL WOMEN: ! Factor loadings still constrained equal to men (except 3) IADL BY cial-cia7* (L_I1-L_I2 L_I3w L_I4-L_I7); ! 2b: Free item 3 ! Item thresholds otherwise CONSTRAINED EQUAL TO MEN BY OMISSION [cia3\$1* cia3\$2* cia3\$3*]; ! 3b: Free item 3 [cia1\$3*]; ! 3c: Free item 1 threshold 3 [cia2\$3*]; ! 3d: Free item 2 threshold 3  ! Item residual variances all fixed=1 cial-cia7@1; ! Factor mean NOW ESTIMATED ! Factor variance still estimated [IADL*]; IADL*;  Thresholds for Men... CIA2\$1      -6.162      0.683      -9.026      0.000 CIA2\$2      -5.290      0.640      -8.269      0.000 CIA2\$3      -2.927      0.554      -5.279      0.000  Thresholds for Women... CIA2\$1      -6.162      0.683      -9.026      0.000 CIA2\$2      -5.290      0.640      -8.269      0.000 CIA2\$3      -3.852      0.587      -6.566      0.000         </pre>	<pre> MODEL FIT INFORMATION  Number of Free Parameters                36  Chi-Square Test of Model Fit Value                                    82.974* Degrees of Freedom                       48 P-Value                                   0.0013  Chi-Square Contributions From Each Group MEN                                       42.552 WOMEN                                    40.422  <b>THIS IS THE TEST OF 2B PARTIAL METRIC VS. 3D PARTIAL SCALAR INVARIANCE</b> Chi-Square Test for Difference Testing Value                                    26.168 Degrees of Freedom                       15 P-Value                                   0.0363  RMSEA (Root Mean Square Error Of Approximation) Estimate                                 0.048 90 Percent C.I.                          0.030  0.065 Probability RMSEA &lt;= .05                 0.556  CFI/TLI CFI                                       0.999 TLI                                       0.999  SRMR (Standardized Root Mean Square Residual) Value                                    0.025  MODEL MODIFICATION INDICES M.I.      E.P.C.      Std E.P.C.      StdYX E.P.C. Group MEN Means/Intercepts/Thresholds [ CIA1\$2 ]      4.629      0.721      0.721      0.162  Group WOMEN Means/Intercepts/Thresholds [ CIA1\$2 ]      4.629      -0.501      -0.501      -0.147  So close... but the DIFFTEST chi-square is still significant, and the modification indices suggest that cia1 threshold 2 is the next to go...         </pre>
------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

**Model 3e. Partial Threshold Invariance Model (also freeing item 1 threshold 2 between groups)**

<pre> ANALYSIS: DIFFTEST=MetricB.dat; ! Compare with 2b partial metric SAVEDATA: DIFFTEST=ScalarE.dat; ! Save 3e partial scalar info  MODEL: ! MEN REFERENCE GROUP MODEL (WILL STAY SAME) ! Factor loadings all freely estimated, just labeled IADL BY cial-cia7* (L_I1-L_I7); ! Item thresholds all freely estimated, just labeled [cia1\$1-cia7\$1*] (T1_I1-T1_I7); [cia1\$2-cia7\$2*] (T2_I1-T2_I7); [cia1\$3-cia7\$3*] (T3_I1-T3_I7); ! Item residual variances all fixed=1 for identification cial-cia7@1; ! Factor mean=0 and variance=1 for identification [IADL@0]; IADL@1;  ! WOMEN ALTERNATIVE GROUP: 3D PARTIAL SCALAR MODEL MODEL WOMEN: ! Factor loadings still constrained equal to men (except 3) IADL BY cial-cia7* (L_I1-L_I2 L_I3w L_I4-L_I7); ! 2b: Free item 3 ! Item thresholds otherwise CONSTRAINED EQUAL TO MEN BY OMISSION [cia3\$1* cia3\$2* cia3\$3*]; ! 3b: Free item 3 [cia1\$3*]; ! 3c: Free item 1 threshold 3 [cia2\$3*]; ! 3d: Free item 2 threshold 3 [cia1\$2*]; ! 3e: Free item 1 threshold 2  ! Item residual variances all fixed=1 cial-cia7@1; ! Factor mean NOW ESTIMATED ! Factor variance still estimated [IADL*]; IADL*;         </pre>	<p>MODEL FIT INFORMATION</p> <table border="0"> <tr> <td>Number of Free Parameters</td> <td>37</td> </tr> <tr> <td>Chi-Square Test of Model Fit</td> <td></td> </tr> <tr> <td>    Value</td> <td>78.436*</td> </tr> <tr> <td>    Degrees of Freedom</td> <td>47</td> </tr> <tr> <td>    P-Value</td> <td>0.0027</td> </tr> <tr> <td>Chi-Square Contributions From Each Group</td> <td></td> </tr> <tr> <td>    MEN</td> <td>38.881</td> </tr> <tr> <td>    WOMEN</td> <td>39.555</td> </tr> </table> <p><b>THIS IS THE TEST OF 2B PARTIAL METRIC VS. 3E PARTIAL SCALAR INVARIANCE</b></p> <table border="0"> <tr> <td>Chi-Square Test for Difference Testing</td> <td></td> </tr> <tr> <td>    Value</td> <td>20.322*</td> </tr> <tr> <td>    Degrees of Freedom</td> <td>14</td> </tr> <tr> <td>    P-Value</td> <td>0.1203</td> </tr> </table> <p>RMSEA (Root Mean Square Error Of Approximation)</p> <table border="0"> <tr> <td>    Estimate</td> <td>0.046</td> </tr> <tr> <td>    90 Percent C.I.</td> <td>0.027 0.063</td> </tr> <tr> <td>    Probability RMSEA &lt;= .05</td> <td>0.627</td> </tr> </table> <p>CFI/TLI</p> <table border="0"> <tr> <td>    CFI</td> <td>0.999</td> </tr> <tr> <td>    TLI</td> <td>0.999</td> </tr> </table> <p>SRMR (Standardized Root Mean Square Residual)</p> <table border="0"> <tr> <td>    Value</td> <td>0.025</td> </tr> </table>	Number of Free Parameters	37	Chi-Square Test of Model Fit		Value	78.436*	Degrees of Freedom	47	P-Value	0.0027	Chi-Square Contributions From Each Group		MEN	38.881	WOMEN	39.555	Chi-Square Test for Difference Testing		Value	20.322*	Degrees of Freedom	14	P-Value	0.1203	Estimate	0.046	90 Percent C.I.	0.027 0.063	Probability RMSEA <= .05	0.627	CFI	0.999	TLI	0.999	Value	0.025
Number of Free Parameters	37																																				
Chi-Square Test of Model Fit																																					
Value	78.436*																																				
Degrees of Freedom	47																																				
P-Value	0.0027																																				
Chi-Square Contributions From Each Group																																					
MEN	38.881																																				
WOMEN	39.555																																				
Chi-Square Test for Difference Testing																																					
Value	20.322*																																				
Degrees of Freedom	14																																				
P-Value	0.1203																																				
Estimate	0.046																																				
90 Percent C.I.	0.027 0.063																																				
Probability RMSEA <= .05	0.627																																				
CFI	0.999																																				
TLI	0.999																																				
Value	0.025																																				
<p>Thresholds for Men...</p> <table border="0"> <tr> <td>CIA1\$1</td> <td>-6.028</td> <td>0.589</td> <td>-10.228</td> <td>0.000</td> </tr> <tr> <td><b>CIA1\$2</b></td> <td><b>-3.826</b></td> <td><b>0.569</b></td> <td><b>-6.729</b></td> <td><b>0.000</b></td> </tr> <tr> <td>CIA1\$3</td> <td>-0.620</td> <td>0.434</td> <td>-1.429</td> <td>0.153</td> </tr> </table> <p>Thresholds for Women...</p> <table border="0"> <tr> <td>CIA1\$1</td> <td>-6.028</td> <td>0.589</td> <td>-10.228</td> <td>0.000</td> </tr> <tr> <td><b>CIA1\$2</b></td> <td><b>-4.817</b></td> <td><b>0.543</b></td> <td><b>-8.877</b></td> <td><b>0.000</b></td> </tr> <tr> <td>CIA1\$3</td> <td>-2.102</td> <td>0.467</td> <td>-4.496</td> <td>0.000</td> </tr> </table>	CIA1\$1	-6.028	0.589	-10.228	0.000	<b>CIA1\$2</b>	<b>-3.826</b>	<b>0.569</b>	<b>-6.729</b>	<b>0.000</b>	CIA1\$3	-0.620	0.434	-1.429	0.153	CIA1\$1	-6.028	0.589	-10.228	0.000	<b>CIA1\$2</b>	<b>-4.817</b>	<b>0.543</b>	<b>-8.877</b>	<b>0.000</b>	CIA1\$3	-2.102	0.467	-4.496	0.000	<p>No more significant modification indices for specific thresholds! Scalar invariance is finally done!</p> <p>The next step is to see if the “residual” variances need to differ between groups. This is only possible (i.e., the model with freely estimated residual variances is only identified) given at least partial metric and scalar invariance per item.</p> <p>So far the residual variances have been fixed=1 in both groups for identification. We now proceed backwards: We first need to estimate a “bigger” model (“ResidualFreeA”), in which the residual variances are freed in the alternative women group for the items with at least partial scalar invariance (so all but item 3), and compare it back to our Scalar E model (in which they were fixed=1), to be renamed as “ResidualFixedB” for consistency with its purpose.</p>						
CIA1\$1	-6.028	0.589	-10.228	0.000																																	
<b>CIA1\$2</b>	<b>-3.826</b>	<b>0.569</b>	<b>-6.729</b>	<b>0.000</b>																																	
CIA1\$3	-0.620	0.434	-1.429	0.153																																	
CIA1\$1	-6.028	0.589	-10.228	0.000																																	
<b>CIA1\$2</b>	<b>-4.817</b>	<b>0.543</b>	<b>-8.877</b>	<b>0.000</b>																																	
CIA1\$3	-2.102	0.467	-4.496	0.000																																	

Partial Scalar E invariance solution

Group MEN					Group WOMEN				
	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
IADL BY: CHANGE IN PROBIT FOR ONE-UNIT CHANGE IN THETA					IADL BY: CHANGE IN PROBIT FOR ONE-UNIT CHANGE IN THETA				
CIA1	4.326	0.475	9.102	0.000	CIA1	4.326	0.475	9.102	0.000
CIA2	4.192	0.585	7.165	0.000	CIA2	4.192	0.585	7.165	0.000
<b>CIA3</b>	<b>3.242</b>	<b>0.476</b>	<b>6.814</b>	<b>0.000</b>	<b>CIA3</b>	<b>6.722</b>	<b>1.377</b>	<b>4.882</b>	<b>0.000</b>
CIA4	4.331	0.524	8.274	0.000	CIA4	4.331	0.524	8.274	0.000
CIA5	2.820	0.316	8.933	0.000	CIA5	2.820	0.316	8.933	0.000
CIA6	2.403	0.271	8.855	0.000	CIA6	2.403	0.271	8.855	0.000
CIA7	1.307	0.182	7.184	0.000	CIA7	1.307	0.182	7.184	0.000
Means: MEAN OF THETA FIXED=0 FOR IDENTIFICATION					Means: MEAN OF THETA ESTIMATED				
<b>IADL</b>	<b>0.000</b>	<b>0.000</b>	<b>999.000</b>	<b>999.000</b>	<b>IADL</b>	<b>-0.314</b>	<b>0.097</b>	<b>-3.239</b>	<b>0.001</b>
Thresholds: EXPECTED PROBIT OF Y=0 IF THETA=0					Thresholds				
CIA1\$1	-6.028	0.589	-10.228	0.000	CIA1\$1	-6.028	0.589	-10.228	0.000
<b>CIA1\$2</b>	<b>-3.826</b>	<b>0.569</b>	<b>-6.729</b>	<b>0.000</b>	<b>CIA1\$2</b>	<b>-4.817</b>	<b>0.543</b>	<b>-8.877</b>	<b>0.000</b>
<b>CIA1\$3</b>	<b>-0.620</b>	<b>0.434</b>	<b>-1.429</b>	<b>0.153</b>	<b>CIA1\$3</b>	<b>-2.102</b>	<b>0.467</b>	<b>-4.496</b>	<b>0.000</b>
CIA2\$1	-6.214	0.686	-9.057	0.000	CIA2\$1	-6.214	0.686	-9.057	0.000
CIA2\$2	-5.343	0.643	-8.307	0.000	CIA2\$2	-5.343	0.643	-8.307	0.000
<b>CIA2\$3</b>	<b>-2.924</b>	<b>0.554</b>	<b>-5.278</b>	<b>0.000</b>	<b>CIA2\$3</b>	<b>-3.923</b>	<b>0.590</b>	<b>-6.645</b>	<b>0.000</b>
<b>CIA3\$1</b>	<b>-4.055</b>	<b>0.510</b>	<b>-7.957</b>	<b>0.000</b>	<b>CIA3\$1</b>	<b>-9.561</b>	<b>1.790</b>	<b>-5.341</b>	<b>0.000</b>
<b>CIA3\$2</b>	<b>-2.937</b>	<b>0.473</b>	<b>-6.202</b>	<b>0.000</b>	<b>CIA3\$2</b>	<b>-8.463</b>	<b>1.653</b>	<b>-5.121</b>	<b>0.000</b>
<b>CIA3\$3</b>	<b>-0.590</b>	<b>0.341</b>	<b>-1.729</b>	<b>0.084</b>	<b>CIA3\$3</b>	<b>-6.125</b>	<b>1.392</b>	<b>-4.401</b>	<b>0.000</b>
CIA4\$1	-5.716	0.563	-10.151	0.000	CIA4\$1	-5.716	0.563	-10.151	0.000
CIA4\$2	-4.195	0.505	-8.299	0.000	CIA4\$2	-4.195	0.505	-8.299	0.000
CIA4\$3	-2.085	0.459	-4.546	0.000	CIA4\$3	-2.085	0.459	-4.546	0.000
CIA5\$1	-4.622	0.368	-12.555	0.000	CIA5\$1	-4.622	0.368	-12.555	0.000
CIA5\$2	-2.590	0.314	-8.239	0.000	CIA5\$2	-2.590	0.314	-8.239	0.000
CIA5\$3	-1.066	0.285	-3.744	0.000	CIA5\$3	-1.066	0.285	-3.744	0.000
CIA6\$1	-4.090	0.337	-12.132	0.000	CIA6\$1	-4.090	0.337	-12.132	0.000
CIA6\$2	-2.961	0.298	-9.929	0.000	CIA6\$2	-2.961	0.298	-9.929	0.000
CIA6\$3	-1.981	0.277	-7.151	0.000	CIA6\$3	-1.981	0.277	-7.151	0.000
CIA7\$1	-3.593	0.295	-12.171	0.000	CIA7\$1	-3.593	0.295	-12.171	0.000
CIA7\$2	-2.879	0.234	-12.324	0.000	CIA7\$2	-2.879	0.234	-12.324	0.000
CIA7\$3	-2.058	0.194	-10.602	0.000	CIA7\$3	-2.058	0.194	-10.602	0.000
Variances: VARIANCE OF THETA FIXED=1 FOR IDENTIFICATION					Variances: VARIANCE OF THETA ESTIMATED				
<b>IADL</b>	<b>1.000</b>	<b>0.000</b>	<b>999.000</b>	<b>999.000</b>	<b>IADL</b>	<b>0.567</b>	<b>0.125</b>	<b>4.531</b>	<b>0.000</b>
Residual Variances ALL FIXED=1 FOR IDENTIFICATION					Residual Variances ALL FIXED=1 FOR IDENTIFICATION				
CIA1	1.000	0.000	999.000	999.000	CIA1	1.000	0.000	999.000	999.000
CIA2	1.000	0.000	999.000	999.000	CIA2	1.000	0.000	999.000	999.000
CIA3	1.000	0.000	999.000	999.000	CIA3	1.000	0.000	999.000	999.000
CIA4	1.000	0.000	999.000	999.000	CIA4	1.000	0.000	999.000	999.000
CIA5	1.000	0.000	999.000	999.000	CIA5	1.000	0.000	999.000	999.000
CIA6	1.000	0.000	999.000	999.000	CIA6	1.000	0.000	999.000	999.000
CIA7	1.000	0.000	999.000	999.000	CIA7	1.000	0.000	999.000	999.000

### Model 4a. Partial Residual Variance Invariance Model (thresholds unconstrained between groups from Scalar E)

This last step for testing measurement invariance proceeds backwards. Because freeing the residual variances is adding parameters, we must estimate model 4a with free residual variances FIRST without comparing its fit to any other nested model. However, we cannot estimate the residual variance for item 3 because its factor loading differs between groups (i.e., separate residual variances are not identified for item 3).

<pre> ANALYSIS: ! Nothing compare to model 4a yet  SAVEDATA: DIFFTEST= ResidualFreeA.dat; ! Save 4a free residual info  MODEL: ! MEN REFERENCE GROUP MODEL (WILL STAY SAME) ! Factor loadings all freely estimated, just labeled IADL BY cia1-cia7* (L_I1-L_I7); ! Item thresholds all freely estimated, just labeled [cia1\$1-cia7\$1*] (T1_I1-T1_I7); [cia1\$2-cia7\$2*] (T2_I1-T2_I7); [cia1\$3-cia7\$3*] (T3_I1-T3_I7); ! Item residual variances all fixed=1 for identification cia1-cia7@1; ! Factor mean=0 and variance=1 for identification [IADL@0]; IADL@1;  ! WOMEN ALTERNATIVE GROUP: 3D PARTIAL SCALAR MODEL MODEL WOMEN: ! Factor loadings still constrained equal to men (except 3) IADL BY cia1-cia7* (L_I1-L_I2 L_I3w L_I4-L_I7); ! 2b: Free item 3 ! Item thresholds otherwise constrained equal to men by omission [cia3\$1* cia3\$2* cia3\$3*]; ! 3b: Free item 3 [cia1\$3*]; ! 3c: Free item 1 threshold 3 [cia2\$3*]; ! 3d: Free item 2 threshold 3 [cia1\$2*]; ! 3e: Free item 1 threshold 2 ! 4A Item residual variances NOW FREE EXCEPT ITEM 3 cia1* cia2* cia3@1 cia4* cia5* cia6* cia7*; ! Factor mean still estimated ! Factor variance still estimated [IADL*]; IADL*;         </pre>	<pre> (Number of Free Parameters              43  Chi-Square Test of Model Fit   Value              72.066*   Degrees of Freedom      41   P-Value              0.0019  Chi-Square Contributions From Each Group   MEN                29.078   WOMEN              42.988  RMSEA (Root Mean Square Error Of Approximation)   Estimate              0.049   90 Percent C.I.      0.029  0.067   Probability RMSEA &lt;= .05    0.515  CFI/TLI   CFI                  0.999   TLI                  0.999  SRMR (Standardized Root Mean Square Residual)   Value                0.021  Residual Variances for Men...   CIA1                1.000    0.000    999.000    999.000   CIA2                1.000    0.000    999.000    999.000   CIA3                1.000    0.000    999.000    999.000   CIA4                1.000    0.000    999.000    999.000   CIA5                1.000    0.000    999.000    999.000   CIA6                1.000    0.000    999.000    999.000   CIA7                1.000    0.000    999.000    999.000  Residual Variances for Women...   CIA1                1.706    0.962    1.772    0.076   CIA2                0.388    0.143    2.720    0.007   CIA3                1.000    0.000    999.000    999.000   CIA4                0.720    0.308    2.333    0.020   CIA5                0.700    0.245    2.855    0.004   CIA6                1.115    0.391    2.855    0.004   CIA7                0.552    0.146    3.784    0.000         </pre>
--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

**Model 4b. Residual Variance Invariance Model (testing all items' residual variances except item 3)**  
**We now constrain the residual variances to be equal between groups and test the decrease in fit (left side is re-labeled Scalar E).**

```

ANALYSIS: DIFFTEST=ResidualFreeA.dat; ! Compare with 4a free residual
SAVEDATA: DIFFTEST=ResidualFixedB.dat; ! Save 4b fixed residual info

! 4B RESIDUAL FIXED MODEL IS THE SAME AS 3E SCALAR
! (needs to re-run for DIFFTEST comparison against 4A RESIDUAL FREE)

MODEL FIT INFORMATION
Number of Free Parameters          37

Chi-Square Test of Model Fit
Value          78.436*
Degrees of Freedom    47
P-Value          0.0027

Chi-Square Contribution From Each Group
MEN          38.881
WOMEN       39.555

THIS IS THE TEST OF 4B FULL RESIDUAL VS. 3E PARTIAL SCALAR INVARIANCE
Chi-Square Test for Difference Testing
Value          11.016
Degrees of Freedom    6
P-Value          0.0879

RMSEA (Root Mean Square Error Of Approximation)
Estimate          0.046
90 Percent C.I.    0.027  0.063
Probability RMSEA <= .05    0.627

CFI/TLI
CFI          0.999
TLI          0.999

SRMR (Standardized Root Mean Square Residual)
Value          0.025

MODEL MODIFICATION INDICES
      M.I.      E.P.C.  Std E.P.C.  StdYX E.P.C.
Group MEN
Variances/Residual Variances
CIA2          4.998      1.004      1.004      0.054
CIA7          9.395      0.632      0.632      0.233

Group WOMEN
Variances/Residual Variances
CIA2          4.998     -1.004     -1.004     -0.092
CIA7          9.395     -0.632     -0.632     -0.321

Although DIFFTEST is nonsignificant, it looks like the residual variance
for items 7 and 2 want to be free, too... I will free both at the same time to
skip a step here (results testing them separately were the same):

```

```

ANALYSIS: DIFFTEST=ResidualFreeA.dat; ! Compare with 4a free residual
SAVEDATA: DIFFTEST=ResidualPartialC.dat; ! Save 4c partially fixed
! residual info

! 4C RESIDUAL MODEL has residual vars partially constrained
cia1@1 cia2* cia3-cia6@1 cia7*;

MODEL FIT INFORMATION for 4c
Number of Free Parameters          39

Chi-Square Test of Model Fit
Value          69.757*
Degrees of Freedom    45
P-Value          0.0104

Chi-Square Contribution From Each Group
MEN          30.125
WOMEN       39.632

THIS IS THE TEST OF 4C PARTIAL RESIDUAL VS. 3E PARTIAL SCALAR INVARIANCE
Chi-Square Test for Difference Testing
Value          2.800*
Degrees of Freedom    4
P-Value          0.5918

RMSEA (Root Mean Square Error Of Approximation)
Estimate          0.042
90 Percent C.I.    0.021  0.060
Probability RMSEA <= .05    0.754

CFI/TLI
CFI          0.999
TLI          0.999

SRMR (Standardized Root Mean Square Residual)
Value          0.021

No more modification indices were significant, so residual variance is now
done! The last step is to test structural invariance to see if the factor variance
can be constrained across groups:

ANALYSIS: DIFFTEST=ResidualFixedC.dat; ! Compare with 4c fixed residual
SAVEDATA: DIFFTEST=FactorVariance.dat; ! Save 5 fixed variance info

! MODEL IS THE SAME AS 4C FIXED RESIDUAL EXCEPT:
IADL@1;

Chi-Square Test for Difference Testing: Keep the factor variance
different!
Value          11.498
Degrees of Freedom    1
P-Value          0.0007

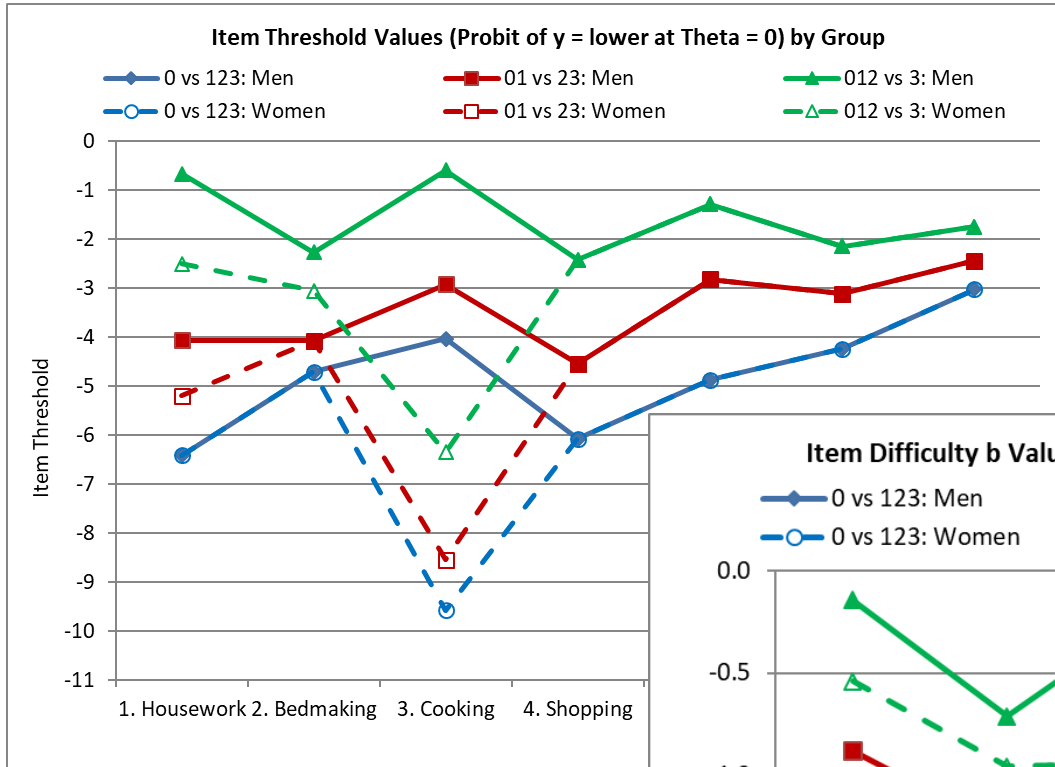
The factor mean was significantly lower for women than mean already (from
the last partial measurement invariance model 4C), so we are done!

```

**Final Model: Partial Measurement Invariance (solution from Model 4c)**

UNSTANDARDIZED MODEL RESULTS (IFA MODEL SOLUTION)					UNSTANDARDIZED MODEL RESULTS (IFA MODEL SOLUTION)						
		Estimate	S.E.	Est./S.E.	Two-Tailed P-Value			Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
<b>Group MEN</b>					<b>Group WOMEN</b>						
<b>FACTOR LOADINGS: CHANGE IN PROBIT FOR 1-UNIT CHANGE IN THETA</b>					<b>FACTOR LOADINGS</b>						
IADL	BY					IADL	BY				
CIA1		4.614	0.532	8.674	0.000	CIA1		4.614	0.532	8.674	0.000
CIA2		3.191	0.506	6.309	0.000	CIA2		3.191	0.506	6.309	0.000
<b>CIA3</b>		<b>3.227</b>	<b>0.467</b>	<b>6.912</b>	<b>0.000</b>	<b>CIA3</b>		<b>6.758</b>	<b>1.277</b>	<b>5.294</b>	<b>0.000</b> cooking
CIA4		4.607	0.571	8.062	0.000	CIA4		4.607	0.571	8.062	0.000
CIA5		3.009	0.352	8.548	0.000	CIA5		3.009	0.352	8.548	0.000
CIA6		2.519	0.292	8.614	0.000	CIA6		2.519	0.292	8.614	0.000
CIA7		1.123	0.174	6.471	0.000	CIA7		1.123	0.174	6.471	0.000
<b>Means: MEAN OF THETA FIXED=0 FOR IDENTIFICATION</b>					<b>Means: MEAN DIFFERENCE OF THETA IN WOMEN</b>						
IADL		0.000	0.000	999.000	999.000	IADL		-0.382	0.095	-4.014	0.000
<b>Thresholds: EXPECTED PROBIT OF LOWER CATEGORY WHEN THETA=0</b>					<b>Thresholds:</b>						
CIA1\$1		-6.411	0.651	-9.855	0.000	CIA1\$1		-6.411	0.651	-9.855	0.000 housework
<b>CIA1\$2</b>		<b>-4.068</b>	<b>0.617</b>	<b>-6.594</b>	<b>0.000</b>	<b>CIA1\$2</b>		<b>-5.198</b>	<b>0.602</b>	<b>-8.633</b>	<b>0.000</b>
<b>CIA1\$3</b>		<b>-0.660</b>	<b>0.461</b>	<b>-1.431</b>	<b>0.152</b>	<b>CIA1\$3</b>		<b>-2.499</b>	<b>0.520</b>	<b>-4.808</b>	<b>0.000</b>
CIA2\$1		-4.709	0.665	-7.081	0.000	CIA2\$1		-4.709	0.665	-7.081	0.000 bed making
CIA2\$2		-4.078	0.597	-6.836	0.000	CIA2\$2		-4.078	0.597	-6.836	0.000
<b>CIA2\$3</b>		<b>-2.268</b>	<b>0.470</b>	<b>-4.823</b>	<b>0.000</b>	<b>CIA2\$3</b>		<b>-3.053</b>	<b>0.497</b>	<b>-6.143</b>	<b>0.000</b>
<b>CIA3\$1</b>		<b>-4.037</b>	<b>0.501</b>	<b>-8.062</b>	<b>0.000</b>	<b>CIA3\$1</b>		<b>-9.576</b>	<b>1.602</b>	<b>-5.976</b>	<b>0.000</b> cooking
<b>CIA3\$2</b>		<b>-2.924</b>	<b>0.467</b>	<b>-6.263</b>	<b>0.000</b>	<b>CIA3\$2</b>		<b>-8.545</b>	<b>1.498</b>	<b>-5.705</b>	<b>0.000</b>
<b>CIA3\$3</b>		<b>-0.588</b>	<b>0.339</b>	<b>-1.732</b>	<b>0.083</b>	<b>CIA3\$3</b>		<b>-6.349</b>	<b>1.307</b>	<b>-4.857</b>	<b>0.000</b>
CIA4\$1		-6.079	0.613	-9.919	0.000	CIA4\$1		-6.079	0.613	-9.919	0.000 shopping
CIA4\$2		-4.544	0.553	-8.217	0.000	CIA4\$2		-4.544	0.553	-8.217	0.000
CIA4\$3		-2.423	0.504	-4.805	0.000	CIA4\$3		-2.423	0.504	-4.805	0.000
CIA5\$1		-4.868	0.409	-11.895	0.000	CIA5\$1		-4.868	0.409	-11.895	0.000 get around
CIA5\$2		-2.822	0.348	-8.106	0.000	CIA5\$2		-2.822	0.348	-8.106	0.000
CIA5\$3		-1.284	0.317	-4.055	0.000	CIA5\$3		-1.284	0.317	-4.055	0.000
CIA6\$1		-4.240	0.356	-11.908	0.000	CIA6\$1		-4.240	0.356	-11.908	0.000 banking
CIA6\$2		-3.117	0.318	-9.794	0.000	CIA6\$2		-3.117	0.318	-9.794	0.000
CIA6\$3		-2.143	0.298	-7.199	0.000	CIA6\$3		-2.143	0.298	-7.199	0.000
CIA7\$1		-3.024	0.357	-8.472	0.000	CIA7\$1		-3.024	0.357	-8.472	0.000 telephone
CIA7\$2		-2.438	0.287	-8.490	0.000	CIA7\$2		-2.438	0.287	-8.490	0.000
CIA7\$3		-1.747	0.225	-7.782	0.000	CIA7\$3		-1.747	0.225	-7.782	0.000
<b>Variances: VARIANCE OF THETA FIXED=1 FOR IDENTIFICATION</b>					<b>Variances: VARIANCE OF THETA</b>						
IADL		1.000	0.000	999.000	999.000	IADL		0.492	0.111	4.424	0.000
<b>Residual Variances ALL FIXED=1 FOR IDENTIFICATION</b>					<b>Residual Variances (NOT ALL FIXED=1)</b>						
CIA1		1.000	0.000	999.000	999.000	CIA1		1.000	0.000	999.000	999.000
CIA2		1.000	0.000	999.000	999.000	<b>CIA2</b>		<b>0.425</b>	<b>0.154</b>	<b>2.769</b>	<b>0.006</b>
CIA3		1.000	0.000	999.000	999.000	CIA3		1.000	0.000	999.000	999.000
CIA4		1.000	0.000	999.000	999.000	CIA4		1.000	0.000	999.000	999.000
CIA5		1.000	0.000	999.000	999.000	CIA5		1.000	0.000	999.000	999.000
CIA6		1.000	0.000	999.000	999.000	CIA6		1.000	0.000	999.000	999.000
CIA7		1.000	0.000	999.000	999.000	<b>CIA7</b>		<b>0.564</b>	<b>0.158</b>	<b>3.558</b>	<b>0.000</b>

**Figures from Partial Measurement Invariance Model 4c (see next page for Mplus code and output for the IRT  $a_i$  and  $b_i$  parameters using theta mean=0 and variance=1 in both groups to maintain comparable invariance):**

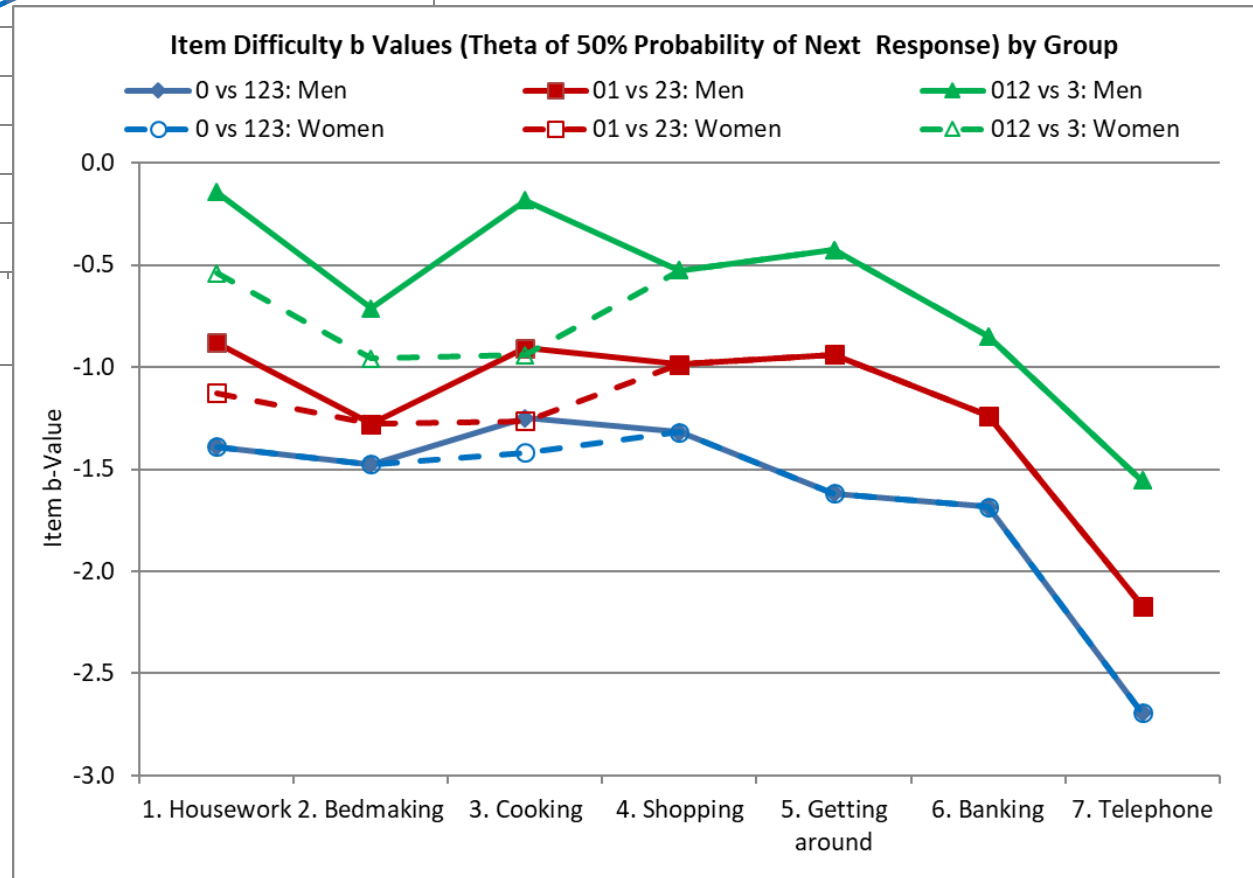


The **thresholds** (shown on the left) predict the probit of  $y=lower$  response for someone with  $\Theta=0$ . At  $\theta=0$ , women (dashed lines) have a *lower* probability than men of not being able to do housework, make the bed, or cook (items 1–3).

The **b-values** (=threshold/loading; shown below) predict the trait level at which the next response becomes 50%. So in women, it takes a lesser amount of the latent trait to be more able to perform these items.

The difference in the loading for item 3 (not pictured) also indicates that cooking is less discriminating (lower  $a$ -value) in men than in women (i.e., it is less useful in men for measuring ability to live independently at its  $b_i$  locations).

In addition, women are less variable and less able to live independently than men (as given by the factor variance and factor mean differences, respectively.)



```

MODEL:   !!! FINAL MODEL 4c FOR MEN REFERENCE GROUP

! Factor loadings all freely estimated, just labeled
IADL BY cial-cia7* (L_I1-L_I7);
! Item thresholds all freely estimated, just labeled
[cial$1-cia7$1*] (T1_I1-T1_I7);
[cial$2-cia7$2*] (T2_I1-T2_I7);
[cial$3-cia7$3*] (T3_I1-T3_I7);
! Item residual variances all fixed=1 for identification
cial-cia7@1;
! Factor mean=0 and variance=1 for identification
[IADL@0]; IADL@1;

MODEL WOMEN: !!! FINAL MODEL 4c FOR WOMEN ALTERNATIVE GROUP
! Factor loadings CONSTRAINED EQUAL TO MEN EXCEPT ITEM 3
IADL BY cial-cia7* (L_I1 L_I2 L_I3w L_I4 L_I5 L_I6 L_I7);
! Item thresholds CONSTRAINED EQUAL TO MEN BY LABELS EXCEPT "w"
[cial$1-cia7$1*] (T1_I1 T1_I2 T1_I3w T1_I4 T1_I5 T1_I6 T1_I7);
[cial$2-cia7$2*] (T2_I1w T2_I2 T2_I3w T2_I4 T2_I5 T2_I6 T2_I7);
[cial$3-cia7$3*] (T3_I1w T3_I2w T3_I3w T3_I4 T3_I5 T3_I6 T3_I7);
! Item residual variances HELD EQUAL EXCEPT 2 AND 7
cial@1 cia2* cia3-cia6@1 cia7*;
! Factor mean and variance ESTIMATED
[IADL*]; IADL*;

MODEL CONSTRAINT: ! IRT parms using current factor mean and variance
! DO (begin, end), replace # with index
! A = discrimination, B1=y>0, B2=y>1, B3=y>2
! Ref group (men) parms
NEW(Am_I1-Am_I7 B1m_I1-B1m_I7 B2m_I1-B2m_I7 B3m_I1-B3m_I7);
! Discriminations
DO (1,7) Am_I# = L_I#;
! Difficulties
DO (1,7) B1m_I# = T1_I# / L_I#;
DO (1,7) B2m_I# = T2_I# / L_I#;
DO (1,7) B3m_I# = T3_I# / L_I#;
! Alt group (women) parms
NEW(Aw_I1-Aw_I7 B1w_I1-B1w_I7 B2w_I1-B2w_I7 B3w_I1-B3w_I7);
! Discriminations
DO (1,2) Aw_I# = L_I#;
Aw_I3 = L_I3w; ! w marks diff loading for women
DO (4,7) Aw_I# = L_I#;
! Difficulties for Thresh 1
DO (1,2) B1w_I# = T1_I# / L_I#;
B1w_I3 = T1_I3w / L_I3w; ! w marks diff thresh for women
DO (4,7) B1w_I# = T1_I# / L_I#;
! Difficulties for Thresh 2
B2w_I1 = T2_I1w / L_I1;
B2w_I2 = T2_I2 / L_I2;
B2w_I3 = T2_I3w / L_I3w;
DO (4,7) B2w_I# = T2_I# / L_I#;
! Difficulties for Thresh 3
B3w_I1 = T3_I1w / L_I1;
B3w_I2 = T3_I2w / L_I2;
B3w_I3 = T3_I3w / L_I3w;
DO (4,7) B3w_I# = T2_I# / L_I#;

```

New/Additional Parameters	Estimate	S.E.	Two-Tailed	
			Est./S.E.	P-Value
AM_I1	4.614	0.532	8.674	0.000
AM_I2	3.191	0.506	6.309	0.000
AM_I3	3.227	0.467	6.912	0.000
AM_I4	4.607	0.571	8.062	0.000
AM_I5	3.009	0.352	8.548	0.000
AM_I6	2.519	0.292	8.614	0.000
AM_I7	1.123	0.174	6.471	0.000
B1M_I1	-1.390	0.117	-11.877	0.000
B1M_I2	-1.476	0.125	-11.816	0.000
B1M_I3	-1.251	0.136	-9.224	0.000
B1M_I4	-1.320	0.113	-11.628	0.000
B1M_I5	-1.618	0.138	-11.698	0.000
B1M_I6	-1.683	0.142	-11.891	0.000
B1M_I7	-2.693	0.287	-9.370	0.000
B2M_I1	-0.882	0.111	-7.977	0.000
B2M_I2	-1.278	0.110	-11.587	0.000
B2M_I3	-0.906	0.115	-7.871	0.000
B2M_I4	-0.986	0.096	-10.239	0.000
B2M_I5	-0.938	0.095	-9.893	0.000
B2M_I6	-1.238	0.109	-11.341	0.000
B2M_I7	-2.171	0.218	-9.946	0.000
B3M_I1	-0.143	0.096	-1.492	0.136
B3M_I2	-0.711	0.101	-7.051	0.000
B3M_I3	-0.182	0.098	-1.865	0.062
B3M_I4	-0.526	0.085	-6.186	0.000
B3M_I5	-0.427	0.086	-4.952	0.000
B3M_I6	-0.851	0.091	-9.331	0.000
B3M_I7	-1.555	0.150	-10.365	0.000
AW_I1	4.614	0.532	8.674	0.000
AW_I2	3.191	0.506	6.309	0.000
AW_I3	6.758	1.277	5.294	0.000
AW_I4	4.607	0.571	8.062	0.000
AW_I5	3.009	0.352	8.548	0.000
AW_I6	2.519	0.292	8.614	0.000
AW_I7	1.123	0.174	6.471	0.000
B1W_I1	-1.390	0.117	-11.877	0.000
B1W_I2	-1.476	0.125	-11.816	0.000
B1W_I3	-1.417	0.120	-11.836	0.000
B1W_I4	-1.320	0.113	-11.628	0.000
B1W_I5	-1.618	0.138	-11.698	0.000
B1W_I6	-1.683	0.142	-11.891	0.000
B1W_I7	-2.693	0.287	-9.370	0.000
B2W_I1	-1.127	0.103	-10.935	0.000
B2W_I2	-1.278	0.110	-11.587	0.000
B2W_I3	-1.264	0.110	-11.444	0.000
B2W_I4	-0.986	0.096	-10.239	0.000
B2W_I5	-0.938	0.095	-9.893	0.000
B2W_I6	-1.238	0.109	-11.341	0.000
B2W_I7	-2.171	0.218	-9.946	0.000
B3W_I1	-0.542	0.088	-6.126	0.000
B3W_I2	-0.957	0.097	-9.914	0.000
B3W_I3	-0.939	0.095	-9.922	0.000
B3W_I4	-0.986	0.096	-10.239	0.000
B3W_I5	-0.938	0.095	-9.893	0.000
B3W_I6	-1.238	0.109	-11.341	0.000
B3W_I7	-2.171	0.218	-9.946	0.000



### Example write-up of these IFA analyses:

The extent to which an item factor model measuring independent daily living (with seven observed items) exhibited measurement invariance and structural invariance between men and women was examined using *Mplus* v. 8.8 (Muthén & Muthén, 1998–2017). WLSMV limited-information estimation (i.e., diagonally weighted least squares) using a probit link and the THETA parameterization was used for all models. Thus, model fit statistics describe the fit of the item factor model to the item polychoric correlation matrix for each group. Nested model comparisons were conducted using the *Mplus* DIFFTEST procedure. A configural invariance model was initially specified in which a single factor was estimated simultaneously in each group. The factor variance was fixed to 1 and the factor mean was fixed to 0 in each group for identification, such that all item factor loadings (one per item) and thresholds (three per item given four response options) were then estimated. The residual variances are not uniquely identified in the configural invariance model and as such were all constrained to 1 in both groups. As shown in Table 1, the configural invariance model had good fit. The analysis proceeded by applying parameter constraints in successive models to examine potential decreases in fit resulting from measurement or structural non-invariance between men and women, with men as the reference group.

Equality of the unstandardized item factor loadings between groups was then examined in a metric invariance model. The factor variance was fixed to 1 in men for identification but was freely estimated in women; the factor mean was fixed to 0 in both groups for identification. All factor loadings were constrained equal across groups, all item thresholds were estimated, and all residual variances were constrained to 1 across groups. Although the metric invariance model did not fit significantly worse than the configural invariance model, DIFFTEST (6) = 9.40,  $p = .15$ , the modification indices suggested localized misfit for the constrained loading of item 3 (cooking). After freeing its loading between groups, the partial metric invariance model also did not fit significantly worse than the configural invariance model, DIFFTEST (5) = 5.53,  $p = .36$ , and no loadings were indicated as individually problematically different. The fact that partial 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. The exception is for the cooking item 3, which was less related to the trait of independent daily living in men than in women.

Equality of the unstandardized item thresholds across groups was then examined in a scalar invariance model. The factor mean and variance were fixed to 0 and 1, respectively, in men for identification, but the factor mean and variance were then estimated for women. All factor loadings (except item 3) and all item thresholds were constrained equal across groups; all residual variances were still constrained equal to 1 in both groups. The full scalar invariance model A fit significantly worse than the partial metric invariance model, DIFFTEST (20) = 91.66,  $p < .01$ . Not surprisingly given its differential loading across groups, the modification indices suggested that item 3 was the largest source of the misfit. After freeing item 3’s thresholds, the partial scalar invariance model B still had significantly worse fit than the partial metric invariance model, DIFFTEST (17) = 44.80,  $p < .01$ . The modification indices suggested that item 1 threshold 3 was the next largest remaining source of the misfit and should be freed. After doing so, the new partial scalar invariance model C (with all item 3 thresholds and item 1 threshold 3 freed) still fit significantly worse than the partial metric invariance model, DIFFTEST (16) = 32.46,  $p < .01$ . The modification indices suggested that item 2 threshold 3 was the largest remaining source of the misfit and should be freed. After doing so, the new partial scalar invariance model D (with all item 3 thresholds, item 2 threshold 3, and item 1 threshold 3 freed) still fit significantly worse than the partial metric invariance model, DIFFTEST (15) = 26.17,  $p = .04$ . The modification indices suggested that item 1 threshold 2 was the largest remaining source of the misfit and should be freed. After doing so, the new partial scalar invariance model E (with all thresholds for item 3, thresholds 2 and 3 for item 1, and threshold 3 for item 2 freed) did not fit significantly worse than the partial metric invariance model, DIFFTEST (14) = 20.32,  $p = .12$ . The fact that partial scalar invariance (i.e., “strong invariance”) held indicates that items 4, 5, 6, and 7 have the same expected response at the same absolute level of the trait, or more simply, that the observed differences in the proportion of responses in each category for those items was due to factor mean differences only. However, at the same absolute level of the IADL factor, thresholds 2 and 3 for item 1, threshold 3 for item 2, and all thresholds for item 3 were more difficult for men, indicating that men had a greater probability of not being able to do housework, make the bed, or cook, respectively.

Equality of the unstandardized residual variances across groups was then examined in a residual variance invariance model. The model comparison at this step proceeded backwards, such that fitted first was a residual variance A model with all residual variances freely estimated in the women (except for item 3, whose residual variance could not be estimated given that its factor loading and thresholds differed across groups), which was then compared with a model in which all residual variances were fixed to 1 in the women (residual variance B; in which all model parameters were estimated as described for the last partial scalar invariance model E). Although the model B with the residual variances constrained to 1 (to be equal to the men) fit nonsignificantly worse than the A

model with those residual variances freed, DIFFTEST (6) = 11.02,  $p = .09$ , the modification indices suggested that the residual variances for items 2 and 7 (bed-making and answering the telephone) were a source of local misfit and should be freed. After doing so, the new partial residual variance invariance model C did not fit significantly worse than the model with free residual variances in the women group, DIFFTEST (4) = 2.80,  $p = .59$ , indicating that residual variances for items 2 and 7 were significantly smaller for women than men. The fact that partial residual variance invariance (i.e., "strict invariance") held indicates that the amount of item variance not attributable to the factor was the same across groups in all five other items.

After achieving partial measurement invariance as was just described, structural invariance was then tested with one additional model. The factor variance in the women (which had been estimated freely) was constrained to 1 (i.e., to be equal to the factor variance in men), resulting in a significant decrease in fit relative to the last partial residual invariance model C, DIFFTEST (1) = 11.50,  $p < .01$ . Thus, women showed significantly less variability in ability to live independently (factor variance of 0.49) than did men (factor variance fixed = 1). The factor mean for women in the partial measurement invariance model was significantly different from 0 as indicated by a Wald test (difference = -0.38, SE = 0.10,  $p < .01$ ), indicating that women on average were significantly less able to live independently on average than men (factor mean fixed = 0).

In conclusion, these analyses showed that partial measurement invariance was obtained across men and women—that is, the relationships of four items to the latent factor of independent living were equivalent between men and women. However, items 1, 2, and 3 (housework, bedmaking, and cooking) were systematically more difficult for men than women at the same level of the latent trait. Structural invariance was not obtained, such that women were less variable and less able on average than men. Model parameters from the final model are given in Table 2.

(see Example 7c spreadsheet for Table 1 and figures; Table 2 would have unstandardized and standardized estimates and their SEs)

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